Expeditionsprogramm Nr. 72

FS POLARSTERN

ANT XXII/3-5
2005

Koordinator: Prof. Dr. P. Lemke

Fahrtleiter:
ANT XXII/3: Dr. E. Fahrbach
ANT XXII/4: Dr. H.-W. Schenke
ANT XXII/5: Dr. T. J. Müller

ALFRED-WEGENER-INSTITUT
FÜR POLAR- UND MEERESFORSCHUNG
in der Helmholtz-Gemeinschaft

BREMERHAVEN, JANUAR 2005

Expeditionsprogramm Nr. 72

FS POLARSTERN

ANT XXII/3

21.01.2005 – 06.04.2005
Cape Town – Punta Arenas

ANT XXII/4

08.04.2005 – 21.05.2005
Punta Arenas – Bahia Blanca

ANT XXII/5

21.05.2005 – 16.06.2005
Bahia Blanca – Bremerhaven

Koordinator: Prof. Dr. P. Lemke

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FS POLARSTERN

ANT XXII/3

21.01.2005 – 06.04.2005
Cape Town – Punta Arenas

Fahrtleiter:

Dr. E. Fahrbach

EXPEDITION ANT XXII/3

FAHRTVERLAUF UND ZUSAMMENFASSUNG

E. Fahrbach (AWI, Bremerhaven, Germany)

Am 21. April 2005 wird POLARSTERN von Kapstadt zur Antarktisreise ANTXXII/3 auslaufen. Zunächst wird der Kurs bis 15°E nach Westen führen. Dort wird POLARSTERN nach Südwesten drehen und bis 53°S der Laufbahn des TOPEX-POSEIDON-Satelliten folgen. Mit Expendable Bathythermographs (XBT), dem Thermosalinographen und dem Acoustic Doppler Current Profiler (ADCP) sollen Temperatur, Salzgehalt und die Meeresströmung vom fahrenden Schiff aus erfasst werden, während der Satellit mit einem Altimeter die Auslenkung der Meeresoberfläche misst. Entlang der Kurs-Linie werden im Rahmen des GOODHOPE-Projekts 12 MAVOR-Driftkörper ausgelegt und Verankerungen mit Bodendruckmessern (PIES) ausgetauscht. Die Arbeiten des Tiefsee-Biologieprogramms ANDEEP III beginnen auf der Anreise bis zur Neumayer-Station mit 3 Stationen. Das Bathymetrie-Programm findet aufgrund der Auflagen des Umweltbundesamts nur in sehr eingeschränkter Form statt. Auf der Anreise kann ein Teil des geplanten deutschen Bathymetrie-Programms ausgeführt werden. Es muss bei 60°S beendet werden. Danach kann auf Grund der Auflagen des Umweltbundesamts nur noch das russische Programm stattfinden.

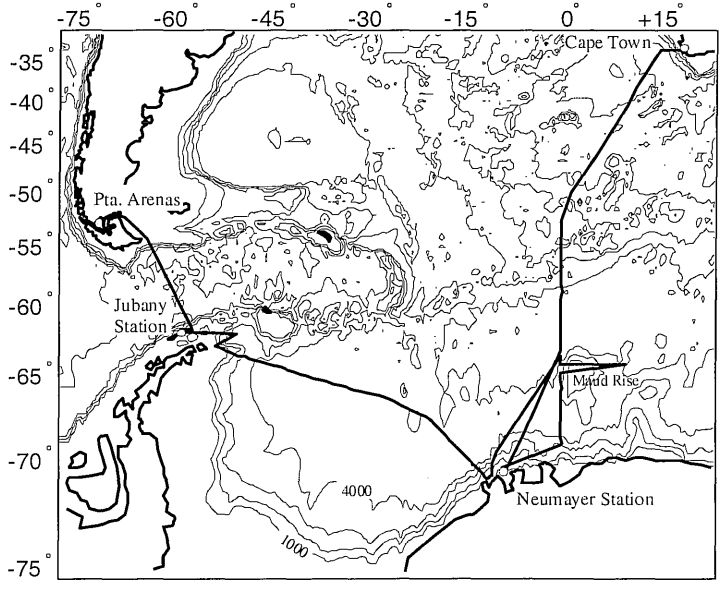

Abb. 1: Karte des Fahrtgebiets und Fahrtroute der POLARSTERN-Reise ANTXXII/3 vom 21 Januar bis zum 6. April 2005.

Fig. 1: Map of the area of observations and cruise track during POLARSTERN leg ANTXXII/3 from 21 January to 6 April 2005.

Bei 53°S wird POLARSTERN den Meridian von Greenwich erreichen. Dann führt der Kurs direkt nach Süden und das ozeanographische Hauptprogramm im Rahmen von WECCON (Weddell Sea Convection Control) wird mit Messungen mit der CTD-Sonde (conductivity, temperature, depth) und der Aufnahme und Wiederauslegung von Verankerungen durchgeführt werden. CTD-Messungen sollen während der gesamten Reise an etwa 100 hydrographischen Stationen mit Wasserschöpfern zur Bestimmung der Konzentration von gelösten Nährstoffen, Sauerstoff, Tracern, und CO_2 erfolgen. Die endgültige Anzahl der Stationen muss dem Fortgang der Arbeiten angepasst werden. Da keine Reservezeit zur Verfügung steht, können Zeitverluste durch unvorhergesehene Ereignisse oder zu langsamen Fortschritt der Arbeiten nur durch die Reduktion der Stationszeit aufgefangen werden. Falls CTD-Stationen gestrichen werden müssen, werden XBTs als Ersatz eingesetzt.

Einen wesentlichen Anteil des Programms der physikalischen Ozeanographie stellt die Aufnahme und Auslegung von Verankerungen dar. Sie enthalten Strömungs-, Temperatur- und Leitfähigkeitsmessgeräte, Schallquellen zur Ortung von Driftkörpern und Eisecholote (upward looking sonar, ULS) zur Messung der Eisdicke. Ferner sollen 30 APEX- (Profiling Autonomous Lagrangian Circulation Explorers) und NEMO- (Navigating European Marine Observer) Driftkörper (Floats) ausgebracht werden. Zur Quantifizierung des Süßwassereintrags durch Eisberge sollen im südlichen Weddellmeer 14 Eisberge mit Satellitensendern ausgestattet werden, die mit dem Hubschrauber auf den Eisbergen abgesetzt werden.

Bei etwa 64°S müssen die Arbeiten auf dem Meridian von Greenwich unterbrochen werden, um rechtzeitig bei der Neumayer-Station anzukommen. Die Beladung der POLARSTERN zum Abtransport von Material muss erfolgen, bevor die Sommermannschaft mit dem Flugzeug die Station verlassen hat. Nach dem Abschluss der Versorgungsarbeiten wird POLARSTERN nach Norden zurückdampfen und die Arbeiten auf dem Meridian von Greenwich wieder aufnehmen.

Die zweite Phase der physikalischen und biologischen Arbeiten findet zwischen Kapp Norvegia und der Nordspitze der Antarktischen Halbinsel statt. Hier liegt auch der Schwerpunkt der tiefseebiologischen Arbeiten mit 8 großen Stationen im Rahmen von ANDEEP III. An der Ostküste des Weddellmeers müssen zusätzlich biologische Verankerungen aufgenommen werden, die auf früheren Reisen ausgelegt worden waren. Die Arbeiten der physikalischen Ozeanographie gehen mit CTD-Stationen und der Auslegung von Verankerungen, Driftkörpern und Eisbergmarkierungssendern weiter. Sollte nach dem Erreichen der Antarktischen Halbinsel noch Zeit zur Verfügung stehen, so sind optional tiefsee-biologische Stationen im Powell-Becken und die Aufnahme amerikanischer Verankerungen südlich der Süd-Orkney-Inseln geplant. Zum Abschluss der Reise wird die Jubany-Station mit dem Dallmann-Labor zum Abtransport von Material und Personal angelaufen. Die wissenschaftlichen Arbeiten werden durch ein Programm der Öffentlichkeitsarbeit begleitet, zu dem auch ein Expeditionsmaler gehört.

Während der gesamten Reise werden, soweit es die Zeit erlaubt, hydroakustische Messungen und Infrarot-Beobachtungen ausgeführt, die zur Weiterentwicklung eines Systems beitragen, das es erlaubt, Meeressäuger zu orten. Damit soll ermöglicht werden, in Zukunft die Auflagen des Umweltbundesamts zu erfüllen und unterschiedliche hydroakustische Messverfahren von POLARSTERN aus einzusetzen.

Die Reise wird am 6. April 2005 in Punta Arenas enden.

Die Arbeiten der Tiefsee-Biologie sind in das ANDEEP-III-Projekt (*ANtarctic benthic DEEP-sea biodiversity: colonization history and recent community patterns*) eingebunden, das ein internationals Projekt zur Erforschung der Biologie von Tiefseeorganismen im Scotia- und Weddellmeer darstellt. Das ANDEEP-Projekt wurde ins Leben gerufen, um das Ökosystem Tiefsee im Südlichen Ozean zu charakterisieren. Die Hauptziele sind, den Einfluss der Habitatvielfalt des Meeresbodens auf die biologische Vielfalt zu untersuchen, und festzustellen, ob und in welchem Maße das Scotia- und Weddellmeer Ursprungsgebiete für das Benthos angrenzender Tiefwassergebiete sind.

Im Verlaufe von ANDEEP I und II im Sommer 2002 wurden bereits mehrere Gebiete im Atlantischen Sektor beprobt. In ANDEEP III soll die Probennahme fortgesetzt werden.

Die Tiefsee des Scotia- und Weddellmeers gehört zu den am wenigsten untersuchten Gewässern der Weltozeane, und wir wissen nahezu nichts über die dort im Boden lebenden Tiere. Erste Ergebnisse von ANDEEP I und II haben Eindrücke über die Artenzusammensetzung und mögliche Wege der Evolution der Tiefseefauna des Südlichen Ozeans vermittelt. ANDEEP III wird unsere bisher gewonnenen Erkenntnisse vertiefen, und zwar in einem etwas erweiterten Untersuchungsgebiet, das außer dem Becken des Weddellmeers und Umgebung auch das Kapbecken umfasst.

ANDEEP ist eines von zwei Projekten, die den ursprünglichen deutschen Beitrag zu CeDAMar (Census of the Biodiversity of Abyssal Marine Life) leisten. CeDAMar ist ein für zehn Jahre ausgelegtes Projekt, das der Erforschung benthischer Lebensgemeinschaften in den Becken des Atlantiks von Pol zu Pol gewidmet ist, und gehört zu dem weltweiten Programm CoML (Census of Marine Life), das 2000 gegründet wurde und bis 2010 dauern soll. Bislang sind Wissenschaftler aus mehr als 70 Nationen beteiligt, die mit standardisierten Methoden Proben nehmen und eine globale Datenbank zusammenstellen, die als frei zugängliche Referenz für spätere Untersuchungen dienen soll. Mit CeDAMar soll versucht werden, Taxonomie und Systematik wieder als zentrale Disziplinen der Biologie zu etablieren. Artbeschreibungen gehören zu den zentralen Aufgaben, die CeDAMar sich gestellt hat. In diesem Rahmen wird ANDEEP zur Lösung zweier grundsätzlicher Fragen beitragen:

- Wie artenreich ist die Tiefsee, und welcher Anteil der Gesamtfauna des Planeten lebt im Meer? Wie groß sind einzelne Verbreitungsareale?

- Welche Faktoren sind für Speziationsprozesse in homogenen Lebensräumen verantwortlich, in denen Umweltbedingungen über große Entfernungen gleichförmig sind und daher nur geringen Einfluss haben dürften?

Spezifische Ziele von ANDEEP sind:

- Die erste umfassende Bestandsaufnahme der Meio-, Makro- und Megafauna der Tiefsee im Scotia- und Weddellmeer durchzuführen und auf Übereinstimmungen mit der Fauna der atlantischen Tiefseebecken sowie dem antarktischen Schelf zu prüfen, und zwar mit morphologischen und molekularen Methoden.

- Die verschiedenen Habitate des Tiefseebodens in tektonisch aktiven und inaktiven Regionen zu beschreiben und den Einfluss der Habitat-Diversität in verschiedenen Größenordnungen auf die Arten- und genetische Vielfalt zu bestimmen.

- Die Rolle der Fortpflanzungs- und Larvalbiologie in der Verteilung und Ausbreitung von Arten zu beschreiben.

- Die Evolutionsprozesse zu untersuchen, die zu den heutigen Verteilungs- und Ausbreitungsmustern und der heutigen Artenvielfalt im Südlichen Ozean geführt haben.

- Die Rolle von geographischen Barrieren, z.B. Rücken oder Seebergen, für Besiedlung und Faunenüberschneidung zu ermitteln.

- Die Bedeutung der Antarktis für den Austausch zwischen Schelf und Tiefsee durch Experimente an Larven hinsichtlich ihrer Druck- und Temperaturtoleranz zu ermitteln.

Das Ziel des WECCON-Programms (Weddell Sea Convection Control) der physikalischen Ozeanographie besteht darin, die Bedeutung des atlantischen Sektors des Südlichen Ozeans für die großräumigen klimatischen Bedingungen besser zu verstehen. Die Intensität und Struktur der thermohalinen Zirkulation bestimmen die Rolle des Ozeans für das Klima. Im atlantischen Sektor des antarktischen zirkumpolaren Wassergürtels wird die globale Zirkulation durch die Variationen der Bildung von Antarktischem Bodenwasser beeinflusst. Messungen im Tiefen- und Bodenwasser des Weddellmeers haben gezeigt, dass sich seine Eigenschaften im Zeitraum der letzten 10 bis 15 Jahren merklich verändert haben. Zum Ende der 80er Jahre fanden eine Erwärmung und die Salzgehaltszunahme des von Norden einströmenden Zirkumpolaren Tiefenwassers statt. Im weiteren Verlauf wurde die Temperaturzunahme in den tieferen Schichten des Boden- und Tiefenwassers sichtbar und breitete sich bis in das westliche Weddellmeer aus. Inzwischen ist die Erwärmung im Zirkumpolaren Tiefenwasser des Weddellmeers zum Stehen gekommen, im Bodenwasser hält sie aber noch an. Gleichzeitig mit der Erwärmung im Weddellmeer wurde eine Temperaturzunahme in der Tiefe des Einstroms von Zirkumpolaren Tiefenwasser auch weiter nördlich im zirkumpolaren Wassergürtel gemessen.

Die Variationen in den verschiedenen Meeresgebieten können hypothetisch als Teile einer längerfristigen Wirkungskette interpretiert werden. Die Wassermassencharakteristik des Einstroms aus dem Zirkumpolarstrom in das Weddellmeer hängt von den Konvergenzbedingungen an der Weddellfront ab. Der Zustrom kann seine Intensität oder Wassermassen-Eigenschaften ändern. Er erfolgt allerdings nicht nur im östlichen Weddellmeer, wie früher angenommen, sondern auch schon westlich des Meridians von Greenwich. Vermehrter Einstrom kann zur Erwärmung im Weddellmeer führen. Andererseits ist in der Folge der großen Weddell-Polynja der 70er Jahre das Tiefenwasser im Weddellmeer durch Konvektion im offenen Ozean abgekühlt worden und wird nun wieder durch wärmeres ersetzt. Demnach wäre die gegenwärtige Erwärmung eine Reaktion auf ein vorhergehendes Abkühlungsereignis. Die Vertikal-

verteilung der Veränderung der Wassermasseneigenschaften im Weddellmeer lässt diese Hypothese allerdings als unwahrscheinlich erscheinen.

Da die Entstehung der großen Weddellmeer-Polynja noch nicht geklärt ist, kann nicht ausgeschlossen werden, dass sie durch Veränderungen im Einstrom von Zirkumpolarem Tiefenwasser ausgelöst wurde, indem die Stabilität der Wassersäule abnahm. Fluktuationen des Einstroms könnten durch die Variation der atmosphärischen Antriebsbedingungen ausgelöst werden, die z. B. im Rahmen der Antarktischen Zirkumpolaren Welle, des Südlichen Annularen Modes oder des Antarktischen Dipols auftreten. Andererseits könnten aber auch lokale Veränderungen der Antriebskräfte im Weddellmeer von Bedeutung sein.

Die Wassermassenformation erfordert, dass warmes, salzreiches Wasser in größerer Tiefe in den antarktischen Bereich einströmt, dort durch Auftrieb in der Antarktischen Divergenz an die Oberfläche kommt und im Kontakt mit der Atmosphäre abgekühlt wird, bis die Dichtezunahme das Absinken ermöglicht. Der Süßwassergewinn durch Niederschlag und durch den Zustrom von Schmelzwasser vom Kontinent, der zum Teil durch das Abbrechen von Eisbergen erfolgt, führt aber zur Dichteabnahme, die erst durch Salzfreisetzung bei der Meereisbildung kompensiert werden muss, bevor die Boden- oder Tiefenwasserbildung einsetzen kann. Daher ist der Salz- oder Süßwasserhaushalt von besonderer Bedeutung.

Im Rahmen globaler Programme haben unsere Messungen das Ziel, einen mittleren Zustand des Weddellmeer-Systems und dessen Veränderlichkeit zu charakterisieren, um über die regionalen Untersuchungen hinaus, globale Zusammenhänge zu beschreiben. Ferner sollen die Daten großräumigen Modellrechnungen als südliche Randbedingung dienen und zur Validierung regionaler Modelle herangezogen werden. Da sich gezeigt hat, dass merkliche Veränderungen des Systems über einen Zeitraum von Dekaden erfolgen, erfordert die Untersuchung der Ursache und der Auswirkungen dieser Fluktuationen Wiederholungsmessungen hoher Qualität über einen entsprechenden Zeitraum.

Das direkte Ziel der Untersuchungen ist es, einen Zusammenhang zwischen den Fluktuationen der atmosphärischen Bedingungen des Antarktischen Zirkumpolarstroms und den Eigenschaften des Weddellmeer-Bodenwassers nachzuweisen. Mit den Messungen sollen die in den vergangenen Jahren im Weddellmeer beobachteten Veränderungen weiter verfolgt werden, um ihren zeitlichen Verlauf und ihre räumliche Verteilung zu erkennen. Um die Ursache der Veränderungen zu bestimmen, sollen die Fluktuationen des Antarktischen Zirkumpolarstroms südlich von Südafrika gemessen werden, wobei die Intensität und die Lage seiner südlichen Strombänder und der Übergang zum nördlichen Stromband des Weddellwirbels von Bedeutung sind.

Im Weddellmeer sollen die Messungen zeigen, ob die Polynja-Bildung westlich der Maudkuppe durch den Einstrom von Zirkumpolarem Tiefenwasser begünstigt wird, oder ob der lokale atmosphärische Antrieb dominiert. Im Falle der Polynja-Bildung soll gemessen werden, wie die Eigenschaften des Weddellmeer-Tiefenwassers durch tiefe Konvektion verändert werden.

Die physikalischen Untersuchungen werden durch ein Programm zur Messung von Tracern erweitert, die zur Wassermassencharakterisierung herangezogen werden. Damit wird die Abschätzung der Wassermassenbildungsraten ermöglicht.

Der Beitrag des atlantischen Sektors des Südpolarmeers als Quelle oder Senke im globalen Kohlenstoffkreislauf wird in einem Projekt zur Messung von Nährstoffen, Sauerstoff und den Komponenten des CO_2-Systems bearbeitet.

Die Arbeiten finden im Rahmen des BMBF-Verbundes CLIVAR/marin-2 statt, der im Rahmen des *Climate Variability and Predictability* (CLIVAR) Programms des *World Climate Research Programme* (WCRP) der UNESCO angesiedelt ist. Die Untersuchungen bei der Maudkuppe finden im Rahmen des von SCOR (Scientific Committee of Oceanographic Research) betreuten iAnzone Programms statt, das einen Beitrag zum *Climate and Cryosphere* (CliC) Programm des WCRP liefert. In diesem Programm ist besonders die Ausbringung der Eisbergsender und der Upward Looking Sonars (ULS) von Bedeutung. Die ULS sind ein Beitrag zum *Antarctic Sea Ice Thickness Project* (AnSITP). Das Ausbringen der Floats erfolgt im Rahmen des internationalen *ARGO* Programms, das zum *Gobal Ocean Observing System* (GOOS) beiträgt. Im Rahmen der internationalen Programme erfolgt besonders enge Zusammenarbeit mit dem Geophysikalischen Institut der Universität Bergen, Norwegen, das am Verankerungsprogramm beteiligt ist. Die gesamte Expedition ist ein Beitrag zum MARCOPOLI-Programm der Hermann von Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF) im Rahmen der Arbeitspakete MAR1 und POL2. Weiter ist es ein Beitrag zum australisch-deutschen Kooperationsprojekt im Rahmen des Antarctic Climate & Ecosystems Cooperative Research Centres.

ITINERARY AND SUMMARY

E. Fahrbach (AWI, Bremerhaven, Germany)

POLARSTERN will leave on 21 April 2005 from Cape Town for the cruise ANTXXII/3 to Antarctica. First, she will steam to the west up to 15°E where she will turn to the southwest and follow up to 53°S to the ground track of the TOPEX-POSEIDON satellite. Temperature, salinity and ocean currents will be measured with expendable bathythermographs (XBT), a thermosalinograph and the acoustic Doppler current profiler (ADCP) from the mowing vessel, whereas the satellite will observe the sea surface elevation with an altimeter. Along the tack line 12 MAVOR floats will be deployed in the framework of the GOODHOPE project and moorings with bottom pressure sensors (PIES) will be exchanged. The deep-sea biology project ANDEEP III will start working on 3 stations. The German bathymetry programme can only occur north of 60°S due to the restrictions by the Umweltbundesamt. South of 60°S only the Russian programme can be realized.

At 53°S POLARSTERN will reach the Meridian of Greenwich from whereon the course will be to the south. The oceanography programme in the framework of WECCON (Weddell Sea Convection Control) will start with measurements by the CTD probe (conductivity, temperature, depth) and the recovery and redeployment of moorings. CTD measurements are planned to be carried out on approximately 100 hydrographic stations with water samplers to determine the concentration of dissolved nutrients, oxygen, tracers and CO_2. The final number of stations must be adapted to the progress of work. Since there is no spare time available, time losses due to unexpected events or slower progress as expected has to be buffered by reduction of station time. If CTD stations have to be cancelled, XBTs will be launched as replacement.

An essential part of the physical oceanography programme consists in the recovery and redeployment of moorings. They contain current meters, temperature and conductivity sensors, sound sources to locate floats and upward looking sonars (ULS) to measure the sea ice thickness. Additionally 30 APEX- (profiling autonomous Lagrangian Circulation Explorers) and NEMO (Navigating European Marine Observer) floats will be deployed. To quantify the freshwater input by icebergs 14 bergs will be equipped with satellite transmitters which will be deployed with helicopters on the bergs.

At approximately 64°S the station work on the Meridian of Greenwich has to be interrupted to reach the Neumayer Station in time. The loading of material to be carried back by POLARSTERN has to be accomplished before the summer crew has to leave the station in order to reach the last flight back to Cape Town. After the supply operation POLARSTERN will steam back to the north and continue the station work along the Meridian von Greenwich.

The second phase of the physical and biological work will take place between Kapp Norvegia and the northern end of the Antarctic Peninsula. The deep-sea biology work within the ANDEEP III project will have its focus in this area and work on 8 stations. At the east coast of the Weddell Sea moorings from an earlier biology project have to be recovered. The physical oceanography will continue with CTD stations and the deployment of moorings, floats and iceberg markers. If there will be time available after having reached the Antarctic Peninsula, there are plans for optional deep-sea -

biology stations in the Powell Basin and recovery of American moorings south of the South Orkney Islands. At the end of the cruise Jubany Station and the Dallmann Laboratory will be visited to take on board material and personal. The scientific work will be accompanied by a public relation project which includes the work of a painter.

During the whole cruise hydro-acoustic measurements and infra red observations will be carried out as much as time allows. The project aims to develop a system to locate marine mammals. When operational, it might allow in future to apply various scientific hydro-acoustic methods from POLARSTERN in spite of the present restrictions given by the Umweltbundesamt.

The cruise will end on 6 April 2005 in Punta Arenas.

The international ANDEEP III project (*ANtarctic benthic DEEP-sea biodiversity: colonization history and recent community patterns*) aims to investigate the deep-water biology of the Scotia and Weddell seas from POLARSTERN. The ANDEEP programme was established to provide baseline data on the Southern Ocean deep-water ecosystem.

Its main objectives are

- to investigate the influence of seafloor habitat diversity on biodiversity and
- to determine if the Weddell/Scotia Seas are a source for deep-water benthos in other oceans.

Sampling was undertaken on ANDEEP I & II during 2002 and will be completed during ANDEEP III.

The deeper waters of the Scotia and Weddell seas are some of the least explored parts of the world's oceans and we know almost nothing about the bottom dwelling animals that inhabit them. First results from ANDEEP I/II have shed some light on the composition and possible evolutionary pathways of the Southern Ocean deep-sea fauna. ANDEEP III will deepen our knowledge gained so far with a somewhat larger geographical scope, spanning not only the Weddell Sea Abyssal Plain and adjacent areas of the Southern Ocean but also the Cape Basin.

ANDEEP is one of the two German pioneering field programmes of CeDAMar (Census of the Biodiversity of Abyssal Marine Life), a ten-year project dedicated to the investigation of benthic communities in abyssal plains in the Atlantic from pole to pole. CeDAMar in turn belongs to the global project CoML (Census of Marine Life) which was launched in 2000 and is planned to run until 2010. Scientists from more than 70 countries are participating so far, sampling with standardized methods and creating a global database that is designed to provide a benchmark for future research efforts. With taxonomic descriptions of deep-sea species being a major component, CeDAMar is promoting the revival of taxonomy and systematics as important disciplines in biology. ANDEEP will help to provide answers to two basic questions raised by CeDAMar:

- How species rich is the deep sea, and how much of the total world species live in the ocean? How large is the area a deep-sea species inhabits?

- What factors drive speciation processes in homogeneous environments where ecological factors are uniform over wide distances and therefore have little influence?

Specific objectives of ANDEEP are:

- To conduct the first comprehensive survey of megafaunal, macrofaunal and meiofaunal deep-water communities in the Scotia and Weddell seas and to investigate their similarity at the taxonomic (morphological) and genetic (molecular) levels to the fauna of Atlantic basins and the Antarctic shelf.

- To describe the variety of seafloor habitats in tectonically active and inactive regions and to determine the influence of 'habitat diversity' on species and genetic diversity over a variety of spatial scales.

- To determine the importance of life history strategies and larval biology in influencing species distributional patterns and geographical ranges.

- To investigate the evolutionary processes having resulted in the present biodiversity and distributional/zoogeographical patterns in the Southern Ocean deep sea.

- To investigate the colonisation and exchange processes of the deep-sea fauna, in particular the role of tectonic structures (for example ridges or seamounts).

- To assess the importance of the Antarctic as a region where shallow-water species may enter the deep sea by conducting experimental studies on the pressure and temperature tolerances of shallow and deep-water invertebrate larvae.

The physical oceanography WECCON (Weddell Sea Convection Control) programme intends to investigate the role of the Weddell Sea in the global climate system. The Antarctic ocean contributes through atmosphere-ice-ocean interaction processes to the variability of the climate system. The ice cover has a strong control on the albedo and on the ocean-atmosphere heat exchange. At the same time the advective heat supply from the ocean controls the ice cover. Atmosphere-ice-ocean interactions lead to water mass conversion which occurs in the open ocean and on the shelves. Whereas the shelf processes affect a reservoir limited through the shallow water depth and the cross frontal transports at the shelf edges, open ocean processes can affect deeper layers directly if the stability of the water column is weak. A major contribution of the global deep and bottom water formation occurs in the Weddell Sea. It is controlled by the transport of source waters into the Weddell Sea, processes within the Weddell Sea, and the transport of modified water out of the Weddell Sea.

In the Weddell Sea, Circumpolar Deep Water enters from the north and circulates in intermediate layers within the large scale cyclonic gyre. By upwelling and entrainment heat and salt is transported from that water mass into the surface layers. The vertical transport of heat and salt counteracts to the heat loss and the fresh water gain at the sea surface. The delicate balance controls the stability of the water

column. The vertical transports can be significantly affected by vertical flow and enhanced mixing in the vicinity of topographical features like Maud Rise. Even relative small scale topographical structures have a significant effect on the water flow and mixing due to the generally weak stratification in polar oceans.

Under conditions of a relatively stable water column shallow open ocean convection represents a preconditioning for the shelf processes through heat extraction and salt redistribution of the source waters which are involved in frontal processes over the continental slope. In the case of relatively unstable conditions, open ocean convection can reach deeper layers and contribute directly to the deep water formation. Unstable conditions enhance the heat transport from the ocean towards the surface to an extent that large areas of the winter sea ice are melted and a open ocean polynya is formed which then allows large heat losses of the ocean increasing the water mass conversion.

Recent observations indicate that the water mass properties of the Warm Deep Water are subject to significant variations. After an initial warming and salinity increase observed during the nineties a cooling followed during the last years. The variations are most likely due to changes in the inflow from the circumpolar water belt, in combination with changes in the ice-ocean-atmosphere interaction in the Weddell Sea induced by changes in the atmospheric forcing conditions. The time variability of the Antarctic Circumpolar Wave, the Southern Annular Mode or the Antarctic Dipole might affect the Weddell Sea and generate the observed variations. Whereas the properties of the Weddell Sea Deep Water remained essentially constant, the Weddell Sea Bottom Water was subject to significant changes as well. Since the Warm Deep Water is the source water of bottom water, the variations of the two water masses seem to be related through the formation process.

WECCON aims to investigate processes which occur in the Weddell Sea in cooperation with the Geophysical Institute of the University Bergen, Norway in the framework of iAnZone, a programme associated to SCOR (Scientific Committee of Oceanographic Research). The cruise occurs in the context of the MARCOPOLI programme of the Hermann von Helmholtz Association of German Research Centres (HGF) as part of work packages MAR1 and POL2 and the Australian-German cooperation within the Antarctic Climate & Ecosystems Cooperative Research Centre. It is a contribution to the *Climate Variability and Predictability* (CLIVAR) and the *Climate and Cryosphere* (CliC) projects of the *World Climate Research Programme* (WCRP). The ULS are a contribution to the *Antarctic Sea Ice Thickness Project* (AnSITP). The deployment of floats occurs in the framework of the international ARGO programme which contributes to the *Global Ocean Observing System* (GOOS). The studies of convection in the Weddell Sea and the influence of variations of the inflow from the Antarctic Circumpolar Current on the conditions in the Weddell Sea occur in the framework of the German CLIVAR/marine-2 programme supported by the German Federal Ministry of Education and Research (BMBF).

LARGE SCALE PROCESSES AND DECADAL VARIATIONS IN THE WEDDELL SEA (WEDDELL SEA CONVECTION CONTROL, WECCON 2005)

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Objectives

The Antarctic ocean contributes through atmosphere-ice-ocean interaction processes to the variability of the climate system. The ice cover has a strong control on the albedo and on the ocean-atmosphere heat exchange. At the same time the advective heat supply from the ocean controls the ice cover. Atmosphere-ice-ocean interactions lead to water mass conversion which occurs in the open ocean and on the shelves. Whereas the shelf processes affect a reservoir limited through the shallow water depth and the cross frontal transports at the shelf edges, open ocean processes can affect deeper layers directly if the stability of the water column is weak. A major contribution of the global deep and bottom water formation occurs in the Weddell Sea. It is controlled by the transport of source waters into the Weddell Sea, processes within the Weddell Sea, and the transport of modified water out of the Weddell Sea.

In the Weddell Sea, Circumpolar Deep Water enters from the north and circulates in intermediate layers within the large scale cyclonic gyre. By upwelling and entrainment heat and salt is transported from that water mass into the surface layers. The vertical transport of heat and salt counteracts to the heat loss and the fresh water gain at the sea surface. The delicate balance controls the stability of the water column. The vertical transports can be significantly affected by vertical flow and enhanced mixing in the vicinity of topographical features like Maud Rise. Even relative small scale topographical structures have a significant effect on the water flow and mixing due to the generally weak stratification in polar oceans.

Under conditions of a relatively stable water column shallow open ocean convection represents a preconditioning for the shelf processes through heat extraction and salt redistribution of the source waters which are involved in frontal processes over the continental slope. In the case of relatively unstable conditions, open ocean convection can reach deeper layers and contribute directly to the deep water formation. Unstable conditions enhance the heat transport from the ocean towards the surface to an extent that large areas of the winter sea ice are melted and a open ocean polynya is formed which then allows large heat losses of the ocean increasing the water mass conversion.

Recent observations indicate that the water mass properties of the Warm Deep Water are subject to significant variations. After an initial warming and salinity increase observed during the nineties a cooling followed during the last years. The variations are most likely due to changes in the inflow from the circumpolar water belt, in combination with changes in the ice-ocean-atmosphere interaction in the Weddell Sea induced by changes in the atmospheric forcing conditions. The time variability of the Antarctic Circumpolar Wave, the Southern Annular Mode or the Antarctic Dipole might affect the Weddell Sea and generate the observed variations.

Whereas the properties of the Weddell Sea Deep Water remained essentially constant, the Weddell Sea Bottom Water was subject to significant changes as well. Since the Warm Deep Water is the source water of bottom water, the variations of the two water masses seem to be related through the formation process.

The detailed objectives of the project are:

- To determine the variation in water mass properties in the Weddell gyre including the convective area north and west of Maud Rise.
- To determine the variability in characteristics and the amount of the inflowing Circumpolar Deep Water.
- To determine the variability of the structure of the Weddell gyre.
- To determine the effect of variations in the elements of the fresh water budget as sea ice transport and iceberg melt on the stability of the water column.
- To estimate the effect of relative small scale topographic features on horizontal flow regimes and vertical mixing.
- To estimate the potential of abrupt changes.
- To provide a long term data set which can serve to validate numerical models.

The observations will be accompanied by a hierarchy of modelling efforts. High resolution models have to be used to investigate the effect of variations in the atmospheric forcing and the inflow from the north. The effect of the shape of the bottom topography, in particular structures like Maud Rise must be investigated in an ice-ocean interaction model with sufficient horizontal resolution.

WECCON aims to investigate processes which occur in the Weddell Sea in cooperation with the Geophysical Institute of the University Bergen, Norway in the framework of iAnZone, a programme associated to SCOR (Scientific Committee of Oceanographic Research). The cruise occurs in the context of the MARCOPOLI programme of the Hermann von Helmholtz Association of German Research Centres (HGF) as part of work packages MAR1 and POL2 and the Australian-German cooperation within the Antarctic Climate & Ecosystems Cooperative Research Centre. It is a contribution to the *Climate Variability and Predictability* (CLIVAR) and the *Climate and Cryosphere* (CliC) projects of the *World Climate Research Programme* (WCRP). The ULS are a contribution to the *Antarctic Sea Ice Thickness Project* (AnSITP). The deployment of floats occurs in the framework of the international ARGO programme which contributes to the *Global Ocean Observing System* (GOOS). The study of convection in the Weddell Sea and the influence of variations of the inflow from the Antarctic Circumpolar Current on the conditions in the Weddell Sea occur in the framework of the German CLIVAR/marine-2 programme supported by the German Federal Ministry of Education and Research (BMBF).

Work at sea

In order to detect regional variations with sufficient time resolution to avoid the effect of aliasing, the observations have to cover at least a decadal time period with sufficient spatial coverage. Furthermore the measurements need sufficient accuracy to assure that even small variations can be distinguished from observational noise. With this background the following works are planned:

Recovery and deployment of moorings

A moored observing system is maintained since 1996 on the Greenwich Meridian. Current meter moorings were exchanged in 1998 and 1999, 2001 and 2003. The recovery o the moorings deployed in 2003 (Fig. 2, 5 and Tab. 1) and the redeployment (Fig. 3, 5 and Tab. 3) is planned during the present leg. Additional moorings are planned in the Weddell Sea proper (Fig. 4, 5 and Tab. 2 and 4) where moorings have been deployed from 1989 to 1996. The moorings are equipped with current meters and temperature and conductivity sensors to measure the vertical distribution of the currents and water mass properties. In the Antarctic Circumpolar Current inverted echosounders (PIES) with bottom pressure recorders will be recovered and redeployed. Upward looking sonars (ULS) are installed in 150 m depth on six moorings to determine the sea ice thickness.

Vertical profiling floats

In the northern part of the area of operation 12 MAVOR floats will be launched. In the Weddell Sea 30 APEX- (Autonomous Profiling Lagrangian Circulation Explorer) and NEMO (Navigating European Marine Observer) floats will be deployed.

CTD transects

Moored systems are not able to measure in the near surface layers and can not provide sufficient horizontal resolution. Therefore ship-borne measurements are required. Hydrographic surveys will be carried out along the Greenwich Meridian and from Kapp Norvegia to the northern end of the Antarctic Peninsula with a CTD probe and a rosette water sampler (conductivity/temperature/depth). Samples will be taken for the components of the CO_2 system, oxygen, nutrients, and tracers.

XBT

Expendable Bathythermographs (XBTs) will be launched on the track when there will be no time to do CTD casts.
Underway measurements

Thermosalinograph and Acoustic Doppler Current Profiler (ADCP) will be operated during the complete cruise.

Iceberg transmitters

Icebergs will be marked by satellite transmitters to determine their tracks from the Antarctic coast into the melting area. The transmitters will be deployed with a helicopter on the icebergs. It is planned to deploy 14 transmitters.

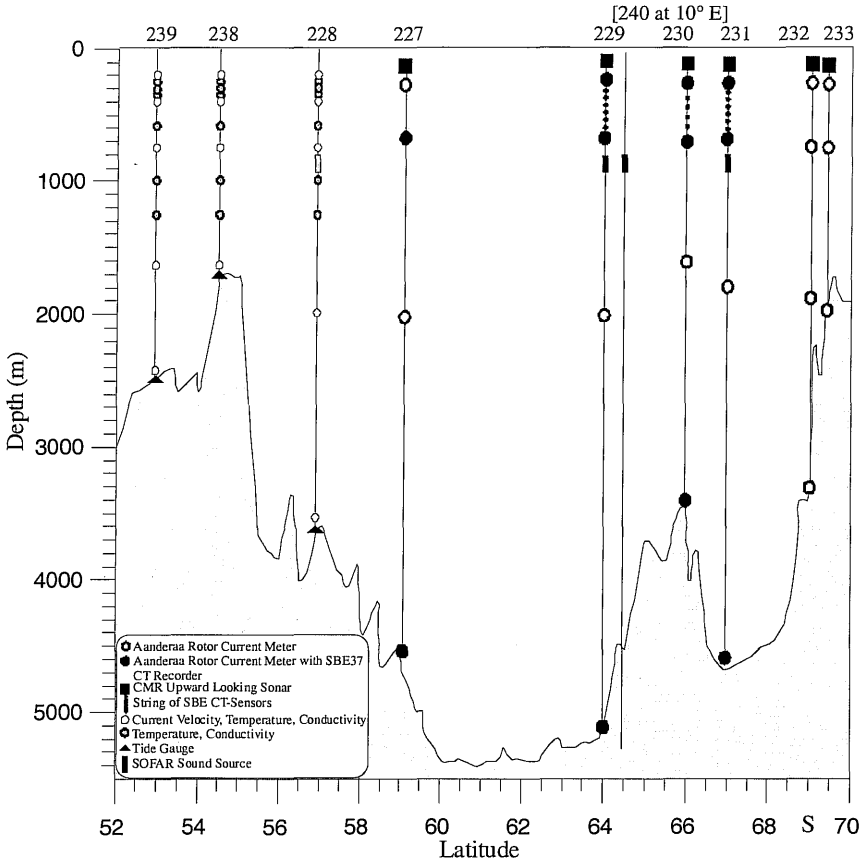

Fig. 2: Distribution of moored instruments to be recovered during ANTXXII/3 along the Greenwich Meridian.

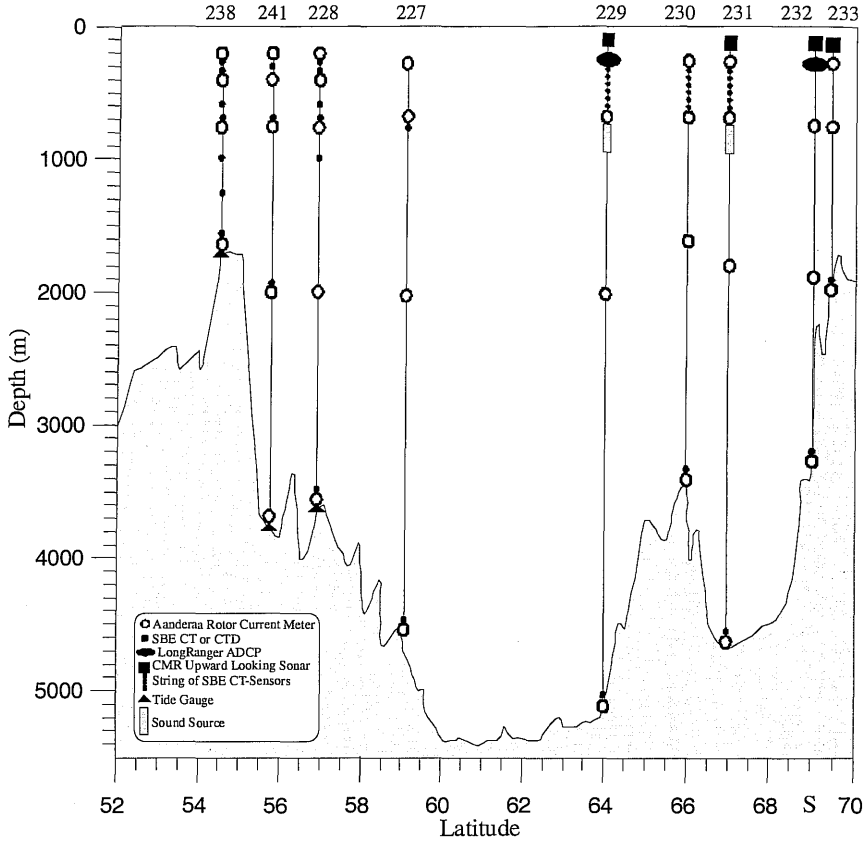

Fig. 3: Distribution of moored instruments to be deployed during ANTXXII/3 along the Greenwich Meridian.

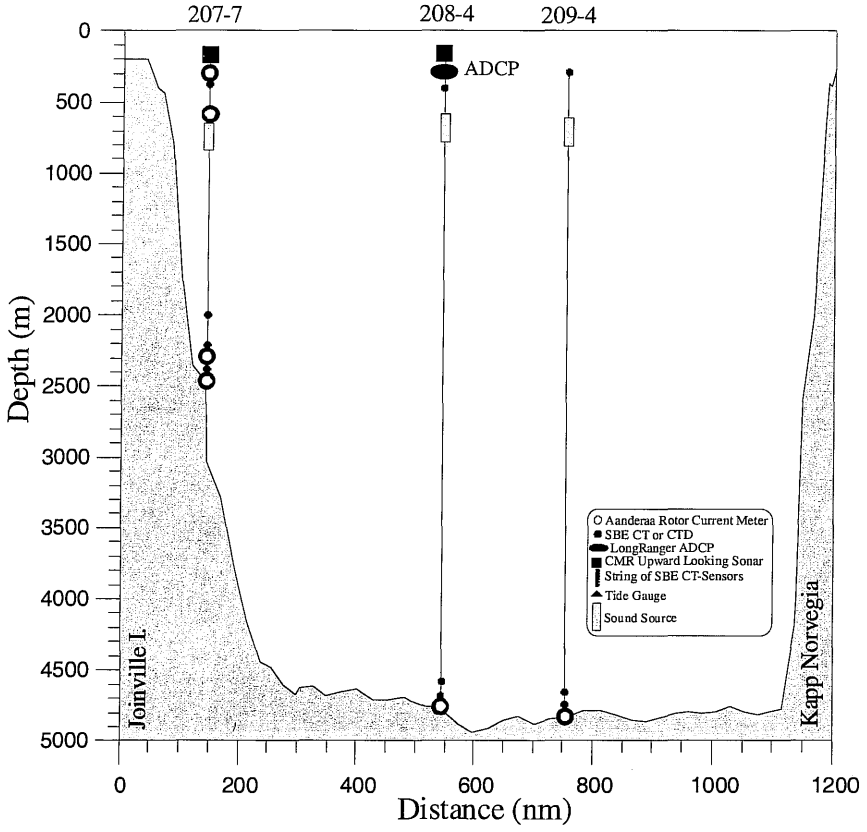

Fig. 4: Distribution of moored instruments to be deployed during ANTXXII/3 in the Weddell Sea between Kapp Norvegia and Joinville Island.

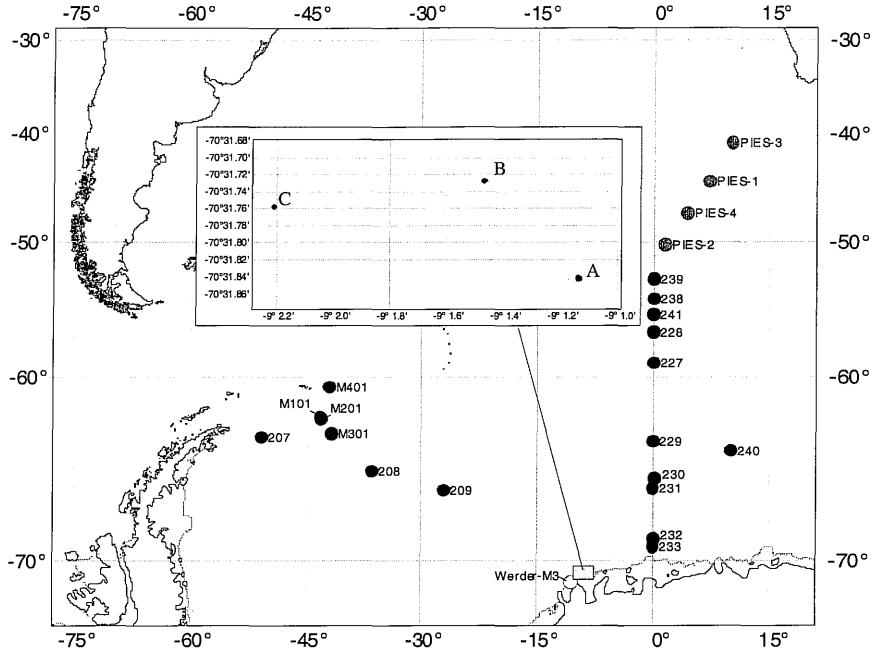

Fig. 5: Distribution of moored instruments to be recovered and deployed during ANTXXII/3 in the Atlantic sector of the Southern Ocean, along the Greenwich Meridian and in the Weddell Sea between Kapp Norvegia and Joinville Island. A set of American moorings which will be recovered if time will allow is displayed as well.

Tab. 1: Moorings to be recovered at the Greenwich Meridian.

Mooring	Latitude Longitude	Water Depth (m)	Date Time (1. Record)	Type	SN	Depth (m)
AWI233-6	69° 23.66' S	1948	15.12.2002	ULS	49	165
	00° 03.98' W		22:48	AVTP	8367	237
				AVTPC	8395	738
				SBE37	1604	1891
				AVT	10499	1892
AWI232-6	68° 59.87' S	3369	16.12.2002	ULS	50	175
	00° 00.32' E		14:46	AVTP	11887	252
				AVTPC	8396	765
				AVT	10498	1809
				SBE37	1605	3314
				RCM 11	127	3315
AWI231-5	66° 30.56' S	4542	18.12.2002	ULS	39	178
	00° 02.03' W		10:55	AVTPC	8400	220
				SBE37	2609	220
				SBE37	211	270
				SBE37	2610	320
				SBE37	214	370
				SBE37	215	420
				SBE37PuP3	2392	470
				SBE37	220	520
				SBE37	222	570
				SBE37	223	620
				SBE37	2234	670
				SBE37Pu	2382	720
				AVTPC	9215	731
				SQ	19/W2	882
				AVT	9768	1837
				SBE37Pu	2383	4492
				RCM 11	133	4498
AWI230-4	66° 00.30' S	3477	18.12.2002	ULS	38	177
	00° 10.29' E		20:53	AVTPC	8401	220
				SBE37Pu	2384	220
				SBE37Pu	2385	320
				SBE37P3	249	420
				SBE37	445	520
				SBE37	446	620
				SBE37Pu	2386	720
				AVTPC	9995	731
				RCM 11	134	1627
				SBE37Pu	2087	3427
				RCM 11	135	3433

Tab. 1: Continuation.

Mooring	Latitude Longitude	Water Depth (m)	Date Time (1. Record)	Type	SN	Depth (m)
AWI229-5	63° 57.23' S	5200	10.12.2002	ULS	38	147
	00° 00.21' W		18:45	AVTP	8402	193
				SBE37P3	2387	200
				SBE37	250	250
				SBE37	448	300
				SBE37	449	350
				SBE37Pu	2086	400
				SBE37PuP3	2393	450
				SBE37Pu	2088	500
				SBE37Pu	2089	550
				SBE37Pu	2090	600
				SBE37	2611	700
				SBE37 PuP7	1564	750
				AVTP	9783	704
				SQ	14/W1	859
				RCM 11	144	2005
				SBE37Pu	2388	5150
				RCM 11	145	5156
AWI227-8	59° 04.20' S	4566	07.12.2002	ULS	41	162
	00° 04.47' E		09:01	AVTPC	10004	274
				AVT	3570	704
				SBE37PuP3	2395	705
				AVT	10503	2011
				SBE37Pu	2091	4616
				RCM 11	146	4622
AWI228-6	56° 57.64' S	3699	04.12.2002	AVTPC	8405	190
	00° 01.62' E		23:00	SBE16P1	1973	191
				SBE37PuP3	2235	241
				SBE37Pu	2092	291
				SBE37Pu	2093	341
				AVTPC	9201	402
				SBE37Pu	2391	403
				SBE37PuP3	2396	562
				AVT	9389	728
				SBE37Pu	2094	729
				SBE37Pu	2095	979
				SBE37PuP7	1565	1227
				RCM 11	100	1934
				RCM 11	101	3635
				SBE37Pu	2389	3636
				SBE26	276	3699

Tab. 1: Continuation.

Mooring	Latitude Longitude	Water Depth (m)	Date Time (1. Record)	Type	SN	Depth (m)
AWI238-4	54° 30.63' S 00° 01.81' E	1718	03.12.2002 14:20	AVTP	11892	187
				SBE16P3	2420	188
				SBE37Pu	2096	238
				SBE37Pu	2097	288
				SBE37Pu	2098	338
				AVTP	10491	399
				SBE37Pu P3	2236	400
				SBE37Pu	2099	570
				AVT	9390	745
				SBE37Pu P3	2237	746
				SBE37Pu	2100	1000
				SBE37Pu	2101	1250
				RCM 11	102	1651
				SBE37Pu	2390	1652
				SBE26	257	1718
AWI239-3	53° 00.49' S 00° 01.96' E	2483	02.12.2002 18:03	AVTPC	8419	240
				SBE37Pu	2231	241
				SBE37Pu	2102	291
				SBE37Pu	2103	341
				SBE37Pu	2104	391
				AVT	9401	441
				SBE37Pu P3	2394	442
				SBE37Pu	2105	613
				AVT	9458	797
				SBE37Pu P3	2238	798
				SBE37Pu	2233	1043
				SBE37PuP7	1566	1293
				RCM 11	103	1793
				SBE37	2232	1804
				RCM 11	104	2429
				SBE26	261	2483
AWI240-1	64° 30.00' S 10° 00.00' E	5200	23.12.2002 15:48	SQ	21/W3	804

Tab. 2: Moorings to be recovered in the area of Atka Bay.

Mooring	Latitude Longitude	Water Depth (m)	Type	Depth (m)
BENDEX F1-A	70° 31.84' S 9° 1.14' W	306	ST	283
			RCM 11	298
BENDEX F1-B	70° 31.73' S 9° 1.47' W	308	ST	285
			RCM 11	300
BENDEX F1-C	70° 31.76' S 9° 2.21' W	304	ST	281
			RCM 11	296
BENDEX F1-D	70° 56.68' S 10° 32.13' W	142	ST	124
			RCM 11	134

Tab. 3: Moorings to be deployed at the Greenwich Meridian.

Mooring	Latitude Longitude	Water Depth (m)	Type	Depth (m)
AWI233-7	69° 23.66' S 00° 03.98' W	1948	ULS	170
			AVTP	200
			AVTP	700
			SBE37	1900
			RCM 11	1900
AWI232-7	68° 59.87' S 00° 00.32' E	3369	ULS	180
			ADCP	240
			AVTP	750
			AVT	1800
			SBE37	3300
			AVT	3300
AWI231-6	66° 30.56' S 00° 02.03' W	4542	ULS	180
			ADCP	240
			AVTPC	200
			SBE37	200
			SBE37	300
			SBE37	400
			SBE37	500
			SBE37	600
			SBE37Pu	700
			AVTPC	700
			SQ	800
			AVT	1800
			SBE37Pu	4500
			AVT	4500

Tab. 3: Continuation.

Mooring	Latitude Longitude	Water Depth (m)	Type	Depth (m)
AWI230-5	66° 00.30' S 00° 10.29' E	3477	AVTPC	200
			SBE37Pu	200
			SBE37Pu	300
			SBE37P3	400
			SBE37	500
			SBE37	600
			SBE37Pu	700
			AVTPC	700
			RCM 11	1600
			SBE37Pu	3400
			RCM 11	3400
AWI229-6	63° 57.23' S 00° 00.21' W	5200	ULS	150
			ADCP	200
			SBE37P3	200
			SBE37	300
			SBE37Pu	400
			SBE37Pu	500
			SBE37Pu	600
			SBE37	700
			AVTP	700
			SQ	800
			RCM 11	2000
			SBE37Pu	5150
			RCM 11	5150
AWI227-9	59° 04.20' S 00° 04.47' E	4560	AVTP	260
			AVTP	690
			SBE37PuP10	691
			AVT	2000
			SBE37Pu	4510
			RCM 11	4511

Tab. 3: Continuation.

Mooring	Latitude Longitude	Water Depth (m)	Type	Depth (m)
AWI228-7	56° 57.64' S 00° 01.62' E	3700	AVTP	215
			SBE37	216
			SBE37PuP3	266
			SBE37	316
			SBE37	366
			AVTP	423
			SBE37	424
			SBE37PuP3	585
			AVT	750
			SBE37PuP3	751
			SBE37PuP3	1002
			SBE37PuP3	1250
			RCM 11	1960
			SBE37Pu	3659
			RCM 11	3660
			SBE26	3700
AWI241-1	55° 40.80' S 00° 00.00' E	3600	AVTP	200
			SBE37Pu	201
			AVTP	400
			AVT	750
			SBE16PuP3	751
			RCM 11	2000
			SBE37	2000
			RCM 11	3550
			SBE26	3600
AWI238-5	54° 30.63' S 00° 01.81' E	1718	AVTP	200
			SBE16PuP3	201
			SBE37PuP3	250
			SBE37PuP3	300
			SBE37Pu	350
			AVTP	400
			SBE37Pu	401
			SBE37Pu	565
			AVTP	745
			SBE37Pu	746
			SBE37Pu	1000
			SBE37Pu	1250
			SBE37PuP10	1625
			RCM 11	1626
			SBE26	1715

Tab. 4: Moorings to be deployed along the western Weddell Sea.

Mooring	Latitude Longitude	Water Depth (m)	Type	Depth (m)
AWI209-4	66° 37.40' S 27° 07.20' W	4860	SBE37P3 SQ SBE16P10 SBE37 RCM 11	300 700 4800 4850 4850
AWI208-4	65° 37.40' S 36° 29.40' W	4740	ULS ADCP SBE37 SQ SBE37 SBE37 RCM 11	150 300 300 700 4680 4730 4730
AWI207-6	63° 45.10' S 50° 54.30' W	2500	ULS AVT SBE37P3 SQ AVT SBE37 SBE37 AVT SBE37 RCM 11	150 250 251 700 750 2100 2300 2300 2490 2490

Abbreviations

ADCP	RD-Instruments, Self contained acoustic Doppler current profiler
AVTCP	Aanderaa current meter with temperature-, conductivity-, and pressure sensors
AVTP	Aanderaa current meter with temperature- and pressure sensors
AVT	Aanderaa current meter with temperature sensor
RCM 11	Aanderaa Doppler current meter
SBE16P#	SeaBird Electronics internally recording CTD measures temperature, conductivity and pressure, type: Seacat; P# indicates the depth rating, e.g. P1 up to 1000psi or P3 up to 3000psi
ULS	Upward looking sonar; Christian Michelsen Research Inc.
SBE26	SeaBird Electronics to measure the bottom pressure
SBE37	SeaBird Electronics, type: MicroCat, to measure temperature and conductivity
SBE37PU	SeaBird Electronics, type: MicroCat, to measure temperature and conductivity including external pump
SBE37PUP#	SeaBird Electronics, type: MicroCat, to measure temperature and conductivity including external pump and pressure sensor; P# indicates the depth rating, e.g. P3 up to 3000psi or P7 up to 7000psi
SQ	Sound source for SOFAR floats
ST	Sediment trap

CARBON DIOXIDE IN ANTARCTIC CIRCUMPOLAR CURRENT AND THE WEDDELL SEA

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Objectives

The level of atmospheric carbon dioxide (CO_2) is continuously rising due to anthropogenic causes, and the CO_2 content of the oceans has increased as well. While the atmospheric CO_2 increase is well documented, it is much harder to monitor the oceanic increase due to high natural variations and the large amount of CO_2 present in the oceans. High-latitude areas are prominent in this issue because in these regions there is intense interaction between the deep and surface waters and between the ocean and the atmosphere. Our overall objective is to trace the anthropogenic CO_2 in the deep and surface waters of the Antarctic Ocean and to investigate what factors exert influence on the CO_2 distribution. Substantial progress in these issues can only be made when time series become available. Data from this cruise will extend the longest combined oceanic time-series of CO_2 and transient tracers, hydrography, nutrients and oxygen on the prime meridian. In addition, data from the Weddell Sea proper will be compared with earlier data of one of us measured in the 1990s, for detecting differences in the distributions and the anticipated increase of CO_2 in a budget of the Weddell Sea.

Particular objectives during this cruise are:

- To determine the exchange of CO_2 between the ocean and the atmosphere in austral summer.
- To correlate total CO_2 (TCO_2) and the partial pressure of CO_2 (pCO_2) with auxiliary parameters to obtain the factors causing variations in the surface waters.
- To investigate small-scale and meso-scale features of the CO_2 system in the surface ocean using the continuous pCO_2 measurements.
- To extend our data base of total CO_2 of the Weddell Sea and Antarctic Circumpolar Current to combine this with transient tracers (CFCs) for obtaining the temporal scale of the invasion of anthropogenic CO_2.
- To obtain a section of the Weddell Sea between Kapp Norvegia and the tip of the Antarctic Peninsula for TCO_2.

Work at sea

We will determine TCO_2 on board ship in discrete water samples taken from the rosette sampler. TCO_2 is the sum of all dissolved inorganic carbon species and is analyzed by a precise coulometric method. The same method and equipment has been used during all of our previous cruises to the Antarctic Circumpolar Current and Weddell Sea, which ascertains full compatibility of the new results with previous data. The accuracy is set by internationally recognized and widely used certified reference material for TCO_2 measurements. In addition, online data of surface water pCO_2 will be collected off the ship's pumping system. pCO_2 is obtained with an infra-red analyzer (Li-cor), both for seawater using an water-air equilibrator and for the atmosphere, the air being pumped from the crow's nest. On hydrographic stations we will get the values of two different parameters of the CO_2 system (TCO_2 and pCO_2), which enables us to calculate other parameters like alkalinity and pH.

ANTARCTIC BENTHIC DEEP-SEA BIODIVERSITY: COLONIZATION HISTORY AND RECENT COMMUNITY PATTERNS. ANDEEP III

A. Brandt (Zoological Museum, University of Hamburg, Germany) and B. Hilbig (Spezielle Zoologie, Ruhr-University, Bochum, Germany)

The ANtarctic benthic DEEP-sea biodiversity: colonization history and recent community patterns project is an international effort to investigate the deep-water biology of the Scotia and Weddell seas from POLARSTERN. The ANDEEP programme was established to provide baseline data on the Southern Ocean deep-water ecosystem. Its main objectives are

- to investigate the influence of seafloor habitat diversity on biodiversity and
- to determine if the Weddell/Scotia Seas are a source for deep-water benthos in other oceans.

Sampling was undertaken on ANDEEP I & II during 2002 in areas 1, 3, 4 (in part), and 6 (Fig. 6), with the aim of concluding the sampling programme during ANDEEP III.

The deeper waters of the Scotia and Weddell seas are some of the least explored parts of the world's oceans and we know almost nothing about the bottom dwelling animals that inhabit them. First results from ANDEEP I/II (special volume of Deep-Sea Research II) have shed some light on the composition and possible evolutionary pathways of the Southern Ocean deep-sea fauna. ANDEEP III will deepen our knowledge gained so far with a somewhat larger geographical scope, spanning not only the Weddell Sea Abyssal Plain and adjacent areas of the Southern Ocean but also the Cape Basin.

ANDEEP is one of the two German pioneering field programmes of CeDAMar (Census of the Biodiversity of Abyssal Marine Life), a ten-year project dedicated to the investigation of benthic communities in abyssal plains in the Atlantic from pole to pole. CeDAMar in turn belongs to the global project CoML (Census of Marine Life) which was launched in 2000 and is planned to run until 2010. Scientists from more than 70 countries are participating so far, sampling with standardized methods and

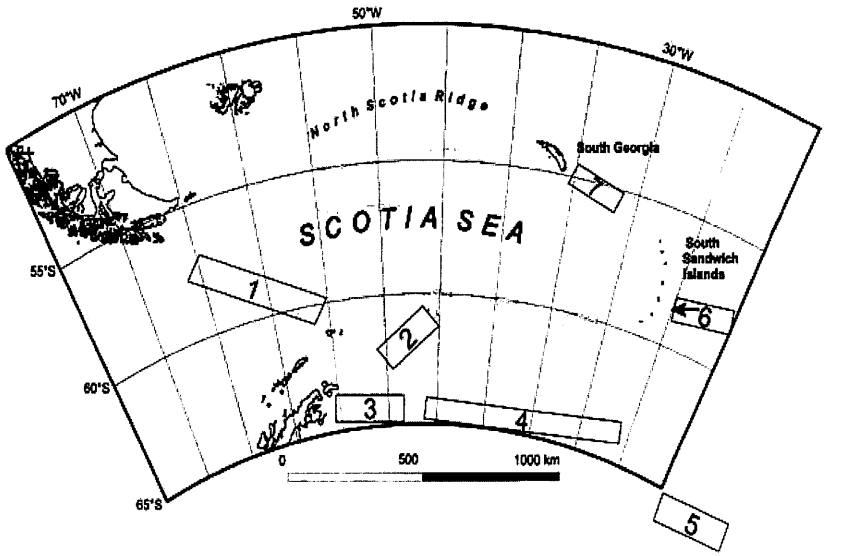

Fig. 6: Proposed sampling areas for the ANDEEP programme.

creating a global database that is designed to provide a benchmark for future research efforts. With taxonomic descriptions of deep-sea species being a major component, CeDAMar is promoting the revival of taxonomy and systematics as important disciplines in biology. ANDEEP will help to provide answers to two basic questions raised by CeDAMar:

- How species rich is the deep sea, and how much of the total world species live in the ocean? How large is the area a deep-sea species inhabits?

- What factors drive speciation processes in homogeneous environments where ecological factors are uniform over wide distances and therefore have little influence?

Specific objectives of ANDEEP are:

- To conduct the first comprehensive survey of megafaunal, macrofaunal and meiofaunal deep-water communities in the Scotia and Weddell seas and to investigate their similarity at the taxonomic (morphological) and genetic (molecular) levels to the fauna of Atlantic basins and the Antarctic shelf.

- To describe the variety of seafloor habitats in tectonically active and inactive regions and to determine the influence of 'habitat diversity' on species and genetic diversity over a variety of spatial scales.

- To determine the importance of life history strategies and larval biology in influencing species distributional patterns and geographical ranges.

- To investigate the evolutionary processes having resulted in the present biodiversity and distributional/zoogeographical patterns in the Southern Ocean deep sea.

- To investigate the colonisation and exchange processes of the deep-sea fauna, in particular the role of tectonic structures (for example ridges or seamounts).

- To assess the importance of the Antarctic as a region where shallow-water species may enter the deep sea by conducting experimental studies on the pressure and temperature tolerances of shallow and deep-water invertebrate larvae.

ANDEEP III – A GEOLOGICAL PERSPECTIVE

M. Thomson (School of Earth Sciences, University of Leeds, Leeds, U.K.)

Scientific background

A geological perspective has always been enshrined in the aims of the ANDEEP project. The ANDEEP region of interest, the Scotia Sea and the Weddell Sea sector of the Southern Ocean, is one with a particularly complex geological history that has profoundly influenced its geographical, oceanographical and biological history. The region also underwent a major climatic cooling over the last 35 million years (Ma) or so, although how much this can be related to the geographical changes is still a matter of vigorous debate. Whereas the Weddell Sea began to form in the Jurassic period (perhaps before 150 Ma ago), during the early stages of Gondwana break-up, the Scotia Sea is a much younger structure (less than 40 Ma old) within it. The tectonic forces involved created new seas, including areas of oceanic depth, and scattered the broken remnants of an old land link between South America and the Antarctic Peninsula to form the Scotia Arc.

It might be expected that such dramatic changes would have had a marked effect on the evolution and dispersal of the benthic marine faunas of the region and one of the ANDEEP aims is to look for evidence of how geological change may be reflected in the faunal distributions we observe today. My role is to provide the geological overview and I would welcome interactions with fellow participants from any biological discipline who think their observations may have some explanation in the geological past.

In order to test possible geological influences on the biological distributions we see today, it is important to compare these with the palaeontological record of the region as far as is possible. However, such studies are limited to those groups which have hard shells capable of fossilization. Much attention has already been focussed on the bivalves and gastropods, and on the decapod crustaceans, all of which have reasonable fossil records in southern South America and the Antarctic Peninsula but there are other groups worthy of investigation, and I would like to review the brachiopods.

RECENT DEEP-WATER SEDIMENTATION: TRACE METAL AND RADIOISOTOPE GEOCHEMISTRY ACROSS THE SOUTHERN OCEAN AND NORTHERN WEDDELL SEA, ANTARCTICA

J.A. Howe (SAMS, U.K.)

Objectives

Sedimentation across the Southern Ocean is controlled both by basement topography, producing regions of erosion and deposition in response to bottom-currents, and hemipelagic settling and down-slope activity. Studies in the Scotia Sea have revealed the influence of the Antarctic Circumpolar Current (ACC) which dominates the deposition and redistribution of sediments in the region. Deposition occurs as mounded contourite drifts or as zones of hemipelagic drape, locally occurring in the lees of the rough basement topography. Biological productivity is controlled by the position of the Polar Front and spring sea-ice edges.

Sedimentation rates vary across this region from 17 – 3 cm per 1000 years and current speeds increase from 7cm/s in the south to 17 cm/s in the north with an associated increase in benthic storm frequency towards to the axis of ACC flow. The north-western Powell Basin, in northern Weddell Sea, displays an area of mudwave development. The active wave-field is located near the base of the continental slope in water depths of 2800-3100 m, and may reveal a pathway of Antarctic Bottom Water (AABW) flow from the Weddell Sea to the Scotia Sea. The original construction of the waves may have been via downslope turbidity currents predominantly supplied from the basin floor channels. Present day deposition appears to be maintained by fine-grained sediment supply as a result of the lateral transfer of distal turbidites from the basin floor channels by bottom currents. The initiation of current-influenced sedimentation appears closely linked to the onset of AABW flow during the Early Miocene, following the separation of the South Orkney Microcontinent and the opening of Powell Basin during the Late Oligocene, 20-25 million years ago.

During ANDEEP II two transects were sampled using short cores (multi & box), seabed photography, video sequences, and sediment profile images across the northwestern Weddell Sea and South Sandwich Forearc, Antarctica. A total of 12 core stations were examined for sediment structure, texture and composition to determine their depositional history. Four of the core stations from the Weddell Continental Slope, Abyssal Plain and South Sandwich Forearc and Trench were further examined for trace metal analysis (Ba, U, Mn and Pb) for sediment source and palaeoproductivity, and ^{210}Pb for age profiles and depth of mixing by bioturbation.

Building upon these previous studies, it is proposed to examine the recent sediment history of the deepwater areas of the Southern Ocean from Cape Town, South Africa to the northern Weddell Sea, Antarctica. Valuable information can be gathered on the processes active across the sites where biological fauna is collected as part of the ANDEEP aims. Little is known of the recent sedimentary processes active in these regions, most importantly, specific questions:

- What are the gross depositional regimes operating in the extreme deep-water areas?
- Are bottom-currents (either Antarctic Circumpolar Current or Southern Origin Bottom Water) influencing sedimentation, downslope turbidity currents or low energy pelagic/hemipelagic settling?

This work aims to support the main faunal studies of ANDEEP by providing general information on sea-floor environment therefore assisting in ecological studies.

Utilising collected short-cores (both from the multi-corer and by sub-coring the box-core) to examine any sedimentary and bioturbation structures (in collaboration with B. Diaz), and microfaunal composition providing information on productivity and hence sea surface conditions and sea-ice distribution.

As a post-cruise study we submit samples for particle size analysis (PSA for bottom-current influences). Radiocarbon (C^{14} AMS of surface sediments for carbon reservoir effect), trace metal geochemistry using Inductively Coupled Mass-Spectrometer – (collaborative project with T.M. Shimmield see below) ^{210}Pb and other radioisotopes

measured on gamma counters at SAMS will be used to determine accumulation rates and any recent (latest Holocene) palaeoclimate record will be considered.

All the post-cruise laser-derived grain size data on all sampled sites will be available to all ANDEEP colleagues via the ANDEEP website

Work at Sea

Box core and multicore samples will be utilised onboard. Box cores will be subsampled by sub-coring using a polycarbonate 89mm (id) liner - obtaining an intact core sample for examination for structures, texture and bioturbation. The box core sample will also be visually described. The multicore samples will be sliced at 1 cm intervals and smear slides prepared from which visual microscopic descriptions will be obtained including texture, sorting and biogenic components.

METALS AND MICROBIAL COMMUNITIES WITHIN DEEP ANTARCTIC SEDIMENTS

B. Danis (Royal Belgian Institute of Natural Sciences, Brussels, Belgium)

Objectives

Once in the marine environment, many contaminants, including heavy metals, accumulate in sediments. It is generally agreed that bacteria, as the most abundant sediment organisms, have a major role in the fate of these contaminants. Bacteria may volatilize, precipitate and transform metals into toxic organic derivatives. They can also produce anionic polymers which can in turn complex metals. According to the type of physico-chemical environment and of microbial metabolism, metals may be released from sediments into the water column. In such cases, marine sediments become a secondary source of pollution leading to the possible contamination of benthic organisms living in their contact, and *in fine* to all the benthic food web.

Despite their importance for environmental and human health risks, the interactions between microorganisms and metals are poorly known in marine sediments. For example, of the three studies which were published about the effects of copper on the genetic diversity of marine microbial communities, only one included sediment communities. The effects of the other metals on the microbial diversity of sediments are virtually unknown. And, of the few reports that have been published about the effect of metals on bacterial diversity in marine sediments, most of them lack important ecological information such as that offered by 16S rRNA sequencing or *in situ* hybridization.

The aim of the present project is to understand the complex interactions between heavy metals and the microorganisms living in deep Antarctic sediments. The microbial communities living at the surface of the sediments will be studied using molecular biology tools (denaturing gradient gel electrophoresis –DGGE-, sequencing, and fluorescent *in situ* hybridization –FISH-). Bioavailability of the metals (Cd, Pb, Cu, Zn) will be evaluated using HCl extraction and biosensors. The mineralogical composition of the sediments and the organic matter content will also be determined. All these microbiological data will be collected in each station considered. Multivariate statistics will then be used to determine the importance of

metals in the composition and structure of the sediment-associated microbial communities.

Work at Sea

Sediments will be collected from box cores and multicores if available and stored as necessary for different analyses.

DIVERSITY AND BIOGEOGRAPHY OF DEEP-SEA BENTHIC FORAMINIFERA – A COMBINED MOLECULAR AND MORPHOLOGICAL APPROACH

A. J. Gooday, N. Cornelius, T. Cedhagen, J. Pawlowski (SOC, Southampton, U.K.)

Objectives

Many common deep sea benthic foraminiferal species are cosmopolitan, and some have bipolar distributions. These geographical ranges are based, however, on comparative morphology and have yet to be examined at the molecular level. We propose to investigate patterns of foraminiferal biodiversity using a combination of morphological and molecular methods and to test the general hypothesis that foraminiferal species living in the deep sea have cosmopolitan distributions. We ask specifically:

- Are populations of the same deep-water foraminiferal morphospecies from the Southern Ocean and Northern Hemisphere genetically divergent and
- is genetic differentiation among foraminiferal morphospecies more strongly developed along bathymetric gradients than across horizontal ranges?

This project will provide a benthic counterpart to recent investigations of cryptic speciation and biogeography in polar and subpolar planktic foraminifera.

Most existing diversity data on benthic foraminiferans originate from geological studies of hard-shelled (fossilisable) taxa. 'Primitive' monothalamous (single-chambered) species are abundant in cold-water settings but are poorly known. They have rather featureless tests, making it difficult to consistently recognise morphospecies and to quantify deep-sea diversity precisely. Our previous work showed that cold-water, polar and deep-sea sites yield many monothalamous species, making these key habitats for investigating the radiation of foraminifera.

Nevertheless, much remains to be learnt. In particular, there are no molecular data for two key groups:

1) the Komokiacea, a dominant deep-sea macrofaunal taxon, and
2) polythalamous, organic-walled allogromiids (*Nodellum, Resigella* and related genera) which occur widely in the deep sea.

The latter group may provide clues about the origin of multichambered tests, a crucial step in foraminiferal evolution. We will address these gaps in our knowledge by analysing DNA sequences from these and other important groups and formally describing species based on morphological and molecular criteria. Our work will complement sampling efforts in the Arctic (Svalbard and Fram Strait), Gulf of Mexico,

NE Atlantic (Porcupine Abyssal Plain), SE Atlantic (Angola Basin), Indian Ocean (Crozet Plateau) and Arabian Sea as well as studies of foraminiferal molecular diversity in McMurdo Sound, Antarctica (collaboration with Dr. S. Bowser, Albany) and Svalbard (collaboration with Drs. M. Hald, Tromso, and S. Korsun, Moscow).

Work at Sea

We plan to collect samples from depths of 1000 m to 4000 m in different areas from those visited during ANDEEP II, using a multicorer (core area 25.5 cm^2) or megacorer (area ~70 cm^2). These hydraulically-damped devices retain light, flocculent surface material and yield significantly higher meio- and macrofaunal abundances than box corers. Box cores will provide a source of larger foraminifera which are not adequately sampled by smaller corers. Sediments for molecular studies will be sieved immediately after collection and living foraminifera hand picked under a binocular microscope onboard the ship, care being taken to keep samples chilled at all times. Individual large specimens will be picked opportunistically from core surfaces and from Agassiz trawl catches. We know from previous experience of sorting at sea that large numbers of live foraminifera can be obtained in this way for molecular research. Selected specimens will be photographed and their DNA extracted using guanidine. Others will be deep-frozen in liquid nitrogen or dried for later DNA analysis. Additional cores will sliced into layers and fixed in buffered 10% formalin for faunal studies.

TAXONOMY, ZOOGEOGRAPHY, ECOLOGICAL AND PHYLOGENETIC ASPECTS OF THE DEEP-SEA SPONGE FAUNA (PORIFERA) IN THE EASTERN WEDDELL SEA

D. Janussen (Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt, Germany)

Objectives

The Porifera of the Antarctic deep sea are largely unknown. During the ANDEEP III expedition, the successful work from ANDEEP II on the taxonomy and zoogeography of the Porifera from the deep Weddell Sea is to be continued and expanded. All new taxa, which are expected particularly of deep-sea Calcarea –a novum for the Antarctica–, must be carefully documented and made available to science as soon as possible. Molecular research is planned for some Antarctic species of the family Rossellidae (Hexactinellida), to help clarifying the problematic systematic situation within this group, and within the class Hexactinellida.

For the first time, natural compounds of Antarctic deep-sea sponges shall be investigated and compared with the existing results from shallow-water sponges and mammals of the Weddell Sea. This will provide important data about the food chain and on dynamic processes between the deep-sea and shelf fauna in the Southern Ocean. Furthermore, the data will contribute to the database for a future chemotaxonomy of the Porifera. We also want to screen the sponges for toxic anthropogenic components (PCBs, pesticides) and investigate, to which degree such pollutants accumulate in the Antarctic deep sea.

Work at Sea

Collection of sponges from all sampling gears and adequate fixation of samples for molecular biology, natural products screening, histology and electronic microscopy. First preparations and preliminary determination of the sponge taxa.

METAZOAN MEIOFAUNA COMMUNITIES IN THE ANTARCTIC AND SUBANTARCTIC DEEP SEA: STANDING STOCKS AND A-DIVERSITY PATTERNS

P. Martínez Arbizu and A. Rose (FIS, Wilhelmshaven, Germany)

Objectives

Efforts on the investigation of deep-sea fauna made some progress during the last two decades, but despite the fact that approximately thirty deep-sea expeditions took place during that period, our knowledge of the meiobenthic diversity and the factors determining its diversity patterns is still very patchy. Meiofauna seems to play an important role in marine benthic food webs due to its intermediate size between macrofauna and microbiota.

It is intended to investigate the diversity of meiofaunal assemblages along gradients and stations in the Antarctic and Subantarctic deep sea, taking into account food availability and other factors. Here it is of interest which factors correlate strongest with meiofaunal major taxa abundance and harpacticoid species diversity. It is also desired to evaluate small-scale vs large-scale diversity differences in the Antarctic and Subantarctic by taking replicates at certain stations. This will complement former ANDEEP programmes as well as investigations conducted during former EASIZ programmes.

The main objective, however, is to complement a latitudinal transect along West African deep-sea basins (Angola Basin, Guinea Basin) taken by the DIVA 1 & 2 expeditions of RV Meteor (2000, 2005), to the Southern Ocean. All ANDEEP and DIVA campaigns are part of CeDAMar (Census of the Diversity of Abyssal Marine Life) which again is part of the CoML (Census of Marine Life). For achieving this main goal, one or two stations in the Cape Basin and/or south of it will be sampled repeatedly (at least 5 replicates) with a multicorer. Since other stations of this transect are sampled in the same way, it will for the first time be possible to get information on deep-sea meiofaunal diversity at 3 different spatial scales (inter-core, inter-replicate, inter-station) along an equatorial to polar latitudinal transect. This will be a major contribution to the assessment of overall deep-sea diversity.

Work at Sea

On the transect from Cape Town to Neumayer Station, about 3 stations will be sampled quantitatively with a multicorer (MUC). At least one of these stations (preferably two: Cape Basin and/or south of it) has to be sampled repeatedly (5 or more replicates necessary). For comparative purposes, it is indispensable to sample with the 100-mm MUC. At Kapp Norvegia and all central Weddell Sea stations, meiofauna will be sampled quantitatively with the 62-mm MUC. Additional stations on

the Greenwich transect and near the Antarctic Peninsula will be sampled as time permits with the same gear.

Received MUC cores will be cut at 5 cm depth (more layers optional) and the upper layer(s) fixed with 5 % formalin on board. Additional qualitative meiofauna samples may be taken by sieving the rinse water of macrofauna samples from other gear. These will be fixed with 70-80 % ethanol and partly investigated at major taxa level on board.

All organisms sampled quantitatively with the MUC will be sorted and quantified to major taxa level at the FIS (Wilhelmshaven, Germany). The sorted material will be made available to other research groups for systematic, biogeographic and other analyses.

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

P. J. López-González (Universidad de Sevilla, Sevilla, Spain)

Objectives

Anthozoans are one of the major components in benthic sessile communities in terms of both abundance and diversity, offering a good substratum (e.g. refuge, feeding) to many other benthic mobile animal groups such as crustaceans, polychaetes, and echinoderms. Furthermore, the Antarctic fauna of anthozoans is still poorly known, present knowledge being estimated to encompass no more than 50 % of all species. Most of the genera and species included in the last cruise reports were described in the 90's, and several undescribed genera and species are being described continuously. The knowledge about the total number of Antarctic (ANT) and Subantarctic (SANT) species is still very imprecise, many speciose genera should be revised preferably using newly collected material (relaxed and fixed using the appropriate procedures) in combination with the type specimens deposited in museums.

Taking as example the octocorals, 60% of all genera are endemic of ANT+SANT. Three main explanations have been suggested to account for the origin of recent Antarctic benthic communities: derivation from indigenous faunal components, immigration from the deep sea, or recent dispersal from neighbouring areas via shallow waters. According to the preliminary global results of the octocoral fauna from EASIZ, ANDEEP, LAMPOS and BENDEX cruises, the alcyonaceans include apparently elements derived from all three sources, while pennatulacean are mainly immigrants from the deep sea of surrounding oceans (*Umbellula*, *Kophobelemnon*) and secondary from shallow waters (*Pennatula*).

Some of the endemic genera found in the Scotia Arc are related to Indo-Pacific genera. However, what is happening in the deep-sea Atlantic sector of the Southern Ocean? Is that IndoPacific-related Antarctic fauna also present in the deep Weddell Sea, or is there an unknown distinct "Atlantic-related" component? Only the study of the deep-sea Atlantic sector of Antarctica and the comparative analysis with shelf and deep-sea Antarctic faunas could give some light to these questions.
Our scientific objectives on board will be:

- To detect the presence of boundaries in the distribution of anthozoans at different taxa levels (family, genus, species) in the deep Weddell Sea.
- To evaluate the potential origin of the Antarctic anthozoan fauna according to the known distribution of genera/species in this and other biogeographical areas.
- To detect undescribed species that could contribute to the understanding of the relationship between Antarctica and other deep-sea bottoms and the continental shelf in the past and present.
- To sustain the study of reproductive patterns in Antarctic anthozoans (already initiated since EASIZ-I), with special attention to Alcyonacea and Pennatulacea.
- To evaluate the taxonomic utility of histological and cytological characters in scleractinians, especially in the genera *Flabellum*, *Gardineria*, *Javania*, and *Caryophyllia*.
- To continue the bank of tissues usable for molecular studies (already initiated since EASIZ III).
- To continue the detection of secondary metabolites in Anthozoan (in collaboration with Spanish/other chemical researcher teams) with a biological activity responsible of the evolutionary success of the group (already initiated since EASIZ-II).

Work at Sea

Anthozoans will be collected mostly from samples taken with the Agassiz trawl. Individuals will be relaxed with methanol in a cold room and fixed in formaldehyde (morphological work) or 96% ethanol (molecular analysis). Photographs will be taken under a stereomicroscope.

BIODIVERSITY AND DISTRIBUTION OF POLYCHAETES OF THE DEEP SOUTHERN OCEAN

B. Hilbig (Spezielle Zoologie, Ruhr-University, Bochum, Germany)

Objectives

As a continuation of investigations made during ANDEEP I and II, polychaetes from quantitative bottom samples will be collected, enumerated, and identified to species level. This information will be used to further characterize the polychaetes communities of the deep Weddell Sea in terms of species richness, abundance, diversity, and faunistic affiliations with adjacent deep-sea basins such as the Cape Basin, which will also be sampled during this expedition and nearly simultaneously by the second DIVA expedition (Cape, Angola, and Guinea Basins).

As first results point to several species being widely distributed, it is expected that the percentage of endemites will be further reduced as more species are going to be found in this very poorly sampled area. This result is of particular interest as other taxa, such as crustaceans, seem to be highly endemic in the deep sea. Polychaetes, therefore, may reproduce to a much higher degree than commonly thought through larvae which are able to cross the Antarctic convergence. Adults may in addition be

able to cross sills between abyssal plains due to their eurybathy, which turned out not to be a specialty of Southern Ocean polychaetes.

Keys for identification of deep-sea polychaetes from the Southern Ocean are under construction, and new species from ANDEEP III will be added as the identification progresses. As part of the requirements of CeDAMar as many new species as possible will be described and made accessible to the scientific community.

Work at Sea

The main source of material will be the Sandia box corer because of the quantitative aspect of the study, but other material from the epibenthic sledge and multicorer will be used for distributional patterns as the opportunity arises. The box corer samples will be processed in the same way as during ANDEEP I and II to ensure comparability. Ten of the 25 subcores will be sieved over 0.3-mm screens (upper 10 cm only, deeper sediments will be spot-checked) and fixed in 4% formalin in seawater. After 48 h or later the samples will be resieved, rinsed in freshwater and transferred into 70% ethanol for preservation. All further processing will take place on land.

ORIGIN AND EVOLUTION OF ANTARCTIC AND DEEP-SEA MACROINFAUNA: BENTHIC COMMUNITY STRUCTURE AND SYSTEMATICS AND REPRODUCTIVE PATTERNS OF POLYCHAETES

S. A. Doner and J. A. Blake (ENSR Marine & Coastal Center, Woods Hole MA, U.S.A.)

Objectives

This research is a continuation of work begun in 2002 on the ANDEEP I and II surveys. ANDEEP III will include collection of samples across the deep Weddell Sea Basin, off Kapp Norvegia, the Scotia Arc, and possibly off the South Orkney Islands and South Georgia Island.

Main objectives are:

- To develop data that will help understand the origins of the deep-sea benthic infauna in relation to the Antarctic shelf and linkages to the deep-sea faunas of the Atlantic and Pacific oceans;
- To test hypotheses proposed to explain high biodiversity in the deep sea;
- To develop data to describe deep-sea benthic community structure in the Southern Ocean; and
- T collect samples to understand biological processes including reproduction and larval development of benthic invertebrates.

Work at Sea

We will collect sediment from box cores and multicores. These cores will be cut to depth of at least 5-cm and carefully elutriated on board ship. Samples will be kept on ice and live-sorted to major taxonomic groups including polychaete families as soon as possible after collection. Selected polychaetes and other invertebrates will be set

aside for further study and photography. The bulk of the specimens will be preserved and labelled.

The specimens set aside for further study will be set up in culture in a refrigerator in the laboratory on board ship. We will primarily focus on the following families of polychaetes: Orbiniidae, Oweniidae, Paraonidae, Spionidae, Cirratulidae, Scalibregmatidae, and Opheliidae. However, other polychaete families will be studied if interesting specimens are collected that exhibit evidence of reproduction or are obviously juvenile or post-larval stages. These specimens will be examined under a compound microscope equipped with a Cooling Stage that will allow sustained observations and time for notes to be written as well as photomicrographs and sketches. After these observations, the specimens will be preserved and labelled. Results of similar work on ANDEEP I and II exceeded expectations.

As time permits, specimens from each sample will identified and enumerated to the lowest practical taxonomic level. A benthic database will be developed to investigate benthic community structure, distribution of infaunal taxa by depth, and species richness and diversity patterns. Interpretation of these results will require collaboration with scientists developing data on sedimentary processes and specialists with various taxa.

BIOGEOGRAPHY AND PHYLOGENY OF DEEP-WATER MOLLUSCS WITH SPECIAL REFERENCE TO BIVALVES

K. Linse (BAS, Cambridge, U.K.)

Objectives

Distribution, diversity and phylogenetic information on marine molluscs, especially bivalves and gastropods, can give key input into investigations of the influences of Antarctica's geological past on the evolution and origin of the marine Antarctic fauna. Molluscan datasets can be used as tracer for possible colonisation routes, evolution and speciation of the Antarctic marine fauna.

Until recently biogeographic studies on Antarctic molluscs referred to shelf faunas only. The ANDEEP I and II collections comprised 12 morphospecies of aplacophorans, 40 morphospecies of bivalve, 55 morphospecies of gastropods and 4 morphospecies of scaphopods. The ratio of 1.37 gastropod to bivalve species is interesting given that three times more gastropod species are known from the Southern Ocean than bivalve species. Epibenthic sledge (EBS) sampling from Antarctic deep-sea areas should elucidate whether this ratio is consistent for the Antarctic deep sea. At least 25% of these species are new to science and the bathymetric records for all species were extended (an important signal with relevance to considerations of historical ice shelf movement and forced changes in shelf fauna distribution).

Preliminary biogeographic results from the malacofauna collected during ANDEEP I and II indicated that the Scotia Arc deep-sea fauna shares lower taxa (species/ genera) with the Antarctic shelf as well as with the deep South Atlantic. Analysis of the community structure within the ANDEEP I and II samples showed differences between the bivalves and the gastropods; while many bivalve species occurred at

every site, most gastropod species were found at one or two stations only. Collections made during ANDEEP III should enhance our knowledge on the Antarctic deep-sea molluscan fauna and will verify if the biogeographic trends found during ANDEEP I and II are consistent.

The selected taxa from malacofauna collected during the 2002 ANDEEP expeditions were used for molecular phylogenetic studies. First analysis of the DNA of Antarctic bivalve molluscs (Limidae, Limopsidae, Philobryidae) has shown that several species from different groups may in fact be complexes of previously unrecognised species. One of these, *Limopsis marionensis* is found from several hundred to more than 3000 m depth. However, it appears that this species really comprises three cryptic species.

Interestingly, these species are separated in distribution by depth but not by geography. There are two species in deep water and one in shallow. Within the genus *Limatula* similar patterns were found, the deep-water specimens resembled their shallow-water relatives in morphology but differed significantly in the gene sequences (16S, 28S, ITS). Similar results have been found elsewhere in the world with different animals, such as amphipods, asteroids, decapods, and fish. Many environmental factors including pressure, temperature, food availability, light, and ocean currents change with depth. During ANDEEP III further material for phylogenetic analyses will be collected to test the theory that selection along the environmental gradient represented by increasing depth may promote speciation. This may help to explain why the continental slope is one of the most species rich zones of the deep sea.

Work at Sea

Living material of molluscs, especially bivalves, will be collected and prepared for further analysis (SEM, TEM, PCR). DNA will be extracted on board for selected species. Additionally the shelf bivalve fauna and Scotia Arc deep-water bivalve fauna will be compared with the deep-sea fauna from ANT XXII-3.

BIODIVERSITY, PHYLOGENY, ZOOGEOGRAPHY AND EVOLUTION OF ANTARCTIC MOLLUSCA AND ECHINODERMATA

M. Schrödl, J. Bohn, E. Schwabe (Zoologische Staatssammlung München, Germany)

Objectives

The ANDEEPI/II expeditions for the first time give an ideal opportunity to study the missing faunistic link between the temperate South American, the South Atlantic deep sea and the Antarctic shelf and deep water fauna. In all these areas, molluscs and echinoderms are amongst the most common and diverse benthic marine taxa. Extensive collecting during previous expeditions to the Magellan region, south Atlantic deep sea and Antarctica provided vast material for our current inventory works, i.e. species descriptions and critical taxonomic revisions on a variety of different groups.

Material collected during ANDEEP III will significantly supplement our knowledge by adding undescribed and highly interesting deep sea taxa, new geographical and

bathymetrical distributions, and new ecological information. Sampling in "virgin" regions and depths will contribute to a better zoogeographical understanding of Antarctic molluscs and echinoderms. In addition, recent distributional patterns shall be explained by historic distributional and evolutionary mechanisms. The phylogeny of selected model groups (i.e. monoplacophorans, opisthobranch gastropods, apodid holothurians) will be investigated using traditional (morphological, histological) and modern (ultrastructural, immunocytochemical, molecular) methods and cladistic analyses. By the resulting cladograms hypotheses on general evolutionary scenarios (e.g. submergence or emergence of deep sea fauna elements, Antarctic Bottom Water as a biodiversity pump) will be supported or rejected. Particularly, it shall be tested whether Antarctica and surrounding deep sea waters gave rise to the enormous nudipleuran gastropod radiation about 40 million years ago or are just a refuge of old/basal nudipleuran taxa.

Work at Sea

To test such hypotheses, we plan to collect Antarctic deep sea molluscs and echinoderms with a variety of different gears. In particular, we are interested in poorly known micromolluscs such as Monoplacophora, basal Opisthobranchia, and meiobenthic holothurians, from various habitats and in sufficient quantities for multiple uses (live observations, special fixations, etc.). The taxonomy, morphology, ultrastructure, and ontogeny of selected groups are a focus of our interest both *per se* and as essential parts of the phylogenetic mosaic towards a better understanding of diversity and evolution.

BIODIVERSITY OF ANTARCTIC ECHINOIDS AND THEIR SYMBIONTS

B. David, C. de Ridder, V. Heterier, (University of Gent, Bruxelles, Belgium), S. Lockhart, J. Pearse (University of Santa Cruz, Santa Cruz CA, U.S.A.) and R. Mooi (California Academy of Sciences, San Francisco CA, U.S.A.)

Objectives

This project investigates, at different structural and functional levels, the biodiversity of the Antarctic echinoids; it also investigates the symbionts harboured by echinoid hosts. The echinoids constitute an abundant and widely distributed component of the megabenthos of Antarctic communities. Relying on the exploration of new or poorly known Antarctic regions (as those prospected during former ANDEEP cruises), this study will examine the nature and distribution of echinoid biodiversity (faunal components and distribution according to depth, basin or latitude), and the associated symbionts of cidaroids.

A. Biodiversity and evolution of echinoids

A conspicuous and important component of the benthic community is the cidaroid echinoids (colloquially known as pencil-spine sea urchins). The cidaroid assemblage of the Southern Ocean belongs to the subfamily Ctenocidarinae and comprises approximately 21 extant species within 5 genera. In spite of the suitability of this taxon for studying major biological factors in the Southern Ocean, problems with the systematics of the group require investigation. In the process, much data relating to the evolution of benthic Antarctic faunas can be uncovered. Morphological

techniques, along with advanced molecular analyses of several genes will be used to elucidate the systematics of this group. This will provide, for the first time, well supported data to construct a comprehensive phylogenetic tree. By studying phylogenetic trees one can map the events that signify environmental change, such as alterations in biogeographic and bathymetric distributions, and in reproductive behaviours.

Although the full ranges of these species are poorly known, many have a circumpolar distribution: a remarkable feat for species without dispersive larvae. Generally, the production of pelagic larvae is the dominant mode of development for benthic organisms of the Antarctic. However, there exist a number of speciose clades that protect their brood. The ctenocidarines are one such clade. Brood-protection has been reported in 13 ctenocidarine species to date and suspected in the remaining. How so many brood protecting taxa, such as these urchins, have come to be so diverse in the Antarctic compared to the other areas of the world's oceans is unknown.

It has been proposed that the unique oceanographic conditions of the Southern Ocean, afforded by the opening of Drake Passage initiating the Antarctic Circumpolar Current (ACC), have contributed to the radiation of these clades. Indeed, a larger number of brood-protecting benthic invertebrate species are found in the region of the Scotia Arc than in surrounding areas. The proposed cruise track of ANDEEP III will cover poorly sampled areas of the Atlantic sector of the Subantarctic sea. Sampling these islands 'downstream' of Drake Passage, and discovering how many, and which, species occur there, will be key to understanding the radiation hypothesis outlined above.

New data collected during the ANDEEP cruises, and taxonomic revisions that result from these collections, will be combined to produce a new edition of the cd-rom database "Antarctic Echinoids" already fully accessible to the scientific community. Digital colour images of live specimens taken during the ANDEEP cruises will be included in this database, allowing easier, and more accurate, identification by the non-specialist.

B. Biodiversity of symbionts in cidaroids

A crucial problem for marine sessile organisms is the availability of hard substrates on which to settle and attach. This problem is particularly intense when hard substrates are lacking or make up a relatively small portion of the sea floor, a situation well illustrated in the deep sea. As a consequence, competition for living space typically occurs among taxa requiring hard bottom for settlement. Therefore, any hard substrate (lacking an antifouling substance or mechanism) would rapidly be colonized, whatever its abiotic or biotic origin. Correlatively, one may expect abundance and diversity of sessile benthos to be increased on soft bottom by the presence of hard supports, even if those are scattered.

In that context, cidaroid sea urchins are of particular interest: (1) they occur on soft and hard bottoms, (2) their large pencil-like primary spines are usually densely coated by sessile symbionts and are also colonized by vagile organisms which find adequate microhabitats there. This latter feature is related to the absence of an epithelium along the shaft that is instead covered by a polycrystalline layer called the

cortex, a unique situation among echinoids. The settlement of ectosymbionts on cidaroid spines could, in theory, lead to an increase of biodiversity in the local environment, particularly the deep sea and Antarctic environments where cidaroids are a prominent taxon on soft substrates from shallow to deep waters.

The main aim of this part of the project is to assess the importance of ectosymbiosis regarding cidaroids on deep-sea Antarctic biodiversity. This will be done in close collaboration between the two teams and will take advantage of the phylogenetic approach being developed on the same urchin clade.

Preliminary observations have demonstrated that some symbionts are facultative (opportunistic) partners while others are obligate. Among the latter, specificity for particular hosts is often displayed. In that context, both the spines morphology and location on the echinoid body are determinant features. We have started the description of the symbioses on the basis of preserved samples collected during previous expeditions.

Work at Sea

The sea urchins are expected to occur mostly in the Agassiz trawl samples. We will take advantage of this expedition to observe living ectosymbionts kept in aquaria. We will more particularly examine the behavior of vagile ectosymbionts in order to determine specific attraction for a particular host (Y tubes experiments). In addition, "classical" samplings and preservations of echinoids and of their load of ectosymbionts will be realized in order to update the biodiversity data (taxonomic and biogeographic) on Antarctic echinoids (so far 81 species of echinoids have been recorded and revisited.)

ANTARCTIC DEEP-SEA BIODIVERSITY: THE OSTRACODA

S. N. Brandao (Biozentrum Grindel und Zoologisches Museum, Universität Hamburg, Germany)

Objectives

The ostracod fauna of the Southern Ocean "shallow waters" (shallower than 1000 meters depth) has been, in a taxonomic view, quite well studied. Contrary to previous assumptions, biodiversity was shown to be quite high in the Antarctic and Subantarctic regions: more than 300 species have been reported, about half of them being endemic to one or both regions. This high biodiversity is thought to have evolved when the Antarctic continent was under warmer climate conditions.

On the other hand, the Antarctic deep-sea ostracod fauna remains until now poorly known because of the relatively few samples collected at greater depths. My investigations during ANDEEP III will thus contribute to the knowledge of the ostracod biodiversity of the Southern Ocean deep sea. Because of the existence of a virtually isothermal water column around the Antarctic continent, which is thought to facilitate the interchange of specimens inhabiting shallower and deeper waters, it is possible that the species occurring in Antarctic shallow waters also occur in the deep environments. The material provided by this cruise will contribute to elucidate this topic.

Furthermore, it will be possible to fix live specimens for electron microscopy of soft parts, which remain quite unknown for various ostracod deep-sea taxa, hence in most of the publications only the valves were analysed. With the knowledge of the soft part morphology it will be possible to contribute to the elucidation of the phylogenetic relationships, and consequently to the classification of ostracod taxa (for example, the Hemicytheridae + Trachyleberididae problem). Also the relationships within the Cypridocopina, which contains the superfamilies Macrocypridoidea (believed to be an ancestral group), Pontocypridoidea and Cypridoidea are still controversial.

DNA of representatives of the different Cypridocopine taxa will be extracted for a phylogenetic analysis. Additionally, I will investigate whether morphological species of the Family Macrocyprididae with large bathymetric ranges - *Macroscapha inaequalis* (G. W. Müller, 1908); *M. inaequata* Maddocks, 1990; *M. opaca* Maddocks, 1990; *M. tensa* (G. W. Müller, 1908) and *M. turbida* (G. W. Müller, 1908), exhibit genetic differentiation between depths.

Work at Sea

Ostracoda will be collected by box corer. Three cores per station will be sub-sampled with a corer of 5 cm in diameter and sieved through four different mesh-sizes – 0.500 mm, 0.355 mm, 0.125 mm, 0.045 mm - and kept under refrigeration. The specimens will then be sorted alive and fixed for electron microscopy. Furthermore, the DNA of representatives of the different Cypridocopine taxa - Superfamilies Macrocypridoidea, Pontocypridoidea and Cypridoidea - will be extracted for phylogenetic and population analyses.

BIODIVERSITY, PHYLOGENY AND THROPHODYNAMICS OF AMPHIPOD CRUSTACEANS IN THE ANTARCTIC DEEP SEA

C. De Broyer (Royal Belgian Institute of Natural Sciences, Brussels, Belgium)

Objectives

The ANDEEP I & II cruises in 2002 have revealed an overwhelming biodiversity in different faunal components of the Southern Ocean deep sea ecosystem. The ANDEEP III expedition is planned to test hypotheses resulting from these data, corroborate results of the previous cruises and seek for the potential origin of some of the taxa which seem to have radiated in the Southern Ocean deep sea like others on the shelf.

The peracarid crustaceans, and in particular the Amphipoda, are known to be by far the most speciose animal group in the Antarctic coastal and shelf communities. For the Antarctic deep sea, the ANDEEP I and II results showed that Amphipoda contribute up to 32% of the large material collected by the epibenthic sledge (EBS), just after Isopoda (38%) which are the usual dominant group in the deep sea.

The present project will aim at completing the ANDEEP I & II results by pursuing the investigations on:

Patterns and processes of amphipod biodiversity

- To discover and characterize the amphipod fauna of the Southern Ocean deep sea and comparing it to the Antarctic shelf fauna and to the fauna of the Atlantic abyssal basins.
- To document species composition and as far as possible ecological traits (habitats, mode of life,...) of the Antarctic deep sea amphipod taxocoenoses on latitudinal and bathymetrical scales, in comparison with the Antarctic shelf fauna and the Atlantic deep sea fauna.
- To contribute by taxonomical material, photographic records, distribution and ecological data to the revision of the Antarctic fauna and the preparation of new identification tools by the "Antarctic Amphipodologist Network" (see www.naturalsciences.be/amphi), and to the future SCAR Marine Biodiversity Information Network (see www.bianzo.be).

Molecular phylogeny and phylogeography

The main objective of this study will be to investigate the phylogeny and phylogeography of selected amphipod taxa (mostly the Lysianassoidea) through parallel molecular and morphological approaches in an attempt to understand the colonisation history of deep-sea taxa.

Trophodiversity and trophodynamics of amphipods and selected macrobenthos

This part of the project aims at characterizing the trophodiversity and the trophodynamic role of the Antarctic deep sea amphipods in comparison with the shelf communities (as far as material to be collected will allow). The trophic approach will rely on digestive tract analyses and ethological observations in aquaria. This will be completed by the use of stable isotope (carbon and nitrogen) ratios and fatty acids as amphipod diet tracers to delineate the trophic relationships involving amphipods in Antarctic deep sea food webs. The trophic adaptive radiation will be investigated in selected taxa by a morphofunctional approach coupled with a molecular identification of trophic homologies and analogies and molecular polarization of the ecomorphological adaptations.

Work at Sea

Amphipods from epibenthic sledge and Agassiz trawl samples will be kept alive in aquaria or fixed for morphological and molecular work.

HEAVY METAL BIOKINETICS IN ANTARCTIC AMPHIPODS

C. De Broyer and B. Danis (Royal Belgian Institute of Natural Sciences, Brussels, Belgium)

Objectives

Pollution of the ocean by heavy metals such as Co, Zn, Ag or Cd is a major environmental problem in many parts of the world. Heavy metals reach the environment *via* natural sources (which account for a background exposure), increased by anthropogenic inputs. To differentiate between natural and

anthropogenic metal inputs which is one of the main objectives in biomonitoring, natural background concentrations of chemicals in organisms and their fluctuations have to be well established. In this respect, investigations in remote areas such as the Southern Ocean are extremely interesting because in these areas anthropogenic metal inputs are considered to be of minor importance. Among candidate bioindicator organisms in these areas, amphipods are particularly suitable, being widespread and key components of Antarctic marine ecosystems.

Investigations on the time course of uptake and loss of metals in organisms are a first step in assessing the potential of test organisms for biomonitoring. Toxicokinetic studies usually focus on the uptake of waterborne heavy metals because this is regarded as the major source for uptake in various organisms. Nevertheless, other sources also have to be considered, such as dietary or sediments uptake.

The objective of this study is to evaluate the suitability of a series of Antarctic amphipod species (depending on collected material) as biomonitors for 4 heavy metals (Co, Zn, Ag, Cd) and 2 anthropogenic radionuclides (^{134}Cs and ^{241}Am) of environmental concern, and to analyse whether toxicokinetic models can be used as a tool to assess the metal uptake. Sampled organisms will be maintained aboard POLARSTERN in controlled conditions, and sent by air transport to the Marine Environment Laboratory (MEL) facilities at the International Atomic Energy Agency (IAEA, Monaco). Prior to experimentation, specimens will be acclimated to laboratory conditions for 1 month (constantly aerated open circuit aquaria, constant salinity, 0±0.5°C, 12/12h dark/light cycle). Antarctic organisms (mainly amphipods) have already been successfully maintained in these facilities for extensive periods (more than one year). Biokinetics will be studied using multi-element exposures with carrier-free or high specific activity radiotracers in order to measure fluxes at realistic contaminant concentrations.

Work at Sea

Amphipods will be collected with the epibenthic sledge and Agassiz trawl and kept alive in aquaria.

INVESTIGATIONS ON THE SYSTEMATICS, ZOOGEOGRAPHY, AND EVOLUTION OF ANTARCTIC DEEP-SEA ISOPODA (CRUSTACEA, MALACOSTRACA)

A. Brandt, W. Brökeland, M. Choudhury and G. Wegener (Zoological Museum, University of Hamburg, Hamburg, Germany)

Objectives

As supposed, in Pliocene and Pleistocene the Antarctic ice shelf never completely eradicated the Antarctic benthic shelf fauna. In the recent geological past Gondwana broke up and the subsequent isolation of Antarctica accompanied by climatic changes with intermittent periods of global warming and global sea-level changes might have determined faunal zoogeographic ranges, migration processes in and out of the Antarctic, and limits. Extensions of the ice sheet may have enhanced speciation processes (as demonstrated for the Serolidae and Arcturidae) on the Antarctic continental shelf, suitably named the Antarctic "diversity pump".

The most appropriate tool for studies of evolutionary biology or zoogeographic origin of taxa is phylogenetic analysis. The fossil record greatly facilitates the recognition of ancient or derived character states, but unfortunately fossils are only available for some taxa. Rich fossil material is available from molluscs and decapod crustaceans, but none of the fossil species are still extistant in the Antarctic nowadays. Other frequent Southern Ocean taxa, which are characterized by a high degree of endemism and which radiated in the Southern Ocean, like isopod crustaceans are not well known in the fossil records.

The Antarctic shelf is well isolated and the zoogeographic distribution of the 371 isopod species, which show a degree of endemism of 88%, is well documented. During the expeditions ANDEEP I&II with POLARSTERN from January to April 2002, 317 species of deep-sea Isopoda were sampled and discriminated from epibenthic sledge material of these expeditions. Of these, 277 were new to the area or even to science, 50 were known from adjacent deep-sea areas and 27 of these from the Southern Ocean (SO), yielding a percentage of 84.7% of deep-sea endemism. During ANDEEP III, questions like the potential origin of Antarctic benthic taxa and colonisation of the deep sea from the Antarctic (submergence versus emergence of species) will still remain major objectives especially off the Kapp Norvegia shelf in the deep eastern Weddell Sea. However, the incredible isopod biodiversity reported opens new questions for ANDEEP III like: is the degree of endemism of the SO deep-sea Isopoda really so high, or is this an artefact due to the little knowledge of the isopod faunas of the adjacent deep-sea basins? Which are the dominant isopod taxa in the SO deep-sea, will we find a similar composition of asellote families like during ANDEEP I&II? Are the deep-sea Isopoda widely distributed or patchy? At which depths can we find a shift from the shelf to the deep-sea isopod fauna? Is there a northern limit of the SO deep-sea isopod fauna towards the Cape Basin? Have some of the isopod deep-sea families radiated in the SO? Where do the closest relatives of selected taxa, like Mesosignidae, Acanthaspididae or other families live? How can we describe the phylogenetic relationship of some selected and important and speciose families?

Some specific aims of ANDEEP III are:

- To expand and deepen insights in the potential origin of Antarctic benthic Isopoda, collected during ANDEEP I and II.
- To continue the analysis of evolutionary biology and current community patterns on Southern Ocean deep-sea Isopoda.
- To test whether the present distribution of Isopoda is the result of progressive retractions of the species from a former more cosmopolitic distribution, which was established during Jurassic or Cretaceous periods, when Gondwana was still clustered, or are these Gondwanian relicts?
- To analyse whether some taxa of the Isopoda have radiated in the Antarctic because of the extinction of potential competitors (brachyurans), i.e. has the emergence of new, adaptive zones and occurrence of mass extinctions in the Antarctic in the Tertiary opened up previously occupied adaptive zones, and thus provided opportunities for spectacular adaptive radiations?
- To analyse whether the Antarctic deep sea serves as a reservoir of high species diversity within all isopod taxa.
- To investigate whether the Antarctic deep-sea fauna differs from that of the deep sea of the other oceans.

- To analyse whether there is still faunal exchange with the isopod fauna found in the area of the Antarctic Peninsula and the Magellan area or are there distinct topographical barriers to migration in and out of Antarctica via the deep sea?
- To analyse whether there is a link between the Antarctic shelf and the deep-sea fauna of the Southern Ocean in present and past.

Work at Sea

Samples will primarily be taken with an epibenthic sledge, however, also isopods from box corer and multicorer samples will be used. The samples will be immediately fixed in 89% precooled ethanol in order to allow also future molecular studies. Large and well preserved animals will be photographed alive to document the colour patterns.

DISPERSAL AND INTRASPECIFIC DIFFERENTIATION OF DEEP-SEA ASELLOTA (CRUSTACEA: ISOPODA) IN THE WEDDELL SEA

M. Raupach (Lehrstuhl für Spezielle Zoologie, Ruhr-Universität Bochum, Germany) and J.-W. Wägele (Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany)

Objectives

Among isopods, the Asellota are the most important component of the deep-sea fauna. They are globally one of the most species rich macrobenthic taxa of abyssal plains, and their study has led to several hypotheses about the origin of deep-sea taxa and about mechanisms that trigger evolution of high species diversity. Asellotes are usually small animals (less than 10 mm length), of reduced mobility (even though some can swim they very rarely appear in the water column), and they have no larvae. This probably reduces gene flow and increases the probability for speciation events. However, some morphospecies seem to have a wide distribution (e.g. *Acanthocope galathea* is found in the Caribbean region and in the Angola Basin) and it is not clear if cryptic species exist, detectable only with molecular methods.

There are three main sources that possibly contributed to the diversity of the Antarctic abyssal fauna: (a) migration from neighbouring deep-sea regions, (b) polar submergence (= colonization by Antarctic shelf elements), and (c) radiation *in situ*. For the isopods that are studied by us, the presence of cosmopolitan genera (as *Desmosoma, Acanthomunna, Eurycope, Disconectes, Ilyarachna, Haploniscus, Leptanthura* etc.) shows that the fauna is composed at least partly by elements that exist also in other regions of the world ocean, however, it is not known if a wide distribution exists also at species level or if many species are endemic to Antarctica. There are also genera that are known only from the Southern Ocean many of which resulted from local evolution and polar submergence (e.g., *Rectarcturus, Furcarcturus, Echinomunna, Lionectes, Euneognathia*).

With the already available ssu rDNA sequences we gained in previous projects we will complete the study of the radiation of deep-sea taxa of the Asellota (Crustacea, Isopoda). Some families are still not represented in our data set. Our main interest is, however, the analysis of the genetic differentiation of abyssal populations across the

northern Weddell Sea. Using sequence information, taking advantage of the high resolution of AFLP fingerprints, 16S rDNA, and – in cooperation with taxonomists – using morphological characters we want to test if geology (ridges, basins) and differences in water masses and depth are barriers to gene flow, if distant localities harbour different populations or cryptic species, if mere geographical distance correlates with genetic distance, if local radiations occur within deep-sea basins, and if and how the local fauna differs from neighbouring ocean regions. The latter question requires comparison with material from other expeditions (e.g., DIVA 2).

Work at Sea

The material will be collected with the epibenthic sledge. It is important that collected specimens are fixed in cold alcohol (96%) as soon as possible to prevent the digestion of DNA, therefore quick sorting is absolutely necessary. Specimens will be used for taxonomic as well as molecular analyses. Sorting of samples and extraction of DNA will be done on board of POLARSTERN, the sequencing work and data analyses will follow in the laboratories of the Ruhr-Universität Bochum.

BIODIVERSITY PATTERNS OF DEEP-WATER MACROFAUNA IN THE ANTARCTIC

B. E. Narayanaswamy (SAMS, U.K.)

Objectives

Large-scale biodiversity pattern and the present-day and historical processes causing it are now thought to be important determinants of high local-scale species richness seen in samples from the deep sea. Although depth related patterns have been detected these vary from site to site. Latitudinal gradients in deep-sea benthos are more controversial, and in the North Atlantic may reflect Quaternary history affecting the Arctic end member as much as modern ecology (e.g. productivity) as thought to apply to benthic foraminifera. In the deep oceans of the southern hemisphere, the pattern of macrobenthos in the northern hemisphere appears absent; from preliminary data these basins appearing to support as high diversity as that at low latitudes in the northern hemisphere. The long history and continuity with the wider deep sea encourages a view that the Antarctic deep-sea functions as a biodiversity pump for the deep ocean. But severe lack of information on its taxonomic composition and affinity to other, better known deep-sea areas, as a result of an almost complete lack of rigorous sampling effort has made such ideas difficult to test. New emphasis on the Antarctic as an end member of clinal gradients in shallow taxa now suggests a new importance in the origin of deep-sea faunal diversity.

Results gathered from the previous ANDEEP cruises have illustrated how limited our knowledge is of deep-water Antarctic macrofauna. Species richness and rarefaction analysis suggest that the fauna was under-sampled and that many of the polychaetes in particular were new to science.

The main objectives of the work to be undertaken during ANDEEP III are:

- To characterise and speciate the benthic macrofauna.

- To compare the macrofaunal community diversity and endemism with other deep-sea regions.
- To compare the shelf, slope communities with abyssal communities in the ANDEEP areas.
- To develop a faunal database similar to that created for ANDEEP II.

Work at Sea

Samples will be taken with a Sandia box corer (surface 50*50 cm, divided into 25 subcores) as well as the multicorer, the samples will be elutriated and fauna collected on a 250 μm sieve. The fauna will be kept cool so that studies can be undertaken on the live material and photographs will be taken. The fauna will then be fixed in 4% buffered formalin in seawater and preserved in 70% ethanol. All fauna will be counted and identified to the lowest possible taxonomic level. Fauna will be compared with those collected from ANDEEP II to ensure standardisation.

This general programme of work aims to use cores collected in conjunction with J.A. Blake (ENSR). The follow-up work will be undertaken at both SAMS, Dunstaffnage Marine Laboratory, and with J.A. Blake at ENSR, Woods Hole. Collaboration will also be undertaken with B Hilbig (Uni Bochum).

SPATIAL PATTERNS OF ANTARCTIC DEEP-SEA SOFT-SEDIMENT BIODIVERSITY

K. E. Ellingsen (University of Oslo, Norway)

Background

In terrestrial systems a marked decline in the species richness of many animals and plants from the tropics to the poles is the general rule. It has long been assumed that a similar trend is also found in the sea, but there is no convincing evidence for a latitudinal cline across all taxa in the sea. In the Southern Hemisphere the evidence for a gradient of increasing richness from Antarctica to the tropics is less convincing than in the Northern Hemisphere.

The idea that coastal diversity is low compared with that of the deep-sea has been firmly accepted. However, high species richness in soft sediments in coastal areas has been shown, questioning whether there is a decline of species diversity from shallow-water to the deep-sea.

Objectives

The ANT-XIX/3 (ANDEEP I) and ANT-XIX/4 (ANDEEP II) POLARSTERN cruises provided a unique possibility to sample benthic data in order to address a variety of questions concerning Antarctic deep-sea soft-sediment biodiversity. The ANDEEP III cruise will provide additional interesting information.

This large-scale study of the biodiversity in the Antarctic will provide fundamentally new data on patterns of diversity in the sea. The main aspects are how biodiversity

varies with scale and depth and how diversity varies with the taxa or size-group of fauna considered.

Using the data from ANDEEP I, II and III we aim to examine patterns of biodiversity of a variety of taxa from the small meiofauna, macrofauna and large-sized epibenthos. This part of the project will be done as teamwork.

The ANDEEP cruses will provide important new data on species distributions and how faunal pattern varies with spatial scale, depth and sediment variables as well as latitude and longitude.

In order to provide new insights into biodiversity issues, spatial scales need to be considered in more detail. Knowledge of faunal patterns and variability at different spatial scales within a given latitudinal area are essential prior to making comparisons of species richness and β-diversity over latitude at larger spatial scales. Furthermore, it is likely that the community structure will vary greatly within any latitudinal area, and a comparison of only a few sites may be insufficient to detect latitudinal gradients in marine systems. It is therefore important to get good quantitative data from Antarctica and especially on spatial scales of diversity.

Having obtained the data from the Antarctic and analysed how diversity varies with scale and depth we will compare these data with other latitudinal areas including coastal waters. This research cannot be done alone as it relies on help from many taxonomists. Thus any papers resulting from the POLARSTERN cruises will be joint ones.

Work at Sea

During ANDEEP I and II box core, multicore, and epibenthic sledge samples were collected at each site, and we will use the same equipment during the ANDEEP III cruise. I will participate in the sampling, in particular with the box corer. At each site a sample will also be analysed for environmental variables (sediment properties such as grain size). Specimens will be preserved, sorted and sent to taxonomic experts for species determinations. I will be involved in data analyses when the specimens have been counted and identified.

AUTOMATIC DETECTION OF MARINE MAMMALS IN THE VICINITY OF A VESSEL

O. Boebel., L Kindermann, H. Klinck (AWI, Bremerhaven, Germany)

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.

Scientific 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 employed in parallel to ensure detection regardless of their location. Under water, 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 and tested. 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.

Sonobuoys with a built in hydrophone and radio transmitter will allow monitoring the underwater acoustics at distances not accessible directly from the ship. Autonomous acoustic data loggers will be deployed at moorings in 1000 m depth. They will register the high frequency echolocation clicks of some species of beaked whales continuously for a year. Two infrared cameras with image processing software will monitor the regions next to the ship for infrared signatures even at night and poor visibility.

GEOLOGY

N. Kurentsova, G. Udintsev (GEOKHI, Moscow, Russian Federation)

During the transit from Cape Town to the Antarctic Neumayer Station on Queen Maud Land, a continuous multibeam survey will be performed in order to enlarge the bathymetric data base for ocean mapping.

Special geomorphological objects which attract attention in this area are lineations of rift valleys and transform faults of the Indian-Antarctic midoceanic ridge, and hilly morphology of the ocean floor on both sides of the ridge. On the approach to the Antarctic continental margin the structure of the continental slope will be surveyed for the recognition of the existence of terraces or marginal plateaus, similar to the known Explora escarpment.

After the visit to Neumayer Station the ship will cross the accumulative apron of the continental slope. Attention has to be paid on deep sea channels and their meandering and in the central basin of the Weddell Sea on the cross section over the structures, known as fish bones skeleton, which is considered as a relict of initial rifting of the early phase of the Gondwana break up and the displacement between the African and Antarctic plates. The additional bathymetric data on the morphology of the lineated ridges will help their interpretation.

BATHYMETRIE

N. Kurentsova, G. Udintsev (GEOKHI, Moscow, Russian Federation)

Bathymetric data play an important role in climate, environmental and solid earth research, especially for:

- geo-referencing and interpretation of bio-geo-marine observations
- studying marine glacial and sedimentation processes
- studying of physiography and tectonics
- supplying DEMs for ocean circulation modelling.

In wide areas around Antarctica, bathymetric data is of low quality and very heterogeneous due to the inherent problems with navigation and sonar measurements in the sea ice.

Under the auspices and umbrella of the intergovernmental and international organisations IOC, IHO and SCAR a new International Bathymetric Chart of the Southern Ocean (IBCSO) will be developed. All involved intergovernmental organisations have expressed their interest to support this initiative. A major effort will be put on the collection of bathymetric measurements in regions of spares data like the Weddell Sea, using multibeam technology.

During the expedition it is planned:

- To conduct multibeam surveys during the entire cruise in order to enlarge the data base for ocean mapping.
- To place track lines of POLARSTERN transits into regions without bathymetric information.

- To investigate the new Hydrosweep operation modes HDBE (high density beam estimator) and ASLC (automatic source level control) by comparing results to existing multibeam data from previous surveys.

The entire programme is directly connected to the preparation of the IBCSO, and can be seen as a contribution to the proposed IPY project POBACE.

The region of the bathymetric programme is closely oriented to the oceanographic and marine biological programmes. No special plane survey with full multibeam coverage is planned during the cruise.

The AWI bathymetry project had to be cancelled because of the restrictions by the Umweltbundesamt.

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ENSR	ENSR Marine & Coastal Center 89 Water street Woods Hole, MA 02543 USA
FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schifferstraße 10-14 27568 Bremerhaven Germany
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GFI	Geophysical Institute University of Bergen Allegaten 55 5007 Bergen Norway
HeliTransair	HeliTransair GmbH Am Flugplatz 63329 Egelsbach Germany
HNA	Servicio de Hidrografia Naval ARGENTINA
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften Düsternbrooker Weg 20 24105 Kiel Germany
IMB	Institute of Marine Biology FEB of RAS Palcheoskogo St. 17 Vladivostok – 41 690041 Russia
IRSN	Royal Belgian Institute of Natural Sciences Rue Vautier, 29 1000 Bruxelles Belgium
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Optimare	Optimare Sensorsysteme AG Am Luneort 15a 27572 Bremerhaven Germany
RUB	Lehrstuhl für spezielle Zoologie Ruhr-Universität Bochum Geb. ND 05/780 Universitätsstr. 150 44780 Bochum Germany
SAMS	Scottish Association for Marine Science Dunstaffnage Marine Lab. Dunbeg, Oban Argyll, PA37 IQA UK
SANAP	Department of Environmental Affairs and Tourism Directorate: Antarctica and Islands 44 Hertzog Boulevard Southern Life Building 4th floor Foreshore, 8001 South Africa
SES	School of Earth Sciences University of Leeds Leeds, LS2 9JT UK
SOC	Southampton Oceanography Centre European Way Southampton, SO14 3ZH UK
SOMS	School of Marine Science Virginia Institute of Marine Science College of William & Mary Gloucester Point, Virginia 23062-1346 USA
UG	Marine Biology University of Gent Krijgslaan 281/S8 9000 Gent Belgium

ULB	Université Libre de Bruxelles Laboratoire de Biologie Marine CP 160/15 50 av. F. D. Roosevelt 1050 Bruxelles Belgium
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ZIM	Zoologisches Museum Hamburg Universität Hamburg Martin-Luther-King-Platz 3 20146 Hamburg Germany
ZSM	Zoologische Staatssammlung München Münchhausenstr. 21 81247 München Germany

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Brökeland, Wiebke	ZIM
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Cedhagen, Thomas	DME
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SCHIFFSPERSONAL / SHIP'S CREW ANT XXII/3

Reederei F.Laeisz G.m.b.H.
Name of Ship : POLARSTERN
Nationality : GERMAN

Cruise ANT XXII / 3
21.01.2005 - 06.04.2005
Kapstadt - Punta Arenas

No	NAME	RANK	NATION
01.	Schwarze, Stefan	Master	German
02.	Grundmann, Uwe	1.Offc.	German
03.	Farysch, Bernd	Ch. Eng.	German
04.	Thomas, Rainer	1.Offc./L.	German
05.	Wunderlich, Thomas	3.Offc.	German
06.	Bratz, Herbert	3.Offc.	German
07.	Kapieske, Uwe	Doctor	German
08.	Hecht, Andreas	R.Offc.	German
09.	Erreth, Gyula	2.Eng.	German
10.	Ziemann, Olaf	2.Eng.	German
11.	Minzlaff, Hans-Ulrich	2.Eng.	German
12.	Scholz, Manfred	Elec.Tech.	German
13.	Nasis, Ilias	Electron.	German
14.	Muhle, Helmut	Electron.	German
15.	Verhoeven, Roger	Electron.	German
16.	Kahrs, Thomas	Electron	German
17.	Loidl, Reiner	Boatsw.	German
18.	Reise, Lutz	Carpenter	German
19.	Vehlow, Ringo	A.B.	German
20.	Hartwig-Labahn, Andreas	A.B.	German
21.	Winkler, Michael	A.B.	German
22.	Guse, Hartmut	A.B.	German
23.	Hagemann, Manfred	A.B.	German
24.	Schmidt, Uwe	A.B.	German
25.	Bäcker, Andreas	A.B.	German
26.	Niehusen, Arne	Trainee	German
27.	Scholl, Christoph	Trainee	German
28.	Preußner, Jörg	Storek.	German
29.	Ipsen, Michael	Mot-man	German
30.	Voy, Bernd	Mot-man	German
31.	Elsner, Klaus	Mot-man	German
32.	Hartmann,Ernst-Uwe	Mot-man	German
33.	Grafe, Jens	Mot-man	German
34.	Silinski, Frank	Cook	German
35.	Völske, Thomas	Cooksmate	German
36.	Möller, Wolfgang	Cooksmate	German
37.	Jürgens, Monika	1.Stwdess	German
38.	Wöckener, Martina	Stwdss/KS	German
39.	Czyborra, Bärbel	2.Stwdess	German
40.	Silinski, Carmen	2.Stwdess	German
41.	Gaude, Hans-Jürgen	2.Steward	German
42.	NN	2.Steward	China
43.	Huang, Wu-Mei	2.Steward	China
44.	NN	Laundrym.	China

FS POLARSTERN

ANT XXII/4

08.04.2005 – 21.05.2005
Punta Arenas – Bahia Blanca

Fahrtleiter:

Dr. H.-W. Schenke

EXPEDITION ANT XXII/4

ZUSAMMENFASSUNG UND FAHRTVERLAUF

H.-W. Schenke (AWI, Bremerhaven, Germany)

POLARSTERN wird am 8. April 2005 von Punta Arenas auslaufen. Für die gesamte Expedition sind 42 Seetage vorgesehen. Die Fahrt wird über die Drake-Passage direkt zur Moe-Insel auf dem Süd-Orkney-Plateau führen, auf der die englische Sommerstation Signy liegt (Abb. 1). Hier soll eine GPS-Beobachtungsstation für die Dauer der Expedition eingerichtet werden. Zwei Beobachter werden während dieser Zeit in der Nähe von Signy Base in einer Field Party untergebracht, um den Betrieb der Anlagen und die Datenaufzeichnung zu überwachen. Die GPS-Messungen, die auf dem während der GAP-Kampagne 1995 eingerichteten geodätischen Referenzpunkt SIG1 durchgeführt werden, sollen für eine genaue Lage- und Höhenbestimmung der POLARSTERN herangezogen werden. Zusätzlich zur GPS-Station wird ein Magnetometer installiert, um die täglichen Variationen im Erdmagnetfeld zu erfassen. Im Rahmen des marin-geologischen Programms werden in diesem Zeitrahmen auf dem Orkney-Plateau südlich der Süd-Orkney-Inseln zwei Sedimentkerne gezogen. Die Transits zwischen dem Vermessungsgebiet und der Station Signy werden für profilhafte Aufnahmen des Gebietes am Pirie Rise, dem Süd-Scotia-Rücken und dem Süd-Orkney-Plateau im Rahmen des Programms der russischen Vernadsky Institutes genutzt.

Anschließend erfolgt die Versegelung in das Hauptarbeitsgebiet der Expedition, das sich in den Grenzen 58°S, 47°W und 55°S, 40°W befindet und eine Fläche von ca. 40.000 km² überdeckt. Das gesamte Gebiet soll flächendeckend mit Parallel-Profilen vermessen werden. Wegen der hier zum Teil unbekannten Tiefenverhältnisse kann eine exakte Planung einschließlich der Profilabstände erst vor Ort erfolgen.

Das Gebiet wird mit dem Fächersonar HYDROSWEEP DS-2, parametrischem Sedimentecholot PARASOUNDS DS-2, Seegravimeter KSS-31 und dem Schiffsmagnetometer vermessen. Alle Vermessungssysteme werden ganztägig eingesetzt, so dass ein ständiger Operateurbetrieb einzurichten ist. Eine vorläufige Auswertung der bathymetrischen Vermessung wird an Bord durchgeführt, um ggfs. neue Erkenntnisse in die weitere Fahrt- und Beprobungsplanung berücksichtigen zu können. Das Vermessungsprogramm im Kerngebiet wird ca. 27 bis 29 Tage dauern.

Zur Erfassung der Schallgeschwindigkeit in der Wassersäule, die im Scotiameer stark variiert, sollen in regelmäßigen Abständen Messungen mit XBTs durchgeführt werden, um die Variationen der Wasserschallgeschwindigkeit in den oberen 1000 m zu erfassen und bei den Fächersonardaten berücksichtigen zu können. Diese XBT-Messungen in der hohen räumlichen Auflösung werden anschließend dem Deutschen Ozeanographischen Datenzentrum (DOD) übergeben.

Im geplanten Vermessungsgebiet sind, abhängig von den topographischen Gegebenheiten und der Sedimentbedeckung, zwei bis drei geologische Stationen (Sedimentkerne, Dredgen) vorgesehen. Die genaue Planung hierzu erfolgt im Verlauf und auf der Basis der aktuellen Vermessung.

Zur räumlichen Erweiterung der Magnetfeldvermessung im Untersuchungsgebiet und zur Unterstützung der Schiffsmagnetometrie werden, wetterabhängig, Helikopter-Flüge mit dem Helimag-System durchgeführt.

Nach Beendigung der Vermessungsarbeiten im Kerngebiet erfolgt der Abbau der Referenzstationen auf Signy. Auf dem anschließenden Versegelungsprofil über ca. 1400 Seemeilen von Signy durch das Scotiameer über das Falkland-Plateau nach Bahia Blanca werden kontinuierlich die Geräte Fächersonar, Sedimentecholot, Seegravimeter und Magnetometer betrieben. Die Expedition endet am 21. Mai 2005 in Bahia Blanca.

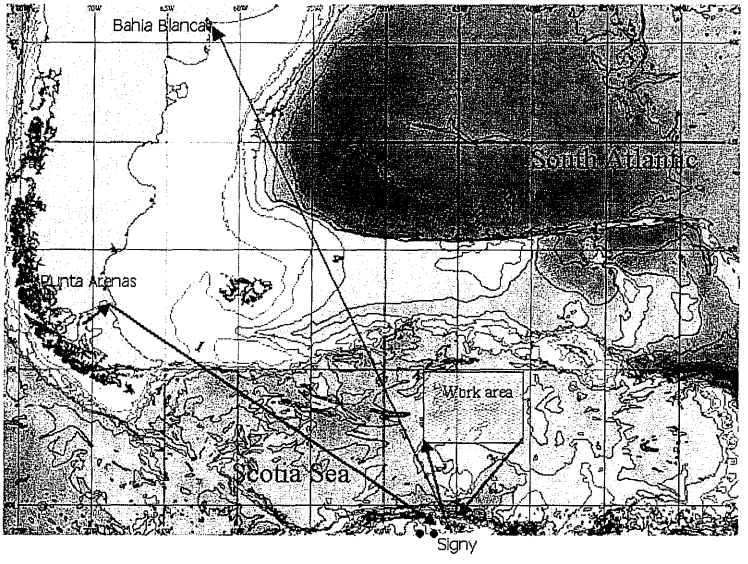

Abb. 1: Arbeitsgebiet der POLARSTERN-Expedition ANT XXII/4.

Fig. 1: Operation area during POLARSTERN leg ANT XXII/4.

EXPEDITION ANT XXII/4

ITINERARY AND SUMMARY

H.-W. Schenke (AWI, Bremerhaven, Germany)

POLARSTERN will leave Punta Arenas on 8 April 2005. The entire expedition will last at sea 42 days. After leaving the Magellan Channel, POLARSTERN will directly head towards Moe Island, on which the British Antarctic research station Signy is established. This station is only operated during the austral summer, and is thus not staffed. The cruise plan including the location of the main working area is shown in Fig. 1. A geodetic GPS-observation station will be installed near the research base of Signy. A two-channel GPS-receiver will be installed on the geodetic reference marker SIG1, which was established and surveyed during the Geodetic Antarctic Project (GAP) in 1995 and 1998. This site is part of the high precision Antarctic Geodetic Network and thus high precision coordinates are available. Two observers will stay in a field party near Signy Base in order to look after the correct technical operation of the receiver and check the high rate data recording. Parallel to the GPS-measurements a magnetometer will be operated at this site in order to monitor and record the daily variations and fluctuations of the Earth magnetic field. In the frame of the marine geological programme two sediment cores will be taken in the region of the South Orkney Plateau south of the South Orkney Islands during this time.

The programme of the Russian Vernadsky Institute includes a profiling survey during the transits between the main study area in the central Scotia Sea and Signy, crossing the submarine features Pirie Rise and South Scotia Ridge, during which multibeam, sub-bottom, gravity and magnetic data will be recorded.

After the establishment of this GPS/Magnetic observation field party, POLARSTERN will sail to the main operation area, which is bordered by 58°S, 47°W and 55°S, 40°W, covering an area of nearly 40.000 km². The entire region will be surveyed with the full multibeam coverage by placing parallel track lines. Due to the mostly unknown depths in that region, a detailed pre-plot of track lines cannot be prepared, the spacing of lines must be adopted to the actual water depths.

The entire region shall be surveyed using the multibeam system HYDROSWEEP DS-2, the sub-bottom profiler PARASOUND DS-2, the ship-borne gravity meter KSS-31 and the ship-borne magnetometer. All systems will be operated whole day under the watch-keeping of well-trained operators. A processing of the multibeam data is performed on board. Preliminary bathymetric charts will be compiled during the survey for further and additional cruise planning and for possible geological sampling. The total survey programme will last between 27 and 29 days.

A dedicated XBT-programme will be carried out in the main working area. Expendable Bathythermographs will be launched spatially well distributed, along the track lines in order to measure in-situ the water sound velocity along the upper 1000 m of the water column. This data are needed for the refraction correction of the slant sonar beam of HYDROSWEEP DS-2 and for the determination of the true water depth. These observations will be supplied afterwards to the German Oceanographic Data Centre (DOD).

In the study area two or three geological coring or dredging stations will be established. However, these activities depend on the topographic structure of the sea floor and from the sediment coverage.

In order to densify and expand the spatial coverage of the ship-borne magnetic survey in the study area airborne magnetic survey will be performed in appropriate weather conditions by helicopter along the ship-tracks, using the Helimag-System.

After the termination of the survey work in the study area, POLARSTERN will steam towards Signy to pick-up the two observers and demobilize the GPS and Magnetometer station. All equipment and belongings including waste and other material will be disposed to POLARSTERN. During the final transit over approx. 1400 nm from the South Orkney Island, Scotia Sea and Falkland Plateau to Bahia Blanca POLARSTERN will continuously operate the multibeam, the sub-bottom profiler, and the marine gravity- and magnetometer systems. POLARSTERN will arrive in Bahia Blanca on 21 May 2005, where the expedition will be terminated.

LARGE SCALE BATHYMETRY OF THE CENTRAL SCOTIA SEA

A. Labrenz, F. Niederjasper, H.-W. Schenke, F. Viêtor, NN, NN (AWI, Bremerhaven, Germany)

Objectives

High resolution digital elevation models (DEMs) of the seafloor enable the spatial allocation of physical, chemical and biological processes in the transition zone of geosphere and hydrosphere. The information about the sea floor topography and its physical properties is crucial for morphogenetic analyses trying to clarify geological formation and for the interpretation of geophysical surveys. To date the bathymetry of the Southern Ocean, and here, the Scotia Sea is poorly investigated.

The area of the central Scotia Sea is up to now only sparsely surveyed by a few hydrographic survey vessels, whalers and other ships. The available single beam data suffer from low quality and from bad navigation in high latitudes and bad weather conditions. Thus the accuracy of the existing bathymetric data sets (GEBCO Sheet 5.16 at a scale 1:10 million), is not sufficient for detailed geoscientific investigations and interpretations of the existing bathymetric structures in the central Scotia Sea.

Work at Sea

During POLARSTERN leg ANT XXII/4 a systematic, full coverage multibeam survey will be performed in the main study area. High precision navigation and positioning will be realized using D-GPS techniques (reference station SIG1) and the proper calibrated ship's attitude system MINS on POLARSTERN. The track planning will be performed during the survey in order to adapt the line spacing to the actual water depth. The refraction correction of the slant sonar beams requires the application of the precise water sound velocity. Due to the substantial water layer mixing especially in this region, a dedicated XBT-programme will be executed along the multibeam survey. Post-processing of the multibeam data is performed on a daily basis using the CARIS-HIPS programme system. The processed data supply the base for

preparing each day a new extended bathymetric chart, which will be utilized for further cruise planning.

Among the depth measurements sidescan images will be acquired (2048 values per beam). Both data sets will be pre-analysed and interpreted during the cruise. The sidescan allows the allocation of small scale structures not resolved by the multibeam. Moreover backscatter intensity information will be logged for every footprint (59 per cross section). The backscatter data can be used for qualitative analysis of the physical properties of the sediments ensonified.

The bathymetric survey lines preferably should be placed orthogonal to the striking of the magnetic anomaly lineations in order to optimize the geophysical and geological interpretation and the planning for petrologic sampling or future seismic surveys for the preparation of an IODP pre-site survey.

The on-line navigation data will be checked and analyzed during the cruise.

MARINE GEOPHYSICAL STUDIES

M. Koenig, V. Leinweber, J. Linder, K. Schmidt, P. Wille (AWI, Bremerhaven, Germany)

Objectives

In general, publications in international journals suggest that the opening of the Drake Passage is answered by the existing geophysical data set. First results from investigations in the late 70's date the opening of this important gateway to 35 Ma. This model is based on a relative dense marine-magnetic data set in the western Scotia Sea. At present no geophysical data set exists, which severely questions this model. However, looking in details of the opening history of the Drake Passage gateway several problems cannot be answered with the available data set:

- When was an effective deep water connection between South America and Antarctica established?
- Which role did the different crustal blocks in the Scotia Sea play in the opening scenario?
- Did they prevent deep water circulation during some time periods?

Critical for this problem are especially basement highs and basins in the western, but more important in the central Scotia Sea. A further question arises regarding the age of the central Scotia Sea. At present no conclusive data set exists, which can provide sound constraints on this problem. Existing models predict ages for this area ranging between Miocene to the Mesozoic. Although magnetic data exist, no clear image is available. Either the subsurface geology is too complex or the data base is too poor to provide good constraints.

Work at Sea

Answers to the above mentioned problems can only be provided through repeated expeditions into this area with a systematic approach to gather new geophysical data. During this first expedition systematic bathymetric and especially magnetic and

gravity data as well as bottom samples from basement highs will be gathered in the central Scotia Sea. The Parasound data acquired parallel to the geophysical survey will provide information on the presence of local basement highs. The prime objective is to gather additional high resolution magnetic data. Helicopterborne magnetic survey (Helimag) will supplement the ship-based measurements, whenever the weather will allow.

MARINE GEOLOGICAL SURVEY AND SAMPLING

A. Borchers, P. Gregorowicz, G. Kuhn, P. Simundic, NN (AWI, Bremerhaven, Germany)

Objectives

The Scotia Sea represents a key area of the Southern Ocean for understanding climate-regulating factors. It allows monitoring of past variability of the eolian import of dust and iron originating in Patagonia and its impact on Southern Ocean productivity regimes and related removal and burial of organic compounds (e.g. organic carbon, biogenic opal) and monitoring past changes in sea ice seasonality and extent, which exerts major control on the formation of water masses, biological productivity and ocean/atmosphere gas and heat exchange.

Besides, the reconstruction of past Scotia Sea hydrography and sea ice distribution will provide second-order information on the environmental development in the Weddell Sea, an area that broadly lacks sedimentary signals for the reconstruction of past environmental conditions. Previous studies have demonstrated that Holocene and Pleistocene sediments have been deposited in the Scotia Sea at high sedimentation rates allowing reconstructions of past climate and Southern Ocean conditions at up to centennial resolution. Such sedimentary sequences are ideal oceanic climate archives to be compared with continental ice core records (e.g. EPICA ice cores).

Work at Sea

The geological sampling programme based on Parasound subbottom echosounder data is focused on the establishment of Holocene and late Pleistocene high-resolution records a) to document the input of dust and iron and related biological response, b) to reconstruct past changes in Scotia Sea physical environment, including surface water temperature, melt water events and stratification, sea ice extent and its seasonality. The records will be compared with climate time-series obtained from continental ice cores. The sediment cores will also be used to generate a tephrostratigraphy that will allow stratigraphic correlation of sediment cores and continental ice cores.

During ANT-XXII/4 25-30 m long piston cores should be recovered at 7 – 8 core locations (Fig. 2). Some core locations have been selected based on previous coring during ANT-X/5 and ANT-XI/2. These shorter cores (PS2304-1, PS2309-1, PS2316-4) are all indicative of areas with high sediment accumulation.

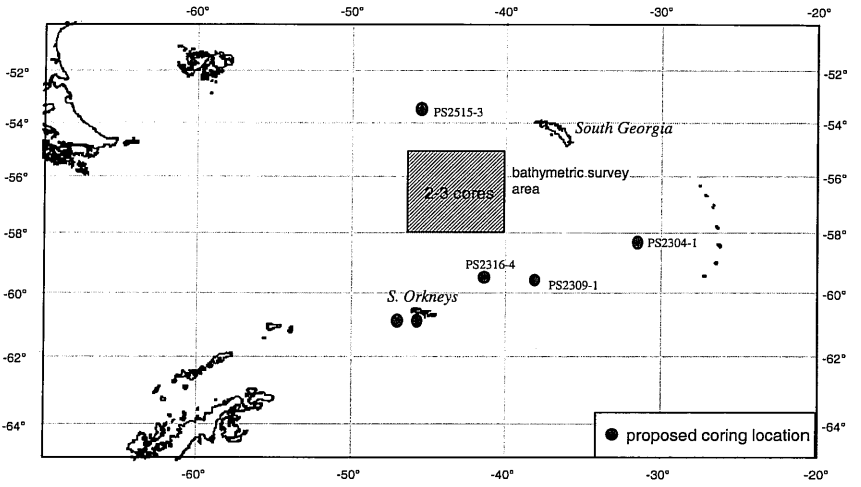

Fig. 2: Location of proposed sediment coring sites. PS-numbers indicate available shorter sediment cores at selected coring location.

The coring programme will be accompanied by extensive high-resolution echo-sounding survey with the Parasound system, to generate spatial information on sediment deposition and accumulation pattern in the Scotia Sea. The survey will be the baseline for final determination of locations for the recovery of surface sediment samples using the multicorer and sediment cores with a 25 to 30 m long piston corer device.

Surface sediments will be recovered in the area of extensive bathymetric survey, to generate a sedimentological data set for calibration of acoustic data (e.g. backscatter survey). Such calibration is prerequisite for the establishment of acoustic methods for the mapping of surface sediment properties. Additionally surface sediments will be recovered at all sediment core locations to ensure a complete sedimentary sequence including the topmost sediments deposited at the sea floor. The surface sediments will also enhance the data base for generation maps of sedimentary compound flux (e.g. biogenic opal, organic carbon) and the distribution of microfossils that are broadly lacking for the central Scotia Sea.

Additionally, surface water samples will be collected from the ships pumping system to gather information on the species distribution of siliceous microplankton in the Scotia Sea. Such information on species autecological demands will augment the significance of siliceous microfossil-based proxies for paleoenvironmental reconstructions.

BATHYMETRY OF THE SOUTH SCOTIA RIDGE

G. Udintsev, V. Udintsev (GEOKHI, Moscow, Russian Federation)

Objectives

A detailed geological and geophysical survey of the region of the Pirie Rise was carried out during the cruise GAP 98 by the Russian RV AKADEMIK BORIS PETROV. During this expedition multibeam echosounding, single channel seismic profiling and marine gravity observations were completed by dredging at the steep faulted scarps of the western slope of the Pirie Rise.

Work at Sea

Multibeam surveys will be performed along three transits from the main study area of ANT XXII/4 to the South Orkney Islands, crossing the South Scotia Ridge and the Pirie Rise, in order to complement the existing data and finally correlate the results obtained form the one-channel seismic surveys from the GAP expedition 1998 and to study the sediment coverage on the South Orkney Plateau.

GROUND TRUTHING SATELLITE ALTIMETRY

R. Käker, T. Krömer, J. Mondzech (AWI, Bremerhaven, Germany)

Objectives

The marine gravity and bathymetry data, as measured during ANT XXII/4, will be utilized to determine a high precision geoid of the main study area. The accurate positioning of POLARSTERN and the good quality of the gravity data give reason, that the geoid can probably be determined with an accuracy of better +/- 10 cm. Geoidal data can be utilized for a geophysical/geological interpretation and for the determination of the Sea Surface Topography (SST). In the operation area, the central Scotia Sea, the difference between the geoid and the actual sea surface are relatively large (-0.7 m >SST< -1.4 m).

The actual height of the sea surface can also directly be measured on POLARSTERN using D-GPS, taking into account the ship's draught, movement and antenna height above the sea surface. The actual height of the sea surface is also measured by Radar Altimetry (RA) satellites, like the ENVISAT, TOPEX/POSEIDON, and CRYOSAT, which will be launched in the first quarter of 2005.

Work at Sea

The precise height determination of POLARSTERN will be realized by using D-GPS techniques. The GPS-reference station shall be installed on Signy Base, a British summer station on Moe Island, South Orkney Islands. The GPS-tracking rate will be 1s, in order to track the ship's position in a high temporal resolution. Special long-distance D-GPS software will be used during the post-processing to determine the ship's positions. Two geodetic observers will stay in a field party near Signy Base and operate the GPS receiver, which will be installed on the existing geodetic reference marker SIG1. This experiment will last during the entire survey programme.

A further goal of this experiment is to compare directly the sea surface heights, measured by RA satellites to the heights on POLARSTERN measured with D-GPS. This ground truthing experiment will be done in the sub-track of the satellite. For this purpose, the ship has to be placed directly in the RA footprint at the moment of the overflight. Place and time of relevant satellite passes will be pre-determined and used by POLARSTERN for the planning of this experiment.

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Punta Arenas – Bahia Blanca

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Kuhn, Gerhard	AWI
Labrenz, Alexander	AWI
Leinweber, Volker	AWI
Linder, Julia	AWI
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Möller, Hans-Joachim	DWD
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Niederjasper, Fred	AWI
Schenke, Hans Werner	AWI
Schmidt, Katrin	AWI
Simundic, Patrick	AWI
Udintsev, Gleb	GEOKHI
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Viêtor, Follrich	AWI
Wille, Peter	AWI
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NN	HeliTransair
NN	HeliTransair

SCHIFFSPERSONAL / SHIP'S CREW ANT XXII/4

Reederei F.Laeisz G.m.b.H.
Name of Ship : POLARSTERN
Nationality : GERMAN

Cruise ANT XXII/ 4
08.04.2005 - 21.05.2005
Punta Arenas - Bahia Blanca

No	NAME	RANK	NATION
01.	Pahl, Uwe	Master	German
02.	Spielke, Steffen	1.Offc.	German
03.	Schulz, Volker	Ch.Eng.	German
04.	Peine, Lutz	2.Offc.	German
05.	Bratz, Herbert	3.Offc.	German
06.	NN	3.Offc.	German
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08.	Koch, Georg	R.Offc.	German
09.	Ziemann, Olaf	2.Eng.	German
10.	Kotnik, Herbert	2.Eng.	Austria
11.	Simon, Wolfgang	2.Eng.	German
12.	Holtz, Hartmut	Elec.Tech.	German
13.	Hoffmann, Mathias	Electron.	German
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15.	Fröb, Martin	Electron.	German
16.	Feiertag, Thomas	Electron.	German
17.	Clasen, Burkhard	Boatsw.	German
18.	Neisner,Winfried	Carpenter	German
19.	Kreis, Reinhard	A.B.	German
20.	Schultz, Ottomar	A.B.	German
21.	Burzan, G.-Ekkehard	A.B.	German
22.	Schröder, Norbert	A.B.	German
23.	Moser, Siegfried	A.B.	German
24.	Pousada Martinez, S.	A.B.	Spain
25.	NN	A.B.	German
26.	NN	A.B.	German
27.	Beth, Detlef	Storekeep.	German
28.	NN	Mot-man	German
29.	Fritz, Günter	Mot-man	Austria
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35.	Martens, Michael	Cooksmate	German
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37.	Wöckener, Martina	Stwdss/KS	German
38.	Streit, Christina	2.Stwdess	German
39.	Schmidt,Maria	2.Stwdess	German
40.	Deuß, Stefanie	2.Stwdess	German
41.	Tu, Jian Min	2.Steward	China
42.	Wu, Chi Lung	2.Steward	German
43.	Yu, Chung Leung	Laundrym.	China

FS POLARSTERN

ANT XXII/5

21.05.2005 – 16.06.2005
Bahia Blanca – Bremerhaven

Fahrtleiter:

Dr. T. J. Müller

EXPEDITION ANT XXII/5

ZUSAMMENFASSUNG UND FAHRTVERLAUF

T. J. Müller (IFM-GEOMAR, Kiel, Germany)

POLARSTERN wird am 21.05.2005 von Bahia Blanca auslaufen. Der Transit nach Bremerhaven soll mit wenigen Tagen Stationszeit genutzt werden, die seit Anfang der 70-ger Jahre vorliegenden physikalisch-ozeanographischen Beobachtungen zur Langzeitvariabilität des Antarktischen Bodenwassers im Vema-Kanal fortzuführen. Im Anschluss ist die Aufnahme der verankerten französischen Schallquellen B6 und B7 des IFREMER beabsichtigt, die nahezu auf der geplanten Fahrtroute (Abb. 1) liegen. Dieses Arbeitsgebiet liegt außerhalb der exklusiven Wirtschaftszonen (EEZ) von Küstenstaaten. Ohne Stationszeit und weitgehend ebenfalls außerhalb der EEZ von Küstenstaaten werden während der Fahrt bis zum Erreichen des Englischen Kanals Messungen von Spurengasen durchgeführt, die der Validierung von ENVISAT-Daten dienen. Ebenfalls ohne Stationszeit sollen Proben zur saisonalen und langzeitigen Variabilität gelösten organischen Kohlenstoffs (DIC) genommen werden. Routinemessungen mit Thermosalinograph, Schiffs-ADCP und Fächerlot ergänzen das Programm. POLARSTERN wird am 16.06.2005 in Bremerhaven einlaufen.

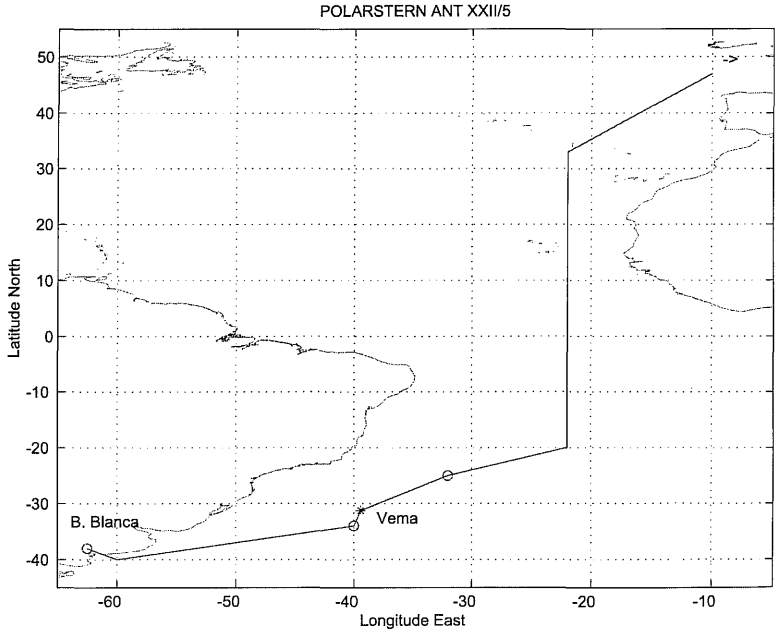

Abb. 1 Fahrtroute während der POLARSTERN-Reise ANTXXII/5.

Fig. 1: Cruise track during POLARSTERN leg ANTXXII/5.

EXPEDITION ANT XXII/5

ITINERARY AND SUMMARY

T. J. Müller (IFM-GEOMAR, Kiel, Germany)

POLARSTERN will leave from Bahia Blanca on 21 May 2005. The transit to Bremerhaven will be used to continue the observations of the long term variability of physical properties of Antarctic Bottom Water (AABW) which have been observed since the early 70's at the sill of the Vema Channel. Afterwards it is planned to recover the moored French sound sources B6 and B7 of IFREMER which are located near to the planned cruise track. The work area is located outside of Exclusive Economic Zones (EEZ) of coastal states. Without using station time and also almost outside any EEZ of coastal states atmospheric trace gases will be measured until the English Channel to validate ENVISAT data. Also without using station time, measurements of the seasonal and long term variability of dissolved organic carbon in surface waters will be carried out. Finally, routine measurements with thermosalinograph, vessel mounted ADCP and a multibeam echo sounding system are made. POLARSTERN will arrive in Bremerhaven on 16 June 2005.

VARIABILITY OF ANTARCTIC BOTTOMWATER (AABW) IN THE VEMA CHANNEL

T. J. Müller, G. Niehus, N.N. (IFM-GEOMAR, Kiel, Germany)

Objectives

The present distribution of land and ocean within the present climate leads to deep vertical convection in winter in some subpolar and polar regions. Suffcient deep passages allow these deep waters to enter all oceans which results to compensating poleward flows of warm waters near the surface. Through this thermohaline component of the circulation (THC), the ocean contributes about 1/3 of the poleward heat transport. The planned world wide observing system, which intends to observe trends in climate variability therefore needs to include important branches of the thermohaline component in key regions and choke points.

Antarctic bottomwater (AABW), which has its coldest component formed in the Wedell Sea, is an important branch of the THC. In the Atlantic, AABW leaves the Argentine Basin northwards through the Vema Channel. The channel's width is 30 km and its depth is more than 4500 m which allows for ca 60% of northward flowing AABW to pass through. Variability and long term trends of the watermass AABW and its northward flow can be observed at this excellent choke point (Fig. 1). Therefore, long term observations of AABW are requested also for the Vema Channel in the future global observing system

The existing 30 year long time series of sporadic observations will be continued by exchanging two moorings which are in site since late 2003 and which observe temperature, salinity and current. In addition some CTD casts will be obtained.

Work at Sea

After leaving the Argentine EEZ, the continuous measuremets with thermosalinograph, ADCP and multibeam echo sonder will begin. Also, the measurements for atmospheric trace gases and sampling for DIC will start. These measurements will continue until the English Channel.

The work area in the Vema Channel (Fig. 2) is almost on the direct course from Bahia Blanca to Bremerhaven. At site V389 two moorings with current meters and moored CTDs (MicroCats) will be recovered and re-deployed. Some CTD casts across the channel and along the Vema Extension supplement the observations of long term variability of AABW. After the last station in the Vema Extension, the course leads over positions 20°S, 022°W and 33°N, 022°W towards the English Channel.

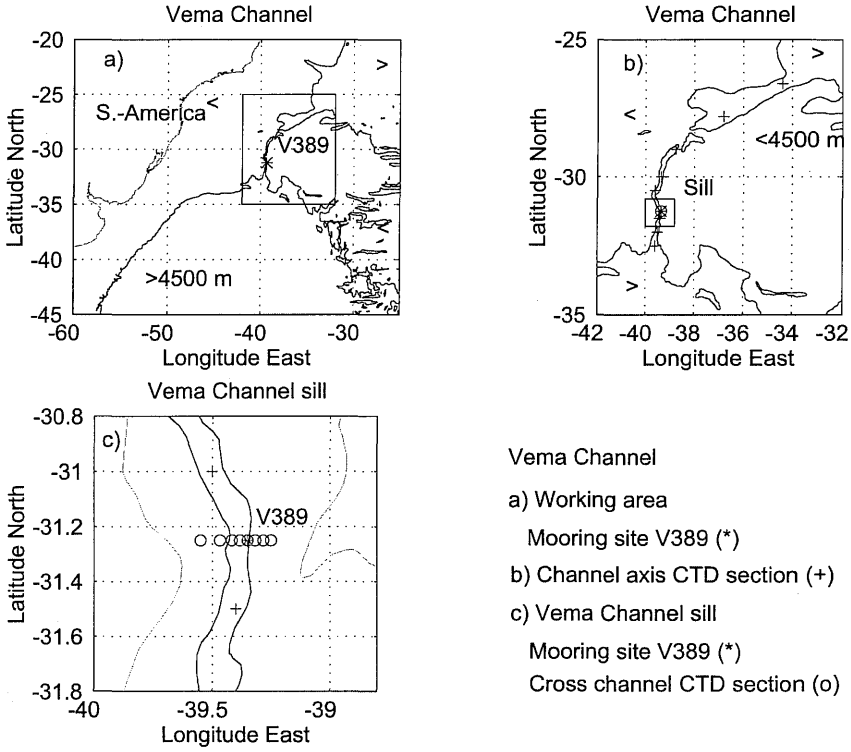

Fig. 2: Location of the observations in the Vema-Channel area during ANT XXII/5.

MAX-DOAS-MEASUREMENTS OF ATMOSPHERIC TRACE GASES FOR SCIAMACHY-VALIDATION

NN, NN (IUP; Heidelberg, Germany)

Introduction

An important aspect of environmental sciences is the knowledge on trace gases and their concentration and distribution in the atmosphere. Especially interesting are troposheric gases like NO_2, H_2O, HCHO, IO and SO_2 as well as stratospheric ones like O_3, NO_2, BrO, OClO, H_2O, HCHO, O_4 and IO. Measurements of these are possibly done by satellites, as by the instrument SCIAMACHY onboard ENVISAT launched into a polar orbit in March 2002. To validate satellite-provided data, however, ground-based control measurements done at locations beneath the satellite's orbit are necessary. In case of SCIAMACHY, measurements onboard POLARSTERN seem best suited for that purpose, because during an Antarctica cruise, the ship follows a polar course corresponding to ENVISAT's orbit.

The DOAS instrumentation

The method used by the satellite's instrument is the proved Differential Optical Absorption Spectroscopy DOAS (Fig. 3). For this principle, the fact is used that solar light passing through the atmosphere is strayed by gas molecules and will thereby gain characteristivc absorption lines within the gained spectra. From these lines, identity and amount of atmosperic trace gases can be obtained. For ground-based measurements it is even possible to decide on height profiles of these trace gases: light coming in vertical will show mainly absorption of stratospheric gases because of this part of the atmosphere's height. Light coming in more horizontal contains absorption of mainly tropospheric gases due to the longer way of the sunlight through this sphere. This is the so-called Multi-Axis-DOAS principle.

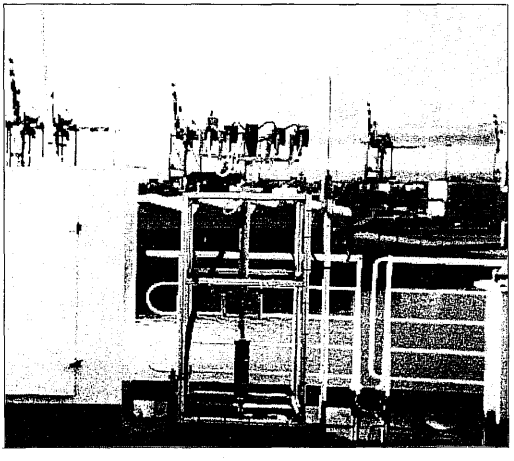

Fig. 3: The on-deck instrumentation of the MAX-DOAS instrument. Four telescope units on both sides of a cable and glass fibre box in the centre are visible as well as the cardanic mounting and the simple pneumatic damping at the bottom.

The validation instrument onboard POLARSTERN uses the same (MAX-)DOAS-measurement principle as the satellites apparatus, of course. Since some of the interesting trace gases like BrO, SO_2 and HCHO show absorption only in the UV and others like H_2O and IO only in Vis spectral range and because both ranges require a different spectral resolution, the ship-based instrument consists of two separate systems for UV and Vis. Both are using moveable telescopes for MAX-DOAS-measurements, but the UV-system three and the Vis-system only one. This is because the UV part of the observed light is less intensive than the Vis one and therefore it takes more time to get bright spectra. This reduces measurement time.

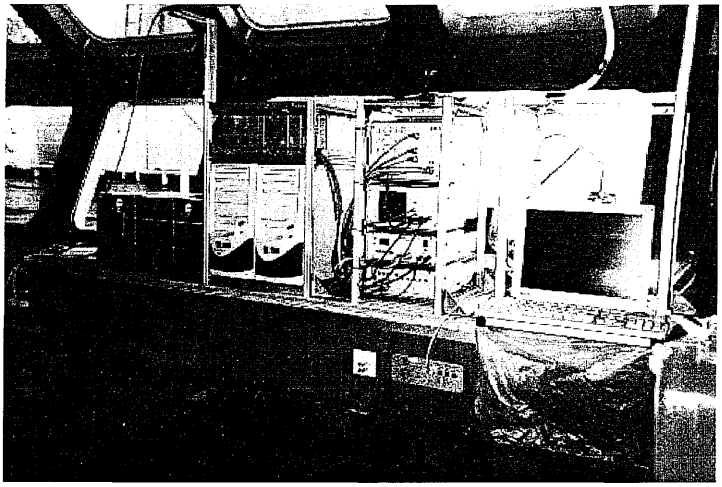

Fig. 4: Just one deck below the telescope units, the spectrographs, computers, supply units etc are mounted.

The telescopes are mounted on a cardanic system to reduce the ship's movements. They are all of the same type, containing in their housings not only a stepper motor for movement, but also protective shutters and HgNe- and Halogen calibration lamps for the apparature. The in-coming light of each UV telescope is conducted to one spectrometer by seven-fold glass fibres making also one of three 1200 μm x 170 μm entrance slist for the system. The spectra from the spectrometer are projected on a two-dimensional 1024 x 256 pixel CCD detector and recorded for further measurements (Fig. 4 and 5). This enables simultaneous measurements of light from three different lines of sight. The Light coming to the Vis telescope is conducted by a normal glass fibre to a spectrograph with one-dimensional 2048 pixel detector row. The Vis- system works consequtive. The whole instrument is working automatically as far as possible and can gather about 8 to 10 GB of data within one month.

Fig. 5: Image of three UV spectra on one two-dimensional CCD array. The seven fibres of coming from each of the three UV telescopes are also visible.

Results

Measurements performed during the ANT XIX-cruise of POLARSTERN from Bremerhaven to Cape Town using the precursor of the nowadays instrumentation (same instruments, but another configuration of telescope units) feature the concentration of BrO and NO_2: The maxima were reached when the ship passed the English Channel with 3.1 +/-1.1 parts per trillion for BrO and 0.36 +/- 0.13 parts per billion for NO_2. The was to be expected from the high air pollution in Europe. Another point is an anti-correlation of both trace gases pointing to a reservoir substance. To gather more data on this and new data principally available with the ship-based DOAS instrumentation is a major point for further participations in Antarctica cruises of POLARSTERN. Besides these measurements done mainly for validation purposes, gathering data in Antarctic seas is important for further atmospheric- and also climate research.

Ship-based DOAS measurements have been carried out before in the years 1990, 1993, 2001/2002, 2002/2003 and 2003/2004 with good success from the Heidelberg Institute for Environmental Physics.

LONG-TERM TRENDS AND SEASONAL VARIABLITY OF THE ^{13}C SIGNATURE OF DISSOLVED INORGANIC CARBON (DIC) IN SURFACE WATERS OF THE ATLANTIC OCEAN

A. Körtzinger (IFM-GEOMAR, Kiel, Germany)

The project is a continuation of a long-term observation study of the ^{13}C signature of dissolved inorganic carbon (DIC) in surface waters of the Atlantic Ocean, which commenced during the POLARSTERN cruise ANT XXI/1. The biannual sampling based on transits of POLARSTERN to/from the Southern Ocean will provide insight into the seasonality and interannual variability of the $\delta^{13}C$-DIC in contrasting climatic and biogeochemical regimes (suptropical vs. subpolar, oligotrophic vs. mesotrophic, thermally vs. biologically controlled CO_2 system). It may also permit quantification of the Suess effect on $\delta^{13}C$-DIC if maintained as a long-term project.

A similar scientific question has been addressed successfully at the oceanic time-series stations such as the Bermuda Atlantic Time Series Study (BATS) an the

Hawaii Ocean Time Series. In addition, sampling programmes have been mounted on „Volunteer Observing Ships“ in the North Pacific and North Atlantic. Within the EU-funded project CarboOcean, the IFM-GEOMAR will measure δ^{13}C-DIC along a trans-Atlantic VOS line from 2005 on for about 4 years. The present long-term sampling programme based on POLARSTERN transits represents a significant extension of the CarboOcean study.

BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES ANT XXII/5
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NN	IFM-GEOMAR
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NN	IUP

SCHIFFSPERSONAL / SHIP'S CREW ANT XXII/5

Reederei F.Laeisz G.m.b.H.
Name of Ship : POLARSTERN
Nationality : GERMAN

Cruise ANT XXII/ 5
21.05.2005 - 16.06.2005
Bahia Blanca - Bremerhaven

No	NAME	RANK	NATION
01.	Pahl, Uwe	Master	German
02.	Spielke, Steffen	1.Offc.	German
03.	Schulz, Volker	Ch.Eng.	German
04.	Peine, Lutz	2.Offc.	German
05.	Bratz, Herbert	3.Offc.	German
06.	NN	3.Offc.	German
07.	Kohlberg, Eberhard	Doctor	German
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16.	Feiertag, Thomas	Electron.	German
17.	Clasen, Burkhard	Boatsw.	German
18.	Neisner,Winfried	Carpenter	German
19.	Kreis, Reinhard	A.B.	German
20.	Schultz, Ottomar	A.B.	German
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35.	Martens, Michael	Cooksmate	German
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38.	Streit, Christina	2.Stwdess	German
39.	Schmidt,Maria	2.Stwdess	German
40.	Deuß, Stefanie	2.Stwdess	German
41.	Tu, Jian Min	2.Steward	China
42.	Wu, Chi Lung	2.Steward	German
43.	Yu, Chung Leung	Laundrym.	China