ANT-XXIV/2

28 November 2007 - 4 February 2008

Cape Town - Cape Town
Weddell Sea

Chief Scientist
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1. ÜBERBLICK UND FAHRTVERLAUF

Ulrich Bathmann (AWI)

Am 28. Dezember 2007 wird das Forschungsschiff *Polarstern* von Kapstadt aus zum 2. Fahrtabschnitt ihrer 24. Antarktis-Expedition auslaufen. Während des Fahrtabschnittes wird sie als Basis für die Durchführung eines umfangreichen marinen Forschungsprogramms während des antarktischen Sommers dienen. Eine weitere wichtige Aufgabe ist der unterstützende eisbrechende Einsatz für die zwei Transportschiffe, die Material für die neue Neumayer III Station anliefern. Zusätzlich wird *Polarstern* so früh die Eisbedingungen es zulassen Neumayer II mit Proviant, Material und Treibstoff für die Sommerkampagne versorgen. Enden wird der Fahrtabschnitt am 4. Februar 2008 in Kapstadt.

Der wissenschaftliche Anteil der Expedition ist drei Projekten des Internationalen Polarjahres IPY gewidmet. SCACE - Synoptische Studie des Zirumantarktischen Klima- und Ökosystems - untersucht physikalische und biologische Zusammenhänge im antarktischen Zirkumpolarstrom (ACC) um die entsprechenden Mechanismen aufzuklären, die die Ozeanproduktivität und den Wassermassentransport bestimmen. SYSCO - Gekoppelte Systeme in der Tiefsee - untersucht den Einfluß der pelago-benthischen Kopplung in der Tiefsee in ausgewählten Gebieten zwischen der Subtropischen Konvergenz und dem antarktischen Kontinent. LAKRIS - Lasarev-See Krill Studie - bestimmt die Verteilungsmuster, Lebenszyklen und die Physiologie antarktischen Krills in der Lasarev-See.

Um die logistischen Aufgaben so früh wie möglich abzuarbeiten, wird *Polarstern* zielstrebig nach Neumayer dampfen und nur eine Station bei 56°S 0°O beproben. Ansonsten werden während der Anfahrt nur wissenschaftliche Untersuchungen durchgeführt, die die Schiffsgeschwindigkeit nicht beeinflussen. Diese Projekte umfassen die Beobachtung mariner Vögel (inkl. Pinguine) und Warmblüter, die von einer holländischen Forschergruppe von einem Beobachtungsposten auf dem Peildeck systematisch gezählt und bestimmt werden. Mit dem hinter dem Schiff gezogenen sogenannten Continous Plankton Recorder wird das Plankton aus dem Oberflächenwasser herausfiltriert und später während der taxonomischen Auswertung den geographischen Sammelpositionen zugeordnet.

Das IPY Programm SCACE wird durch duch die Programme CCMLAR - Konvention zum Schutz lebender antarktischer Resourcen - und das durch das BMBF geförderte LAKRIS komplettiert. Das übergeordnete Ziel von SCACE ist die synoptische Aufnahme biologischer und physikalischer Umweltparameter im ACC rund um den Kontinent im Rahmen von IPY, um diese mit historischen Daten zu vergleichen um Änderungen zu erkennen.

SCACE verbindet verschiedenste Disziplinen, um folgende Fragen zu beantworten:
- Welche physikalischen, biologischen und chemischen Prozesse regulieren die ozeanischen Systeme im Südozean und beeinflussen somit die Entwicklung des globalen Klimas?
- Wie sensibel reagieren die Prozesse im Südozean auf natürliche und anthropogen beeinflusste Störungen?

Der Südozean spielt eine zentrale Rolle in der Kontrolle des Systems Erde. Der ACC verbindet alle großen Ozeane miteinander, isoliert aber auch die Antarktis von diesen. Er

transportiert Wärme und Süßwasser und sorgt für die Verteilung gelöster Substanzen. Er ist Heimat verschiedenster Ökosysteme, die sich bei sich ändernden Klimaregime ggf. gegenseitig ersetzen. Auftrieb von Tiefenwasser fördert Makronährsalze in die lichtdurchflutete produktive Ozeanoberfläche und bildet so günstige Ausgangsbedingungen für eine umfangreiche Primärproduktion, die das Potential hat, atmosphärisches CO_2 zu binden. Ein Team aus Norwegen wird sich der Änderung des Karbonatsystems im Oberflächenwasser widmen, die durch diese Prozesse angetrieben wird.

Die Systeme des Südozeans sind ihrerseits aber auch sensibel gegenüber global wirkenden Änderungen. So werden wir eine der zahlenmäßig häufigsten Copepodenarten (*Oithona* spp) darauf hin untersuchen, wie flexibel sie auf Änderungen reagieren kann. *Oithona* ist weltweit verbreitet und es ist bisher unklar, um wie viel Arten es sich handelt und wo die Plastizität jeder Art je nach Verbreitungsgebiet gleich ist. Das Zooplankton des Zwischenwassers (Mesopelagials) ist vom Nahrungseintrag von oben abhängig, ansonsten jedoch an eine sehr gleichförmige Umgebung angepasst und somit für kleinste Änderungen hoch sensibel. Aber auch Organismen, die direkter Nutzung durch den Menschen zur Verfügung stehen werden, wie der antarktische Krill, werden während der Expedition intensiv untersucht.

Im Wesentlichen stammt unser Wissen über den antarktischen Krill aus nur wenigen Gebieten, insbesondere solchen um die Antarktischen Halbinsel. Neue Untersuchungen zeigen, dass die saisonalen Überlebensmechanismen von Krill regional variabel sind und 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 Lasarev-See ergänzt werden.

Innerhalb des Wasserringes um die Antarktis gibt es unter anderem zwischen der Antarktischen Halbinsel und dem Nullgrad-Meridian, bzw. der Lasarev-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 Lasarev-See sollen zur Klärung dieser Fragen entscheidend beitragen.

Wenn Krill mit Meeresströmungen in das Weddellmeer eingetragen wird, dann am wahrscheinlichsten im Bereich der Lasarev-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 Lasarev-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.

SYSTCO ist ein weiteres großes IPY Programm der Expedition. Große Teile des Meeresbodens um die Antarktis zählen zur Tiefsee. Im Gegensatz zu den relativ gut bekannten

Schelfgebieten der Antarktis ist die Tiefsee noch so gut wie unerforscht. Erste Untersuchungen während des internationalen Projekts ANDEEP haben eine erstaunliche Artenvielfalt von Tiefseeorganismen gezeitigt. Basierend auf diesen Ergebnissen werden wir jetzt die Prozesse der atmosphärische-pelagische-benthischen Kopplung untersuchen. SYSTCO soll helfen die Rolle der Tiefsee des Südozeans im globalen Energiehaushalt, deren Funktion beim Klimawandel und beim Erhalt der biologischen Diversität aufzuklären.

Die Ziele von SYSTCO sind
- Prozessstudien in verschiedenen Tiefseegegenden in der Antarktis
- Aufklärung wie die pelago-benthische Kopplung dieser Systeme funktioniert.

Hierzu werden die eigenen Untersuchungen zu denen der anderen Arbeitsgruppen in Beziehung gesetzt, sodass
- der Einfluss der atmosphärischen CO_2-Konzentration auf das Karbonatsystem und somit auf die Produktion und den Export organischen Materials beleuchtet wird,
- und dessen Einfluss auf die Biologie abyssaler Schlüsselarten, auf das Recruitment benthischer Organismen in der Nephloid-Bodenschicht, auf Nahrungsmenge und -qualität für abyssale Organismen und deren Reaktion in Hinbilck auf Fraßökologie und trophische Interaktionen,
- der Einfluss der Bodentopographie, der Sedimenteigenschaften und der Biogeochemie des Meeresbodens und des Porenwassers auf benthische Organismen in der Gegenwart und der Erdgeschichte möglich wird. Die Aufnahme der Bathymetrie soll die Bildung von Mikrohabitaten aufklären helfen.

Unter dem Schirm des IPY Rahmenprogramms ICED (Integrated Circumpolar Ecosystem and Climate Dynamics), wird SCACE ein Transekt auf die Antarktis abarbeiten, dass von anderen Programmen auf anderen Forschungsschiffen in verschieden Regionen um den Antarktischen Kontinent ebenfalls durchgeführt wird. Solche synoptischen zirkumantarktischen Studien stellen die einzige Möglichkeit dar, einen Momentanzustand antarktischer Systeme vor dem Hintergrund hoher zwischenjährlicher Schwankungen aufzunehmen. Die enge Kooperation mit SYSTCO wird es erlauben die Kopplung von Prozessen in der Atmosphäre, in den oberen Wassermassen, im gesamten Wasserkörper bis in die Tiefsee aufzuklären.

ITINERARY AND SUMMARY

On 28 December 2007 RV *Polarstern* will leave from Cape Town for the second leg of her 24th expedition. During this cruise that will end in Cape Town on 4 February 2008, RV *Polarstern* will support an extensive marine research programme during the austral summer and will allocate ship time to support the logistic operations of two other ships that transport material for the construction of Neumayer III. In addition *Polarstern* will supply Neumayer II as early as possible in the season but depending on sea-ice conditions.

The scientific part of the cruise is part of three major IPY projects. SCACE aims to investigate the physical and biological patterns in the Antarctic Circumpolar Current to understand the temporal and spatial variability's that determine ocean productivity and water

mass transport. SYSCO-ANDEEP aims to understand the impact of pelagic-benthic coupling on deep-sea biota in distinct regions between the STC and the Antarctic continent. LAKRIS aims to reveal the life cycle pattern, distribution and physiology of Antarctic krill in the Lazarev Sea.

In order to access the working area for the logistic part of the cruise as soon as possible, RV *Polarstern* will head almost straight towards its first scientific position at 56°S 0°E and than continue to Neumayer II station. On the way to the Antarctic only such scientific activities will be performed that need no extra ship time.

The projects planned on the way south focus on observations of marine vertebrates and zooplankton. A Dutch team will visually observe penguins, seabirds and marine mammals from the upper bridge from out two wooden cabins. 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 IPY programme SCACE, with addition of the CCMLAR programme and the BMBF funded LAKRIS programme will form one scientific backbone of the cruise. The overarching goal of SCACE is to use the outstanding chance provided by the IPY for an international collaboration to collect a unique data set that can serve as a benchmark for comparison with existing data to identify and quantify polar changes.

SCACE aims at welding together a broad range of ocean science disciplines in order to address currently elusive questions such as:

- Which physical, biological and chemical processes regulate the Southern Ocean system and determine its influence on the global climate development?
- How sensitive are Southern Ocean processes and systems to natural climate change and anthropogenic perturbations?

The Southern Ocean is critically involved in the machinery driving earth´s climate. The Antarctic Circumpolar Current (ACC) connects all the other oceans. Thus it plays a major role in the global transports of heat and fresh-water and the ocean-wide cycles of dissolved substances. It harbors a series of distinct ecosystems that displace each other with changing climate regimes. Upwelling of deep water masses results in an extraordinary high supply of plant macronutrients, which could sustain much higher primary production and hence CO_2 uptake than however observed. Thus, the Norwegian team will concentrate on the reaction of the carbonate system of the surface ocean to changes.

While the Southern Ocean thus exerts a control on earth's climate, it is itself sensitive to climatic changes, which may occur on various time scales and affect the biota. We will closely investigate one of the most important zooplankton specimens in the system, namely the cyclopoid copepod *Oithona* spp. These species have world-wide distribution and cope with extreme warm and cold environmental conditions similarly well. It is the focus of these studies to find out, if it is really the same species we are seeing. We will also investigate species' physiologyical reactions on changing environment. Zooplankton in the mesopelagic zone depends on food supply from above and therefore is subject to studies of species adaptation to very stable environmental conditions. There are, however, also direct anthropogenic influences on the ecosystem, namely by harvesting marine living resources such as krill.

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 extrapolated easily 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. They are thus 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.

SYSTCO - system coupling in the deep-sea - will form the other large IPY programme operational during the cruise. Vast areas of the Southern Ocean surrounding the Antarctic continental shelf are deep sea. In contrast to our knowledge of the benthos in Southern Ocean shelf areas, corresponding data from the deep sea are still scarce. However, the pioneering investigations of ANDEEP aboard the *Polarstern* have revealed a remarkable biodiversity in the Southern Ocean deep sea.

We will now build on those results to elucidate the functioning of atmospheric, pelagic, and benthic systems of the Southern Ocean in a process oriented context. SYSTCO will help to understand the role of the Southern Ocean in global energy budgets, climate change, and the maintenance of the diversity of marine life on the Blue Planet.

SYSTCO is an ambitious programme designed to

- study processes in different realms of the biosphere in Antarctica and
- uncover how these systems are linked to each other (pelagic-benthic coupling processes)

Important objectives in the different realms are to connect own investigations with those of other expedition programmes, namely

- Atmosphere: to study surface fluxes, for example, of CO_2 and vertical profiles of fluxes in the atmospheric boundary layer.

- Water column and plankton: to define the influence of atmospheric processes on processes in the water column, the influence of the biogeochemistry of the surface water on primary productivity, the importance of the nanoplankton in the food web, and to describe vertical changes in the plankton community to abyssal depths.
- Benthos: to investigate the biology of abyssal key species, the role of the bottom-nepheloid layer for recruitment of benthic animals, the influence of the quantity and quality of food sinking through the water column on abyssal life, feeding ecology and trophic relationships of abyssal animals.
- Seabed characteristics: to study the effects of topography, sedimentology and biogeochemistry of sediment and pore water on benthic life in the present and past (palaeontology), to map bathymetry to understand microhabitat formation.

By coordination under the umbrella of the IPY lead project ICED-IPY (Integrated Circumpolar Ecosystem and Climate Dynamics), SCACE strives for performing in the same season and year sections that cross the ACC and extend to the Antarctic continent at several key longitudes. Such synoptic circumpolar assessment is the only way to document the current state of the polar environment without bias introduced by interannual variability. By close cooperation with the IPY project ANDEEP-SYSTCO, which is focused on benthic biology and geochemistry, the projects aim at also obtaining new insights into the coupling between processes in the productive near-surface euphotic zone and at the deep-sea sediments.

Fahrtroute und Stationen / Ships track and stations

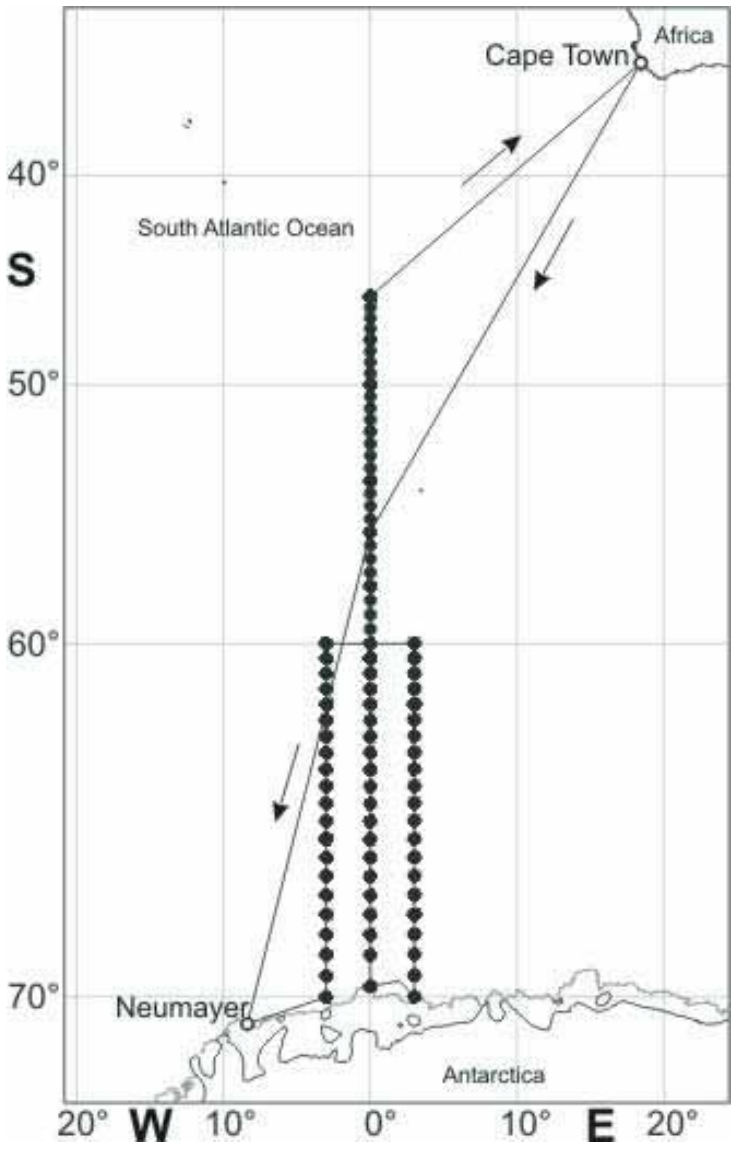

Fig. 1: Geplante Fahrtroute mit Stationen (hellere Punkte) und Positionen für andere Aufgaben (dunklere Punkte) während ANT-XXIV/2. Aufgrund logistischer Aufgaben (u.a. Versorgung Neumayer) wird nach dem Auslaufen Kapstadt fast direkt die deutsche Antarktisstation angelaufen.

Planned cruise track with positions for scientific sampling (lighter dots) and for other tasks (darker dots) during ANT-XXIV/2. After departure Cape Town we will head nearly directly to this German Antarctic station due to logistic reasons (e.g. supply Neumayer station).

2. PHYSICS OF BIOGEOGRAPHIC ZONATION IN THE ANTARCTIC CIRCUMPOLAR CURRENT - A CONTRIBUTION TO THE *SYNOPTIC CIRCUM-ANTARCTIC CLIMATE AND ECOSYSTEM STUDY* (SCACE)

D. Ewe, S. Maßmann, M. Olischläger, F. Richter, V. Strass (AWI); H. Leach (Univ. Liverpool); T. Witte (OPTIMARE)

Objectives

The physical and oceanographic measurements planned for *Polarstern* cruise ANT-XXIV/2 will form part of the IPY-Project Synoptic Circum-Antarctic Climate and Ecosystem study (SCACE). The overarching goal of SCACE is to use the outstanding chance provided by the IPY for an international collaboration to collect a unique data set that can serve as a benchmark for comparison with existing data to identify and quantify polar changes.

SCACE aims at welding together a broad range of ocean science disciplines in order to address currently elusive questions such as:

- Which physical, biological and chemical processes regulate the Southern Ocean system and determine its influence on the global climate development?
- How sensitive are Southern Ocean processes and systems to natural climate change and anthropogenic perturbations?

The Southern Ocean is critically involved in the machinery driving earth's climate. The Antarctic Circumpolar Current (ACC) connects all the other oceans. Thus it plays a major role in the global transports of heat and fresh-water and the ocean-wide cycles of dissolved substances. It harbours a series of distinct ecosystems that displace each other with changing climate regimes. Upwelling of deep water masses results in an extraordinary high supply of plant macronutrients, which could sustain much higher primary production and hence CO_2 uptake than however observed.

Although much progress has been made during the last decades in documenting the Southern Ocean hydrographic and biographic features, in quantifying fluxes and in understanding the dominating forcing, there is still a big gap in knowledge, especially with regard to the interaction of physical, chemical and biological processes. While this gap in knowledge is basically due to the remoteness of the area and its inhospitality for humans, it is also due to the fragmentation of research as carried out usually.

Work at Sea

The data base for this study will be collected at hydrographic stations, regularly spaced along the prime meridian south of 46° S and along two parallel sections running along 3°E and 3° W south of 60°S, respectively. A CTD (Conductivity, Temperature, Depth) sonde will be routinely deployed at the hydrographic stations and give vertical profiles of temperature, salinity and density. The CTD will hold additional instruments such as a chlorophyll-sensitive fluorometer to provide an indication of the abundance of phytoplankton and a transmissiometer to measure the attenuation of light. It will be attached to a carousel water sampler holding 24 bottles of 12 l volume each. The CTD carousel sampler will be the major tool for supplying the various scientific disciplines on board with water samples.

The CTD measurements shall be analysed together with measurements of horizontal currents in the top few hundred metres, to be recorded continuously with a vessel mounted ADCP (acoustic Doppler current profiler) installed in the ship's hull. Besides its major purpose, the ADCP shall be used as a detector for zooplankton abundance by evaluating the backscattered echo amplitude.

Within SCACE the physical and oceanographic measurements will be complemented by suite of chemical and biological measurements performed during the cruise. Data of zooplankton abundance derived from the net catches, for instance, will by used for calibration of the ADCP backscatter signal. Combined analysis of the physical, chemical and biological is hoped to result in a better understanding of the coupling between the different realms.

3. CARBON, OXYGEN AND NUTRIENT BIOGEOCHEMISTRY

K. Brown, J. Hauck, O. Hofmann, C. Neill, F. Pey (UiB);
Not on board: R. Bellerby (UiB)

Objectives
To measure the distributions of inorganic carbon, total alkalinity, oxygen and nutrients in the Weddell Sea and Antarctic shelf

Work at Sea
Underway pCO_2 and oxygen from the ships online seawater line. Sampling water column samples will be measured for inorganic carbon, total alkalinity, oxygen and nutrient concentrations. Ice samples will be collected and measurements of inorganic carbon, total alkalinity, oxygen and nutrients will be done.

Expected results
The work done will extend the long time series of measurements now collected by the group in the Southern Ocean. The new information will be used to determine the anthropogenic content, seawater pH and carbonate species distributions in the waters between South Africa and the Antarctic mainland. The shelf study will provide new information on the contribution upwelled deep water and its modification conditioning the water properties prior to high salinity shelf water production later in the season.

4. BIODIVERSITY IN THE SURFACE LAYER OF THE ANTARCTIC CIRCUMPOLAR CURRENT - A CONTRIBUTION TO THE *SYNOPTIC CIRCUM-ANTARCTIC CLIMATE AND ECOSYSTEM STUDY* (SCACE)

U. Bathmann, S. Herrmann (AWI); J. Kitchener (AAD)

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 Foundation for Ocean Science, Plymouth. Data acquired by partners in the SO-CPR Survey are shared between partners. In addition continuous chlorophyll measurements and discrete samples of phytoplankton will be collected to obtain productivity distribution pattern in the different water masses of the surface ocean.

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.
- Determine the patchiness and species composition of phytoplankton distribution.

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 nautical 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.

Thus, no dedicated ship time is required. CPR can be deployed and retrieved at normal ship speed; although brief swing to 3 - 5 knots is advisable for the final few metres of retrieval. No deviation is required from the scheduled cruise track. 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.

The continuous measurements of chlorophyll fluorescence will be performed by means of a Turner design flow thru fluorometer that will be supplied by the Teflon clean running sea water system of *Polarstern*. Discrete plankton samples will be obtained from the Niskin bottles attached to the CTD frame from up to 10 water depth per station.

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

U. Bathmann, S. Krägefsky (AWI)

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, there is only rare information about the development in krill stock in the Antarctic waters of the Eastern Weddell Sea and the Lazarev Sea during the last decades.

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. E.g. using different scattering models and discrimination methods, additional data analysis will be performed, to account for current difficulties in interpretation of acoustic measurements. The echosounder has to be physically calibrated.

Work at sea
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.

6. KRILL DEMOGRAPHY AND POPULATION DYNAMICS

J. Edinger, M. Haraldsson, K. Stürmer, M. Vortkamp (BFA Fisch)
Not on board: V. Siegel (BFA Fisch)

Objectives

There have been very few attempts in the past to carry out standardized krill net sampling surveys to study seasonal aspects of krill distribution and demography in high latitude areas, which are covered by sea-ice during most of the year. Only one major exercise was conducted during the years 1983-85 by the international BIOMASS programme. The SIBEX surveys were carried out in the Antarctic Peninsula region and covered most of the annual cycle, however, sampling was mainly carried out in ice-free areas or in the marginal ice zone. The EPOS *Polarstern* study included the pack-ice region of the northern Weddell Sea from late winter to mid summer, but was more process orientated and less designed as a quantitative survey. The LAKRIS project started in austral autumn 2004 conducting a regular survey in the Lazarev Sea (3°E to °W) south of 60°S. Since the first survey a spring and winter survey have followed to collect data on the seasonal and interannual variability in the krill population.

The Antarctic ecosystem exhibits great spatial and temporal variability. Mesoscale, seasonal and interannual variability in abundance of Antarctic krill (*Euphausia superba*) impacts their dependent predator populations. Because of this variability over the multi-year (> 5 year) krill life span, long-term monitoring is essential to assess and understand the underlying physical and biological processes affecting krill recruitment success and population size. Information on seasonal and interannual abundance variations of short-lived salps (*Salpa thompsoni*) and biomass dominant other Euphausiacea species, sampled along with krill, provide additional insight on processes influencing the high latitude Lazarev Sea ecosystem. Included are studies on the distribution, abundance and demographic structure of krill and salps and abundance and distribution of other zooplankton taxa. Results from the various cruises will be compared with those from previous LAKRIS surveys to assess seasonal and between-year differences in krill demography and zooplankton composition and abundance over the studied period.

Experience gained through participation in other international programmes like BIOMASS has shown that standardization of equipment and methods is one of the most crucial steps for any successful work during the IPY 2008 field sampling period and later analytical work. The following net sampling protocols set out the procedures so that carrying out the cruise can collect comparable high quality data sets that will facilitate the establishment of a uniform and valuable database and allow for a simplified data exchange between CAML (Census Antarctic Marine Life) participants.

There are two primary objectives for the net sampling programme:

- to describe krill demography and large scale distribution patterns of size groups and maturity stages as well as regional recruitment indices,
- to collect quantitative data on other key zooplankton species, their quantitative distribution and abundance.

Work at Sea

The CCAMLR (Convention on the Conservation of Antarctic Marine Living Resources) Working Group as well as the CAML IPY steering group recommended the use of a standard type of net to avoid potential variation in catchability and selectivity of nets during krill centered survey activities. The most appropriate type of net presently available is the RMT8+1 (Rectangular Midwater Trawl). This net shall be used as the standard net for target and random hauls. The net has a mesh size of 4.5 mm. The net will be equipped with a calibrated flowmeter to estimate the filtered water volume as accurately as possible, and a real-time time-depth-recorder (TDR) to follow the track of the net.

At each station a quantitative standard double oblique tow will be conducted from the surface down to 200 m (or to within 10 m of the bottom at stations shallower than 200 m). Such a depth range is considered to be the best compromise between the time available for sampling and the likely vertical depth range of krill. During the hauls a constant ship's speed of 2.5 ± 0.5 knots is suggested. It is recommended to maintain a wire speed of 0.7 to 0.8 m/sec during paying out and of 0.3 m/sec during hauling. The net mouth angle is remarkably constant during hauling within the speed ranges given above. When the net reaches maximum depth, the winch should be stopped for about 30 seconds to allow the net to stabilize before starting to retrieve the net. If the net is hauled from the stern of the ship then the propeller of the ship should be stopped when the net reaches a depth of 15 to 20 m; this is to minimize the effects of the propeller action on the net operation and avoids damage of the samples. The total time of the net haul from surface to bottom to surface should be approximately 40 minutes.

The use of a real-time TDR is essential to maintain a smooth net trajectory and control the maximum fishing depth. Calibrated flowmeters will be used to give a measure of net speed during the haul as well as the total distance travelled. The flowmeter should be mounted outside the net opening to avoid clogging which may reduce the efficiency. The dependence of mouth angle to net speed has been investigated for the RMT system.

The quantitative study of the krill population will be carried out along three parallel meridional transects which will extend from the continental coast into oceanic waters as far north as 60°S. Net samples will be taken every 30 nautical miles along each transect. This standardized station grid will also enable us to investigate the horizontal and vertical distribution of krill as well as estimate the actual krill biomass in the area by net sampling and hydro-acoustics.

Samples will be sorted immediately after the haul. Antarctic krill, salps and other Euphausiid species will be sorted quantitatively and length measurements will be taken from representative sub-samples. Additional information will be collected from sex and maturity stages of euphausiids according to the classification established by Makarov and Denys. These measurements will serve the interpretation of the success of the current reproductive season and the status of the spawning stock, but will as well give us some indication on the survival rate of recruits in the population spawned in the previous year.

The description of krill demographic parameters and the investigation of population dynamics of the stock will be the major focus of the krill net sampling programme to the Lazarev Sea in austral summer 2008. However, the collection of quantitative macro-zooplankton data will also play an important role during the current field campaign. The zooplankton data will be a subset of the internationally collected survey data by several CAML IPY participants around the entire Antarctic continent. These data will serve to establish a possible concept for

bioregionalisation of the pelagic system of Southern Ocean. Such analyses will be carried out during planned joint workshops and will try to delineate bioregions at the broad scale. This work will be an important contribution to the achievement of a range of scientific, management and conservation objectives, including large-scale ecological modelling, ecosystem-based management and the development of an ecologically representative system of potential marine protected areas.

7. BIOLOGY OF OITHONA SIMILIS (COPEPODA: CYLOPOIDA) IN THE SOUTHERN OCEAN

U. Bathmann, B. Wend (AWI)

Objectives

Oithona similis belongs to the order of cyclopoid copepods. It is highly abundant through-out many parts of the world ocean and is supposed to be a cosmopolitan species. The work on this cruise is part of a project that challenges whether *O. similis*, a key species in three chosen study areas (Southern Ocean, Arctic Ocean and North Sea), is indeed a cosmopolitan species. A further goal is a better understanding of its life cycle (or the ones of the existing cryptic species) including feeding habits and generation times of the developmental stages.

Work at sea

Samples will be collected with Niskin bottles mounted on a CTD and additionally a towed multinet (55 µm) will be used. Samples will be taken out of the epipelagic layer down to a depth of 250 m. They will partly be preserved in formalin for further morphological identifications of species, reproduction in the field as well as feeding habits and in ethanol for genetic examinations. These examinations will be done at the home laboratory.

On board experiments with living animals will be conducted dependent on the numbers of animals found at each station. These experiments aim on the determination of egg production, egg development, nauplii hatching and stage duration. Moreover experiments on the feeding behaviour are planned by placing adults of *O. similis* (or eventually existing cryptic species) in small bottles containing unfiltered natural seawater, from which large zooplankton will be removed. All experiments will be conducted with 10 individuals per vial. To examine the feeding preferences a control bottle containing no copepods will be used and furthermore a sample of the sea water will be preserved in acidic lugol prior to the beginning of the experiment. After 24 hours all individuals will be removed and a part of them will be preserved in ethanol to perform genetical experiments and the rest will be conserved in formalin for morphological investigation as well as for gut content analysis in the home laboratory. This procedure allows to control whether cryptic species exist.

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

U. Bathmann, S. Kruse (AWI)

Objectives

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 of the Southern Ocean. Chaetognaths are one of the most important carnivorous plankton taxa in Antarctic meso- and bathypelagic waters. Swarming amphipods are also able to control mesozooplankton-standing stocks. Consequently, carnivores may 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 and amphipods, comprehensive seasonal and geographical studies on little known mesopelagic taxa are required. During this cruise, 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. Special attention will be given to the depth range between 500 and 3000 m. As the expedition ANT-XXIII/6 already provided information about the winter situation, this expedition shall complete the existing picture of the carnivores in this area. Among the chaetognaths the focus will lie on the species *Eukrohnia hamata* and the two deep water species *E. bathypelagica* and *E. bathyantarctica*. In addition the amphipods *Cyllopus lucasii*, *Primno macropa* and *Lanceola sp.* will be of special interest.

Work at sea

Investigations on board RV *Polarstern* will be done by a combination of sampling and experimental approaches. Stratified sampling will be performed from down to 2,000 m with a Multinet (100 µm, 5 nets; depth intervals: 2,000-1,500 m, 1,500-1,000 m, 1,000-750 m, 750-500 m, 500-0 m). Chaetognaths being in a good condition will be sorted out of these samples for feeding and respiration experiments. Additional specimens will be picked for C/N analysis, gut content as well as for lipid and fatty acid analysis, which will be quickly stored at -80° C for further analysis in Germany.

Further samples will be taken by means of a RMT 1 and RMT 8 (rectangular midwater trawl) from down to 3,000 m water depth. This kind of sampling is of high importance for obtaining amphipods, as they cannot be caught with a Multinet. The RMT cod-end will be modified in such a way that the animals are neither too compactly and concentrated nor fallen dry. The water volume in the cod-end comprises approximately 26 l. Therefore, animals damaged by the net sink to the bottom of the cod-end, while the major portion stays alive in the cod-end bucket. Actively swimming specimens will be sorted for feeding and respiration experiments as mentioned before for the chaetognaths. Additional samples will be frozen (-80°C) for later analysis in the home laboratories.

For the feeding experiments chaetognaths as well as amphipods will be placed in containers with seawater and will be allowed to defecate. After a certain starvation period, one day for the chaetognaths and two days for the amphipods, 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 needed to calculate the daily feeding rate and to draw conclusions about the predation impact.

The faecal pellets produced 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 ambient temperature. Moreover, the size and the C/N-ratio of additional pellets will be investigated (home laboratories).

For the respiration experiments the species will be kept in 0,5 or 1 l bottles depending on the size of the specimens. The oxygen consumption rate will then be measured according to the Winkler-method in subsamples of water from these bottles and compared to the oxygen content of the water in the control bottles (without animals). Individuals from different depth intervals will be compared to get information on their activity.

9. GEOCHEMICAL INVESTIGATIONS AT THE SEDIMENT-WATER INTERFACE

O. Sachs, E. Sauter (AWI)

Objectives

The AWI geochemistry group participates in the *Polarstern* ANT-XXIV/2 cruise to study compare organic carbon (C_{org}) fluxes reaching the seafloor of the target area as well as the interactions between geochemical microgradients and benthic organisms. This work not only comprises the main field phase of the DFG project DOMINO (Dynamics of benthic Organic Matter fluxes In polar deep-Ocean environments) but also acts as an interface between the two main projects ANDEEP-SYSTCO (ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns - SYSTem Coupling) and SCACE (Synoptic Circum-Antarctic Climate-processes and Ecosystem study), both, as DOMINO does, contributing to the IPY programme ICED (Integrating Climate and Ecosystem Dynamics).

On the one hand, the quantification of organic carbon influx onto the sediment surface is projected to better constrain carbon export to the seafloor as an “end member” of the biological pump. On the other hand the measurement of geochemical microgradients exhibits a tool to describe the geochemical milieu around benthic organisms and, thus, to explain faunal communities and their ecologic and metabolic characteristics.

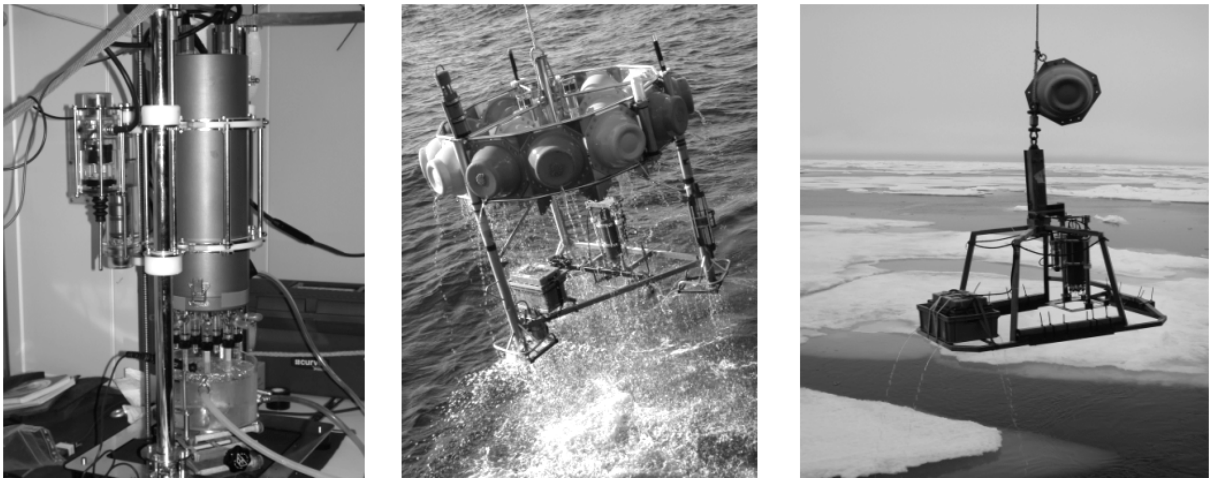

Fig. 9.1: Microprofiler (a), free falling lander system (b), and wire-driven profiler (c)

Most of the organic carbon arriving at meso and oligotrophic sediments is remineralized right below the sediment/water interface, consuming dissolved oxygen as a primary electron acceptor. In addition, oxygen functions as a final oxidant for anaerobic pathways. Thus, the measurement of the pore-water oxygen distribution provides a suitable tool for the determination of C_{org} fluxes through the sediment/water interface and of C_{org} remineralization rates. Beside the quantification of oxic respiration rates by *in situ* chamber or laboratory core incubation, O_2 microelectrodes have proven to be an appropriate tool to determine diffusive oxygen fluxes via the measurement of the pore water O_2 depth distribution in very high resolution. In order to avoid sampling and pressure artifacts during core retrieval it is highly desirable to measure O_2 microprofiles *in situ*, i.e. at the sea floor (Sauter et al., 2001).

Only little data, mostly measured *ex situ*, exist for high latitudes beyond 60°N or S. During ANT-XXI/4 we had the opportunity to measure *in situ* fluxes at the Polar Front (Sachs et al., submitted). Up to now, only little is known also about the total amount of organic carbon remineralized and fixed within surface sediments of the Southern Ocean.

During this cruise the main focus will therefore be put on the *in situ* measurement of O_2 microprofiles and a complementing sediment and bottom water sampling programme to be conducted during the ANDEEP-SYSTCO benthos stations.

Work at sea

In this study *in situ* microprofile measurements will be performed by means of an autonomously working microprofiler (Fig. 9.1a) able to drive microsensors for O_2, pH, and H_2S as well as a resistivity probe into the sediment with a minimal vertical resolution of up to 0.1 mm. The profiler can either be mounted into a free falling lander system (Fig. 9.1b) co-equipped e.g. with a video camera, an acoustic doppler velocimeter and/or a water sampler. In case the lander deployment is too difficult due to ice or sea stage, the microprofiler can be mounted into a wire-driven frame (Fig. 9.1c).

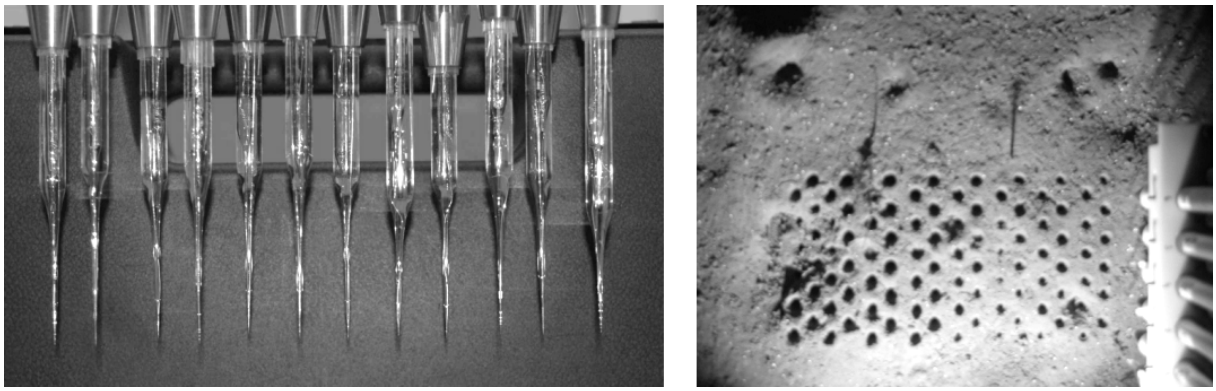

Fig. 9.2: (a) Microsensor array of the 3D microprofiler. (b) Sediment image from above taken after the measurement during ARK-XXII/1c. According to the small scale bottom topography, the penetration depth of the sensors is different, which can be seen by the different diameter of the individual holes.

In order to further resolve 3D gradients around biogenic structures, the development of a special 3D deep-sea microprofiler was initiated at the AWI. This system was designed to allow new insights into spatial small scale variabilities generated by benthic organisms. The new device is not restricted to lower sensors vertically into the sediment but is able to displace its sensor array (up to 12 microsensors, Fig. 9.2a) horizontally in order to measure cascades of microprofiles over a target area of ~30 x 35 cm (Fig. 9.2b). Together with a sequence of photographs taken prior, during and after the measurements, this allows the 3D reconstruction of the pore water oxygen distribution for descriptive geochemical habitat characterization e.g. around biogenic structures, as well as for 3D pore water modelling. The system was deployed for the first time during the ARK-XXII/1c cruise in the AWI *Hausgarten* area and is now projected to work in the Southern Ocean for the first time.

In situ measurements will be complemented by *ex situ* measurements of microprofiles, sediment, pore water and bottom water sampling for the determination of other geochemical parameters like C_{org}, C/N ratio and nutrient profiles. Sediment sampling will be performed by a conventional multicorer whereas water samples from the near-bottom zone will be taken by a special bottom water sampler allowing the collection of water from 6 levels within the lower most two meters above the sea floor (Fig. 9.3).

In addition, the sea floor surrounding the sampling and measuring locations will be characterized hydroacoustically while approaching and leaving the site using Parasound and Hydrosweep. This is for both purposes, 1) to have a control about water depth and bottom topography and 2) for later correlation acoustic data with surface sediment parameters.

Expected results

Our contribution is to be seen as the interface between the water column investigations projected in SCACE and the benthos biology work of ANDEEP-SYSTCO: The sea floor as the final recipient of deep carbon export stands between pelagic production and particle sedimentation on the one hand and the utilization of carbon resources by the benthic fauna on the other side. Therefore we hope not only to get the opportunity to perform repeated measurements at the same spot in order to estimate seasonal and episodic variabilities of fluxe. It is also hoped from this cruise that we gain new insights into small scale heterogeneities of benthic oxygen distribution in relation to benthic habitats which is the link to the ANDEEP bioregionalization approach. From the geochemical point of view we will expand the still small data base of high quality benthic flux measurements in the Southern Ocean. This enables us to improve budget considerations in respect to organic carbon influx

to the seafloor as well as the chance to improve transfer functions to correct existing laboratory measurements.

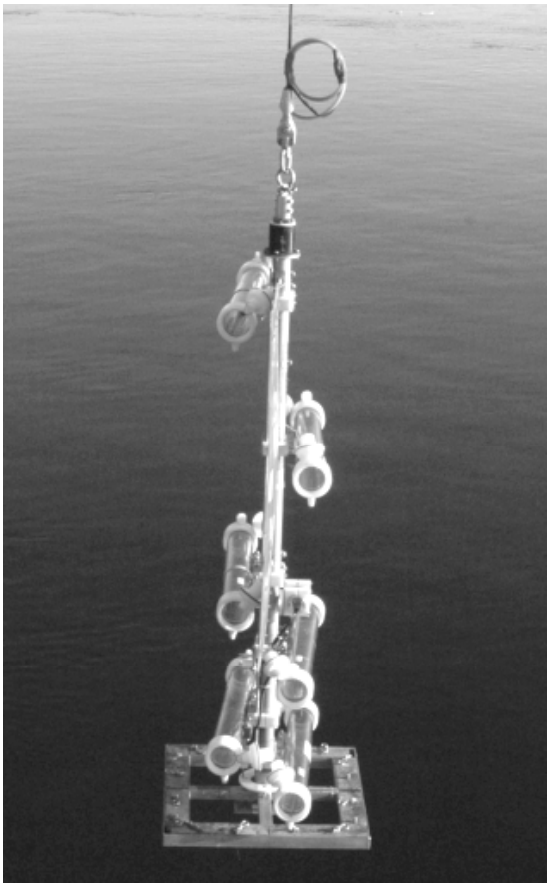

Fig. 9.3: Bottom water sampler

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10. ANDEEP-SYSTCO (SYSTEM COUPLING) IN THE SOUTH ATLANTIC OCEAN BENTHIC FORAMINIFERA OF THE DEEP SOUTHERN OCEAN: DIVERSITY AND BIOGEOGRAPHY

D. Fontaine (University Geneva)
Not on board: J. Pawlowski (University Geneva)

Background and objectives

Benthic foraminifera are a dominant faunal element in the deep-sea and high latitude settings. These amoeboid protists are highly diversified and abundant, yet they are often overlooked in biological studies because they are unfamiliar organisms, which are difficult to extract from sediment samples and to identify. As a result, the contribution of foraminifera to deep-sea benthic diversity is poorly known, although mounting evidence suggests that it is substantial.

Recent developments in molecular systematic have provided new tools for studying foraminiferal diversity (Pawlowski, 2000; Pawlowski *et al.*, 2003). Molecular studies have revealed a high genetic diversity in some benthic (Holzmann & Pawlowski, 1997; Tsuchiya *et al.*, 2003) and planktonic (De Vargas *et al.*, 1999) foraminiferal morphospecies. Genetic analysis of some common Antarctic deep-sea species showed surprisingly low level of molecular diversity and strong similarity to the Arctic populations (Pawlowski *et al.*, 2007). This is in agreement with bipolarity observed in some planktonic foraminifera (Darling *et al.*, 2000) but contrasts with strong genetic differentiation of shallow-water benthic species (Pawlowski *et al.*, in prep.). Extremely high eukaryote diversity was found within enigmatic foraminifera-like Komokiaceans, although their relationship to other foraminifera was not definitely established (Lecroq *et al.*, in prep.).

The main objective of this project is to examine the diversity of foraminifera in deep-sea Antarctic sediments. Using material collected during this cruise, we aim to answer following questions

(1) How many deep Southern Ocean species are globally distributed?
(2) Are deep-sea species less variable genetically than shallow-water taxa?
(3) Do deep-sea benthic foraminifera possess planktonic dispersal stages? and
(4) What are the phylogenetic origins of foraminifera-like Komokiacea?

Work at sea

During RV *Polarstern* cruise ANT-XXIV/2, we will collect surface sediment samples from a wide range of water depths and sites in the Weddell Sea using the multicorer or box corer. For molecular studies, multicores and subsamples of box cores will be sieved immediately after collection and living foraminifera hand picked under a binocular microscope. Some specimens will be photographed and their DNA will be extracted. Others will be deep-frozen for further DNA analysis. Some sediment samples will preserved in ethanol for later molecular study. Additionally, plankton samples will be collected to search for dispersal forms (larval stages, propagules) of deep-sea benthic taxa.

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11. THE LINK BETWEEN STRUCTURAL AND FUNCTIONAL BIODIVERSITY OF THE MEIOBENTHOS IN THE ANTARCTIC DEEP SEA

K. Guilini (University Gent)
Not on board: Ann Vanreusel,M. Raes (University Gent)

Objectives

The overall aim of this study is to identify the role of meiofauna in the C flow through benthic deep-sea sediments of the Antarctic in relation to their biodiversity. In order to unravel the link between meiofaunal biodiversity and function, it is essential to reveal the interactions in the benthic food web and the trophic position of different meiofauna taxa and functional groups at locations with contrasting food input. Many studies have illustrated the high biodiversity of small benthic taxa in the deep sea. However it remains unclear what drives this high local biodiversity. As for many systems a relation with productivity of the system has been hypothesized but correlation with water depth and other associated environmental factors often hampers to unravel the link between biodiversity and food input. At the transition of the South Atlantic into the Southern Ocean strong climatic and trophic gradients exist. A latitudinal gradient at similar water depths between 47°S and 69°S would allow to estimate the variation in local biodiversity in relation to changing productivity levels.

Work at sea
The importance of meiofauna taxa in the C turnover in deep-sea sediments is still an unknown factor limiting detailed C modelling of the benthic boundary layer. Despite their high numerical dominance and potential high reproductive turnover rates there is little evidence that nematodes are strong agents in the carbon mineralization but indirectly they may interact with microbiological activities (by grazing on bacteria populations). Through enrichment experiments food pulses to the deep-sea sediments will be simulated by offering different labelled food items (especially phytodetritus and bacteria). In this way the C uptake by meiobenthic taxa in response to a specific food input, and the importance of different meiobenthos taxa in the C cycle will be estimated. Although the meiofauna standing stock in deep-sea sediments is closely linked to the degree of organic matter input and consequently the surface primary production as shown by previous studies their response to seasonally varying deposition of phytodetritus is often delayed in time, in addition to the fact that in stead of increase in densities at the surface of the sediments, subsurface maxima in densities appear. Although still restricted so far, evidence for a microbial related feeding activity rather than using fresh phytodetritus as food source is growing. In order to test if deep-sea nematodes show more preference for microbial related food sources enrichment experiments with different potential 13C labelled food sources will be performed. Natural biomarker analysis (stable isotopes and fatty acids) of selected taxa will unravel their degree of selectivity and food preferences for particular components of the deep-sea ecosystem.

12. ON THE FUNCTIONAL BIODIVERSITY AND ECOLOGY OF MACROBENTHIC ABYSSAL KEY SPECIES WITH FOCUS ON THE ISOPODA, MOLLUSCA AND POLYCHAETA

A. Brandt, L. Kramer, T. Riehl, L. Würzberg (ZIM); S. Brix, B. Ebbe (DZMB);
M. Schüller (LMU); H. Robert (RBINS)

Objectives
Very little is known about the ecology and role of deep-sea fauna in the trophodynamic coupling and nutrient cycling in oceanic ecosystems. This project examines the trophic structure and functioning of the abyssal macrobenthic community of the Southern Atlantic Ocean, focusing specifically on the role of the Isopoda, Mollusca and Polychaeta including 1) general feeding biology, 2) bentho-pelagic coupling, 3) the reproduction of certain key species, and 4) population genetics of selected abundant key species. Epibenthic sledge samples from three previous *Polarstern* expeditions (ANDEEP I-III) and new epibenthic sledge and sediment core samples taken on the RV *Polarstern* expedition ANT–XXIV/2 will be analysed. A variety of methods will be used including gut content analysis, functional morphology of target species as well as biochemical measurements. The latter include analyses of lipid classes, biomarkers, quantification of nucleic acids (RNA:DNA ratios), and examination of stable isotopic signatures of epifaunal animals and surrounding sediments.

The results will be compared and combined with the findings of research groups examining other aspects of the southern ocean food web or biogeochemistry of the sediment. Combining the comprehensive datasets concerning diversity and colonisation patterns

available from ANDEEP I-III and this planned study focusing on food web dynamics allows us, for the first time, to better understand the trophodynamic role of deep-sea fauna in the ecology of the Southern Atlantic Ocean.

Work at sea

We will start our analyses with the alcohol fixed samples from the ANDEEP I-III expeditions and determine key abyssal species. Of these species we will then analyse the biomass using he wet weight and conversion factors. We also plan first analyses of the mouthparts and foregut (including the gut contents) in the laboratory before we start with the expedition, in order to obtain some ideas on the general feeding biology of the key species (e.g. suspension feeders, deposit feeders, scavengers, predators, etc.).

The identification of key species prior to the expedition will allow us to more quickly identify and collect them from the new SYSTCO samples in the coolroom.

During ANT-XXIV/2 we plan to sample 5 stations on our way south from Cape Town, and revisit two of the most interesting stations on our way back to the north. In total, we hope to be able to obtain 7 stations (see Fig. 12.1), including epibenthic sledge samples, which will serve as a basis for the above-described investigations. The positions of the stations are preliminary and could be changed if satellite data indicates noteworthy peaks in primary production. This current adjustment would allow us to obtain information about a possible benthic reaction to events in the water column.

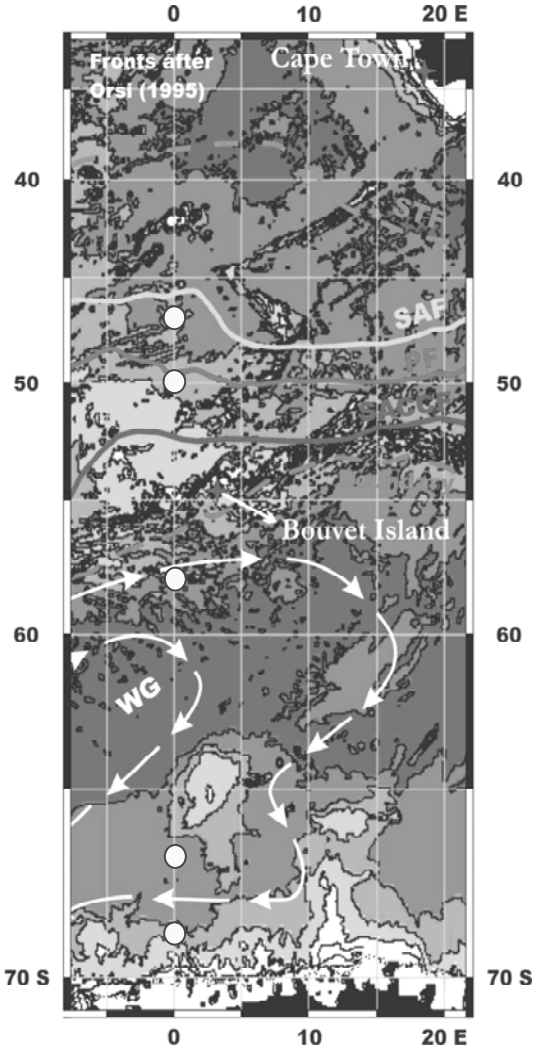

Fig. 12.1: 7 deep-sea stations are planned during SYSTCO (ANT-XXIV/2). Time permitting two interesting stations will be revisited.

- **Station 1**: 0°W 47°S, 4000 m (north of the Polar Front)
- **Station 2**: 0°W 50°S, 3500 m (in the Polar Front)
- **Station 3**: 0°W, 58°S, 4,200 m (south of the Polar Front, at the border to the Weddell Gyre
- **Station 4**: 0°W, 67°S, 4,700 m (is a revisit of the ANDEEP station 59, south of Maud Rise)
- **Station 5**: 0°W, 69°S, ca. 2,000 m (bathyal station)

As soon as the samples will be on board, they will be sorted in a coolroom or container by the most important taxa and key abyssal species of these groups, in order to freeze it immediately for the further described treatment in the laboratories in Hamburg (ZIM and IHF). At each station we will also take sediment samples which will be worked up either directly by a sedimentologist on bord or - if this is not possible - later in Germany in close collaboration with the Alfred Wegener Institute for Polar and Marine Research.

Those isopod specimens from the expedition ANT-XXIV/2 which will not be used for biochemical analyses, will be studied with regard to the functional morphology of the mouthparts, gut contents or they will be available for other projects dealing with systematic or phylogenetic investigations. For molecular genetic studies concerning phylogenetic relationships or population genetics of selected key species, we will extract DNA on board after precooling of the samples at -20°C for at least 48 hours. These results will be compared with those obtained from the isopod material from the previous ANDEEP expeditions.

Our data and those which will be obtained on primary production and abundances and biomasses of important pelagic species (in cooperation with U. Bathmann and colleagues)

will help to identify potential links between these two ocean realms and possibly document the processes critical to bentho-pelagic coupling.

13. QUANTITATIVE INVESTIGATIONS ON THE BIODIVERSITY AND BIOGEOGRAPHY OF MACROBENTHOS UNDER DIFFERENT NUTRITIONAL REGIMES

B. Ebbe (DZMB)

Scientific background and objectives
Macrobenthic biodiversity has been studied during the preceding ANDEEP expeditions and first results have been published. As the overwhelming majority of species was found to be rare and patchily distributed, it can be expected that additional samples will yield more new species and additional material of rare species. Any taxonomic information will be shared with the Census of Antarctic Marine Life (CAML).

The SYSTCO expedition offers the opportunity to collect quantitative samples under different nutritional conditions from the same place (before and during or after a plankton bloom). Possible changes in density and species composition as well as changes in reproductive features will provide helpful data to support the investigations to be undertaken with material from the epibenthic sledge by Brandt et al. (above) and make comparisons with results from the CeDAMar companion project CROZEX. If organisms are found to be reproductively active, plankton data will be examined with regard to larvae, especially of polychaetes.

Work at sea
Two box core samples will be taken at each station. If the sediment is soft enough, vegematic boxes consisting of 25 subcores will be used to yield 25 subsamples with a surface of 10x10 cm. At least ten of these, amounting to 0.1 m^2, will be sieved through 0.3-mm sieves, fixed in formalin and after 48 hours (if feasible) transferred to 70 % ethanol for storage. Organisms will be picked, sorted, enumerated and identified at the lab after the end of the expedition. Other subcores can be used by other participants as needed and will be processed according to the respective protocols.

A survey of the sediments before employing the box corer will be done with the SPI camera system which will provide surface and profile images of the seafloor. SPI images will be particularly helpful in finding fluff layers indicating the arrival of fresh material from the water column. Profile images will provide information on the degree of bioturbation, depth of the oxygenated layer, and grain size.

14. THE ROLE OF SPONGES IN THE BENTHIC-PELAGIC COUPLING IN BIOTOPES OF THE DEEP WEDDELL SEA AND ADJACENT AREAS

N. Brenke (FIS); M. Schrödl, E. Schwabe (LMU); V. Wadley (AAD)
Not on board: Dorte Janussen (FIS)

Background and objectives

According to our findings from ANDEEP I-III, the sponge fauna of the deep Weddell Sea differs substantially from that of the adjacent areas in being richer, more diverse and the fact that sponges of some groups may become very large for deep-sea conditions. We found large faunal variability between stations, but it is unknown whether this is due to differences in the water chemistry and food supply, bottom sedimentology and topography, or simply a result of insufficient sampling. Probably more than one factor controls the distribution of sponges and associated benthic organisms. In the further course of Antarctic deep-sea investigations, we can expect to identify key associations of sponges characteristic of various ecological zones. These communities probably do not represent a long-term, stable system, but rather stages within a cycle of ecosystems; and successions of ecosystems in time, are likely to be found in a larger area also as a succession in space.

Scientific questions central for this research project are:

- What kind of consortia of animals are associated with sponges in the Antarctic deep sea?
- Do especially the larger sponges control the occurrence and diversity of other organisms?
- Which are the key associations of Antarctic deep-sea sponges and which processes lead to the present Antarctic fauna??
- How closely are the Antarctic shelf and deep-sea sponge species related at a molecular level, and how closely related with representatives from other deep-sea areas?
- Is the apparently patchy distribution of most sponge taxa a function of ecological successions in time?

Work at sea

- Sampling, documentation, preliminary identification and quantification of sponges from all benthic sampling gears.
- Fixation for histological and electron microscopic investigations and freezing of sub-samples for molecular biology and FISH-analysis of the micro-infauna.
- Skeletal preparation and preliminary identification of the main sponge taxa represented.
- In cooperation with DZMB: Separation of tissue samples from the bigger sponges for meio-infauna investigations.
- In cooperation with other groups (optional): Sampling of bottom water and surface sediment samples and their fixation for microbial investigation. Search for sponge larvae within plankton.

Work at home institution

- Taxonomic identification and description of the sponge fauna. Quantification of the sponge communities from different localities and depths.

- In cooperation with DZMB: Sorting and quantification of major taxonomic groups of meiofauna found on and in sponges.
- Investigations of the microbial communities within the sponge tissues and of the bottom water samples (in cooperation with Chinese and German partners).
- Molecular investigations and comparison of selected shelf and deep-sea representatives of sponge taxa.
- Possibly identification of key communities of sponges and associated organisms for different habitates of the deep Weddell Sea area.

15. DIVERSITY, ORIGIN AND EVOLUTION OF THE DEEP-SEA ANTARCTIC ANTHOZOAN FAUNA

M. Conradi (DFZ)

Background

It is already well known that Anthozoans are one of the major components in benthic sessile communities in terms of both abundance and diversity. Despite of this, the Antarctic athozoan fauna is still poorly known, and most of our knowledge comes from the continental shelf, while deep-sea fauna is perhaps not as diverse as that living on the shelf but is much less known and unpredictable.

The last ANDEEP cruise, among other sampling stations, extensively prospected the deep Weddell Sea in the limits of 4,000-5,000 m depth, showing an interesting anthozoan asemblange (*Umbellula*+*Galatheanthemum*+Antipatharia), with clear influence of deep-sea bottoms from surrounding oceans. In the proximity of the Antarctic Peninsula deep-sea fauna becomes more diverse but still differentiable from that of the shelf.

Anthozoans are one of the most interesting benthic sessile animal groups to study the importance of the possible immigrant - or emigrant- ways and relict Cretaceous stock conforming the extant Antarctic fauna.

Scientific objectives

- To detect the presence of boundaries in the distribution of deep-sea anthozoans at different taxa levels (family, genus, species).
- To evaluate the potential origin of the deep-sea Antarctic anthozoan fauna according to the known distribution of genera/species in this and other biogeographical areas.
- To detect undescribed species that could help to the understanding of the relationship between Antarctica and other deep-sea bottoms and continental shelf in the past and in the present.
- To continue to build up the bank of tissues usable for molecular studies (already initiated since EASIZ III).
- To sustain the study of the reproductive pattern in Antarctic Anthozoans (already initiated since EASIZ-I).

Work at sea
Anthozoans will be extracted from all samples, most likely the Agassiz trawl will prove to be most useful to catch these organisms.

16. MEIOBENTHOS AND THEIR ROLE IN THE DEEP ANTARCTIC FOOD WEB

A. Henche, G. Veit-Köhler (DZMB)

Objectives
Biomarkers such as stable isotopes and fatty acids can be traced throughout food webs and thus are suitable for the understanding of trophic positions and food resource selectivity of marine species. Detailed analyses of fatty acid, fatty alcohol and wax ester compositions can elucidate similarities between taxa and reveal indications of feeding behaviour and food sources. The advantage of applying lipid compositions to feeding studies is that trophic lipid markers integrate longer time periods than conventional methods and feeding experiments verified the concept of trophic marker lipids using algae and copepods of known lipid composition. But generally, benthic species have relatively low lipid contents as compared to herbivorous zooplankton species and do not rely on depot lipids in the same way. Often fatty acids of the available food sources dominate the fatty acid composition of the species, masking potential taxon-specific patterns and emphasising the intensity of the pelago-benthic coupling. Therefore stable isotope ratios $\delta^{13}C$ and $\delta^{15}N$ will be used as an additional tool which can contribute to the determination of food sources and selectivity in meiofauna organisms, even at species level.

Meiofauna can significantly contribute to the regulation of benthic turnover and serve as food for secondary consumers. The role of meiofauna in the deep Weddell system as trophic link between sedimented organic matter and higher level consumers is another question that will be investigated in this study. It will be clarified whether there exists a coupling of meiofauna with higher trophic levels or if, on contrary, meiofauna in the deep Weddell system represents an energy-sink only accelerating decomposition. This and the determination of total meiofaunal standing stock at the investigated sites will be a crucial contribution to the generalised energy-flux model and food web study - a common objective of the ANDEEP-SYSTCO cruise.

Work at sea
Sediment samples taken with the multicorer (MUC) as well as residual sediment from deployments of other devices will be sieved and decanted, meiobenthic animals will be picked out and frozen for fatty acid and stable isotope analysis. The meiofauna will be sorted to the lowest taxonomic level possible. Nevertheless, very high numbers of these animals are necessary. Sediment cores will be fixed in formalin for the determination of meiofaunal standing stock as well as frozen for sediment analysis.

Additionally, the collection of benthic animals of groups other than meiofauna will be supported and intensified. For that reason the DZMB additionally provides a -80°C freezer, dry shippers and laboratory material.

Expected results
This work will be part of the first deep-sea food web study in the Antarctic. The benthic realm as a very diverse part of the Weddell system will be sampled and investigated from meio- to megafauna thus perfectly complementing the already existing food web study of the Weddell continental shelf area.

17. MARINE TOP PREDATORS AND THEIR PREY - 'SCRATCHING THE SURFACE'

M. van Dorssen, B. Feij, H. Flores, J.A. van Franeker, A. Meijboom
(IMARES)

The ANT-XXIV/2 expedition (November 2007-February 2008) is the third *Polarstern* cruise into the Lazarev Sea in which IMARES participates with research that links quantitative assessments of top predators with the density of prey in the surface layer of the seasonal sea ice zone. Earlier expeditions in the Lazarev Sea Krill Study (LAKRIS) in which we participated were conducted in autumn (ANT-XXI/4, Mar-May'04) and winter (ANT-XXIII/6, Jun-Aug 2006). We aim for a full coverage of seasonal changes. The ANT-XXIV/2 expedition represents our opportunity to study the summer situation.

Objectives
1. To improve quantitative assessment of distributional patterns of marine birds and mammals in the Southern Ocean, further documenting high abundances in sea ice areas and,
2. to start a top-down survey of the food web structure that could explain high predator abundance in sea ice, which we believe to be largely triggered by ice algae concentrating higher food web levels in the poorly studied upper layer of surface water.

Both objectives have high relevance for policies in conservation and management, especially in the light of potential effects of global climate change on the extent and characteristics of the Antarctic sea ice zone.

Methods and work at sea
Top predator censuses
Censuses of marine birds and mammals are conducted from 'open' observation posts installed on the bridge roof (Peildeck). Distribution and abundance of top predators is determined by international standard census methods, using band-transect and snapshot methods for birds (Tasker et al. 1984), supplemented with line-transect elements for marine mammals (Buckland et al. 2001). Ship based predator surveys are conducted whenever the ship is transecting under daylight conditions. In addition to ship based surveys, in the sea ice areas, helicopter surveys will be used to maximize coverage. Although ecology of individual species has our strong interest, our basic aim is to supply an integrated picture of abundance and food requirements of the whole community of warm-blooded top predators.

To achieve this, density figures for individual species are translated to daily food requirements per km^2, which then can be summed for all species together.

Surface fishing

In our opinion, the surface layer and its link to sea ice is of critical importance to the Antarctic food webs. Unfortunately, the standard fishing techniques or bioacoustics are not well adapted to reflect animal abundance in the surface layer of the ocean, especially not where this layer is covered by sea ice. We therefore have spent considerable effort on the construction of a special net to sample fish and zooplankton residing in the upper water layer, even when directly under sea-ice. The scraping off of the under ice fauna is reflected in our project's name *'Scratching the Surface'.* We built a special heavy-framed but floating net that can 'roll' along the undersurface of sea-ice: SUIT = *Surface and Under-Ice Trawl*. The net can be operated from the rear gangway of *Polarstern* and shears sidewards to starboard away from the ship's trackline. Because of the heavy steel frame, floaters and wheels, the construction weighs ± 1,000 kg. The netframe-opening is square with sides of about 2.2 m and has a 'slide-out' system for heavy lumps of ice. The net is made of a shrimp-net type (7 mm half mesh) and about 13 m long. The rear three meters of the net are lined with 0.3 mm mesh, ending in a large codend bottle. Based on experiences with the SUIT-net in the 2004 and 2006 expeditions, we have made further improvements to the design of frame and net.

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 food web analysis and productivity estimates.

For our 'food web' objective, we aim to collect new data on consumption when possible. We aim for gut content analysis of organisms caught with the SUIT net. Seabird diets can be studied without harm to animals by stomach flushing. For this we will mostly use birds accidentally landed on the ship. On an opportunistic basis, we may also 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. SUIT net catches will be used to estimate energetic values of prey groups relevant to the top predators.

Expected results

As experienced in earlier SUIT deployments during ANT-XXI/4 and ANT-XXIII/6, we expect that our surface fishing will produce significant new results on abundance and diversity of marine life in the surface layer of the Southern Ocean. The role of seasons will further assist in beginning to understand the processes that are involved and their overall meaning for Antarctic food webs and their populations of top predators. We closely co-operate with, and benefit from other research conducted during the interdisciplinary LAKRIS expeditions. Our detailed information on the surface layer biology is complementary to results obtained by standard fishing for krill with e.g. RMT nets or the bioacoustics programme. We continuously improve our net design with also the aim to catch under-ice organisms in such a good condition that they are beneficial to a range of experimental work by colleagues on board. Ultimately it is the goal of these expeditions to all contribute to improved ecosystem understanding in which all levels from physics to biology are integrated.

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