Expeditionsprogramm Nr. 73

FS POLARSTERN

ARK XXI/ 1a

21.07.2005 - 13.08.2005

Bremerhaven - Longyearbyen

ARK XXI/ 1b

13.08.2005 - 19.09.2005

Longyearbyen - Bremerhaven

Koordinator: Eberhard Fahrbach

Fahrtleiter:
ARK XXI/1a: Gereon Budéus
ARK XXI/1b: Eberhard Fahrbach, Peter Lemke

STIFTUNG ALFRED-WEGENER-INSTITUT
FÜR POLAR- UND MEERESFORSCHUNG

JUNI 2005

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INHALT / CONTENTS

ARK XXI/1a

1. ÜBERBLICK UND FAHRTVERLAUF

Der erste Fahrtabschnitt der 21. Polarstern-Expedition in die Arktis beginnt am 21.7.2005 in Bremerhaven. Das Forschungsschiff Polarstern wird direkt Kurs nehmen auf das westliche Ende eines Langzeit-Schnittes über den Grönlandsee-Wirbel und bei der Shannon-Insel dicht vor der grönländischen Küste in eisbedeckte Gewässer laufen. Auf dem zonalen Schnitt entlang dem 75. Breitenkreis wird eine Vielzahl von chemischen, optischen, biologischen und physikalischen Untersuchungen durchgeführt. Dieser Schnitt verläuft von der Küste Grönlands bis zur Bäreninsel. Er wird unterbrochen durch die Auswechslung von autonom profilierenden Tiefsee-Verankerungen mit einem integrierten akustischen Experiment sowie durch eine Exkursion zu einem kleinskaligen (Durchmesser 20 km), langlebigen, kohärenten Wirbel, dessen Position zunächst gefunden werden muß. Das Einlaufen im Hafen von Longyearbyen ist für den 13. August vorgesehen.

Der Schnitt entlang 75°N wird seit einigen Jahren jährlich wiederholt, da man erkannt hat, daß auch die arktischen Gewässer durch hohe Dynamik gekennzeichnet sind und die komplexen Veränderungen, bedingt durch Konvektion und Austausch mit den Randwassermassen, nur mit Hilfe langer Zeitreihen konsistenter Qualität richtig erklärt werden können. Während dieses Schnitts wird das Schiff überwiegend stehen, da einer Dampfstrecke von etwa einer Stunde jeweils eine Station von circa 2 Stunden Dauer folgt. Auf diesem Weg von West nach Ost wird eine Vielfalt von Forschungsaktivitäten durchgeführt. Die chemischen Arbeiten umfassen neben mehr üblichen Untersuchungen der Wassersäule auch spezialisierte geochemische Analysen. Die Bestimmungen von Nährstoff- und Sauerstoffkonzentrationen stehen in engem Zusammenhang mit den hydrographischen und planktologischen Untersuchungen. Zum einen spiegeln die Nährsalz- und Sauerstoffkonzentrationen die Entwicklung des Phytoplanktons wieder, und zum anderen eignen sie sich als "Tracer" für die Identifizierung und Verfolgung von Wassermassen. Die geochemischen Forschungen untersuchen den Kreislauf des klimarelevanten Methans und nutzen die Elemente Radon und Radium um die Süßwasserzirkulation in der Arktik detailliert zu bestimmen. Während die bis hierher genannten Untersuchungen die gesamte Wassersäule bis zum Meeresboden beproben, dienen die bio-optischen Messungen der Validierung der Farbsensorik auf SeaWiFS und MoDIS, die Biomassenkonzentrationen und physiologische Parameter im Ozean vom Weltraum aus messen. Studien zur Validierung paläontologischer Proxies unter Verwendung von Foraminiferen und Coccolithophoren nutzen die Seewasserversorgung des Schiffes, um die Hauptwassermassen und Fronten entlang des Schiffsweges zu bestimmen. Die Verteilung von Seevögeln und marinen Säugern wird ebenfalls entlang des Schiffsweges in der Grönlandsee bestimmt.

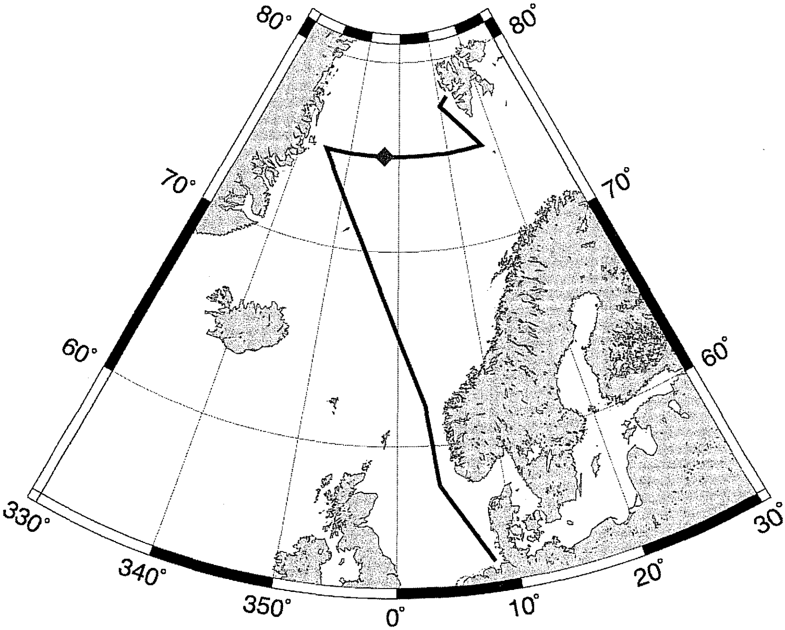

Abb. 1: Fahrtroute während ARK XXI/ 1a

Fig. 1: Cruise track during ARK XXI /1a

OVERVIEW AND ITINERARY

The start of the first leg of the 21st Polarstern expedition to the Arctic is scheduled for the 21st of July 2005. The ship will be heading directly to the western limit of a long-term transect in the Greenland Sea and enter ice covered waters close to Shannon Island and the Greenland coast. A zonal transect will be performed along 75°N with a multitude of chemical, optical, biological, and physical measurements. The transect extends from the Greenland coast to Bear Island. It is interrupted by the exchange of autonomously profiling deep sea moorings with integrated acoustics and by an excursion to a small scale (20 km diameter) long-lived coherent eddy whose location has first to be determined. We will call at the port of Longyearbyen on August 13th .

For a number of years, the transect at 75°N is repeated annually since it has been recognised that the Arctic Waters experience highly dynamic changes and that the complex modifications by convection and exchange with the surrounding waters can be correctly explained only with the aid of quality consistent long term time series. While performing this transect, the ship will keep its position most of the time, as 2 hour station times alternate with 1 hour steaming. On this way from west to east there will be a multitude of activities. The chemical work comprises familiar research in the water column as well as specialized geochemical investigations. Nutrients, oxygen and dissolved organic matter are measured in the water column. The determinations of nutrients and oxygen are closely connected with the physical and planktological investigations, and the development of phytoplankton blooms is especially dependent on the available nutrients. On the other hand nutrients and oxygen are well suited as tracers for the identification of water masses. Geochemical research investigates the important methane pathways in the subarctic, and uses Radon and Radium concentrations to identify freshwater circulation. Bio-optics contribute to the validation of remote sensing algorithms applied to the colour sensors SeaWiFS and MoDIS for deriving biomass concentrations and physiological parameters from space. While the aforementioned investigations all use water from the full ocean depth, proxy validation studies by sampling of foraminifera and coccolithophores use the ship's sea water supply to gain on track samples across the main frontal systems. The distribution of higher trophic levels (seabirds and marine mammals) will be quantified at-sea in the Greenland Sea, as a function of the main hydrological parameters.

2. DEVELOPMENT OF THE HYDROGRAPHIC STRUCTURE IN THE GREENLAND SEA

Greil, Hans, Kattner, Ronski, Plugge, Poppe, Wischnewski (AWI),
Kaletzky (University of Cambridge)

Physical processes in the Polar Oceans are regarded with increased attention because of their high sensibility against climatic changes. This is also true for the hydrographic development in the Greenland Sea, which is one of the few regions worldwide where surface waters can gain by atmospheric forcing such high densities that they sink to great depths and drive hereby the thermohaline circulation. Today it is clear that the straightforward idea of regular, repeated bottom water renewal in winter is not correct and that the proposed concepts for deep convection do not adequately describe the processes in the Greenland Sea. Since regular field expeditions have been started during the end of the 1980s, there was not a single year during which bottom water has been ventilated by winter convection. In this situation, bottom water properties change towards higher temperatures and salinities. This can to a large part be explained by vertical displacement of the water column together with bottom water export. At the same time lateral inputs do also modify deep water as well as shallow water properties. For a correct interpretation of these changes long term time series with consistent quality are undispensible.

Work during the recent years showed a.o. that even the seemingly simple identification of winter convection fails when using single criterions. In contrast to present knowledge, temperatures in a ventilated volume can be higher as well as lower after a convection phase. The same is true for salinities. The application of a more complex criterion catalogue shows that in the last decade winter convection penetrated to a density step in mid depth during most years. This density step is also observed in increasing depths levels which leads to increasing convection depths. Consequently, these increasing depths are not synonymous with the ventilation of older water masses. The described two layered density structure is principally different from the dome structure with rotation symmetry of the early 1980s.

Most recently, surprisingly long lived submesosclae vortices (SCVs) have been detected in the Greenland Sea (diameter about 10 to 20 km). In the centre of these features convection reaches depths that are about 1000 m greater than in the background (some 2600 m). These eddies seem to survive a number of years by a repeated homogenization during winter. It is in the centres of these eddies where winter convection will meet the ocean bottom first. In order to assess the importance of the SCVs a cooperative effort is made to follow the development of a single, relatively stationary SCV over some years.

As before, no attempt will be made to investigate the convection processes directly by shipborne measurements because of the inherent small time and space scales. The detailed development of winter ventilation is instead measured by our autonomous Jojo-moorings. In addition, acoustic moorings will be deployed in 2004 which directly detect vertical movements of water pacels especially during the winter convection phase.

During the 2005 expedition, three Jojo-moorings will be replaced, and two acoustic moorings will be recovered. A zonal transect on 75° N will be performed which contains approximately 60 stations. The investigation of an SCV is also scheduled.

3. RECENT CHANGE IN THE ARCTIC: FEEDBACKS TO GEOCHEMICAL PATHWAYS IN SEAWATER

Vöge, Klassen, Liebehentschel, Friedrich (AWI)

Recent change in the Arctic alters water mass formation and convection, which may have profound effect on natural biogeochemical cycles in seawater. Especial feedback effects to pathways of climatically relevant biogases like methane will loom large in the equation of change. The present marine methane cycle is influenced mainly by atmospheric methane transported by downward diffusion and convective ventilation into the deeper ocean, by fossil methane released from gas venting sites at the sea floor, microbial in-situ methane production in the upper ocean and microbial oxidation in the whole water column. With this expedition we expect to expand the knowledge about the changing of the methane background signal by methane released from active gas venting sites and the methane in-situ production in the upper water column and to quantify these processes. The aim of our investigations is to estimate the balance between the pathways and the resultant isotopic fractionation processes as well as the methane budget in different water currents related to background concentrations and super-saturations. Another goal is to calculate sink and source capacities of water currents influenced by gas venting sites in order to estimate this marine contribution to the atmospheric methane budget at the high northern latitudes.

These investigations extend work which was performed in the Fram Strait during ARKXIV and ARKXVI in 1998 and 2000 respectively. Water will be sampled with the rosette in different water depths for a number of stations on the 75° and 79° N transect. Furthermore methane measurements are planned on stations at the Spitsbergen shelf and the Greenland shelf. Additionally, in the upper water column (200m) water samples will be analyzed for DMSP (dimethylsulphoniopropionat) content. Methane concentration measurements have to be done on board. Gas samples for isotopic analyses, as well as samples for DMSP measurements will be stored and analysed in the home lab.

Within the realm of the GEOTRACES initiative, we aim to use natural radionuklides as tracers for water masses and particle export in the East Greenland current and on a transect from the Greenland to the Spitsbergen shelfs during ARK XXI/1a.

First, we want to test whether the activity ratio of the radium isotopes ^{228}Ra/^{226}Ra can be used as a tracer for identifying the input of freshwater from the Greenland glaciers versus the freshwater input from the Arctic into the East Greenland current. Commonly, the ^{228}Ra/^{226}Ra activity ratio used as a tracer for identifying river water hundreds to thousands of kilometres from its riverine source. ^{228}Ra is supplied by desorption from river-borne particles and by release from river and shelf sediments (half-life 5.7 years). ^{226}Ra is primarily supplied by desorption from river-borne particles. Shelf sediments are a negligible source because of the time required to generate new ^{226}Ra (half-life 1600 years). Unlike their precursors ^{232}Th and ^{230}Th which are common in rocks and sediments, ^{228}Ra and ^{226}Ra are soluble in seawater. As in the river, the contact of ice and water with rocks and sediments on the downside of the glacier is supposed to be a source of radium. Then, when the water leaves continent and shelf, the ratio will only change by decay of ^{228}Ra and mixing. Hence, we expect a decrease of the ^{228}Ra/^{226}Ra ratio with increasing salinity and distance from the melt water input. In other words, we expect the ^{228}Ra/^{226}Ra ratio to decrease with decreasing percentage of glacier melt water. The success of the test largely depends on the amount of ^{228}Ra introduced by glacier melting and whether it is measurable in a few tens of liters of water since the tight cruise schedule does now allow for the use of large volume in-situ water pumps. Sampling will be done within the East Greenland Current as close as possible to the coast. Samples will be taken from the CTD's rosette bottles (upper water column) and surface samples from the ship's sea water supply.

Second, we aim to evaluate the use of Po as tracer for downward export of organic carbon in oligotrophic waters. There is a paradox in global data that show that ^{210}Po deficiencies (the difference between ^{210}Pb, its precursor, and ^{210}Pb) decrease as ocean productivity increases which is contrary to the widely held concept that removal of bioreactive elements is more efficient in the productive ocean due to a larger population of sinking particles. This implies a major problem in the use of ^{210}Po as an export tracer of particulate carbon or trace elements since ^{210}Po deficiencies seem to be not necessarily associated with downward organic particle export. The largest deficiencies have been found in oligotrophic oceans, in the subsurface were bacterial production is largest. Due to efficient enrichment of Po to bacteria, 15-75% of the total Po is in the particulate phase, which is much higher than in productive oceans. To evaluate the use of Po as tracer for downward motion we need good spatial sample coverage, i.e. samples from as many regions as possible. Sampling will be done during all transects, to get a good spatial coverage. Samples will be taken from the rosette bottles.

4. BIO-OPTICS

Schwarz, Klassen, v. Seggern (AWI)

Bio-optical measurements have been made around Svalbard and across the Greenland Sea for 2 successive years: spring 2003 and early summer 2004. These measurements are contributing to the accumulation of a database of bio-optical and biogeochemical parameters for the validation of remote sensing algorithms applied to the colour sensors SeaWiFS and MoDIS for deriving biomass concentrations and physiological parameters from space. Means of monitoring particulate and organic carbon fractions by means of optical sensors deployed on floats or CTDs are also under investigation.

Results from spring 2003 showed a pronounced bloom of Thalassiosira sp at the ice-edge – in partial ice cover – at both the Greenland and Svalbard coasts. The bloom was associated with an increase in buoyancy caused by lowered salinity, i.e. melting ice (data from U. Schauer/G. Budéus), and depleted nutrients (data from E. Falck/G. Kattner). Ice samples in Storfjorden in March 2003 showed a markedly more diverse assemblage, predominantly of diatoms, of flora in the ice than in the water column beneath it. One question to be addressed is the impact of varying phytoplankton assemblages on the colour of the water in these regions, and hence on the satellite algorithm performance.

Further issues identified during spring 2003 are the calibration of beam transmission (measured with the CTD) against POC: a 2-mode calibration was obtained, enabling transmission profiles to be used to generate POC profiles, however, owing to sparsity of samples, the regression was barely significant. Similarly, more intensive sampling of chlorophyll is required for calibration of beam transmission and chlorophyll fluorescence sensors on the CTD. Calibration of the gelbstoff fluorometer (G. Budeus) against DOC was successful only in the polar water east of Greenland, which is strongly influenced by terrigenous matter from the Siberian rivers. Spectrofluorometric measurements (Excitation/Emission matrices) are now being measured with the hope of identifying wavelengths at which dissolved organic matter of marine origin can better be monitored in this region.

It has been found that, for the sample region in question, only monthly composites of remotely-sensed ocean colour data give full, cloud-free coverage over ice-free regions. For example, only 7 stations during spring 2003 were cloud-free for satellite observations, and these stations were in the North Atlantic, on the return journey to Bremerhaven: many more match-ups are required for algorithm validation in ice-free Arctic waters. Monthly compositing naturally raises the problem that compositing smooths over shorter-term biological events, resulting in lower biomass and, consequently, primary production estimates. This makes the North Atlantic Arctic an ideal site for the combined use of *in situ* monitoring, remote-sensing and coupled ocean-ice-ecosystem modelling, and the dataset being gathered is being expanded to include several parameters useful for ecosystem modelling.

The parameters to be analyzed during this cruise are:

Phytoplankton pigments (HPLC)
Absorption by phytoplankton and other suspended matter
Absorption by dissolved matter
Spectrofluorometry of dissolved matter
Dissolved organic carbon
Particulate organic carbon/nitrogen
Alkalinity
Primary productivity (total)
Particle size distribution
Phytoplankton taxonomy
Bacteria enumeration

5. MARINE CHEMISTRY: NUTRIENTS, OXYGEN AND DISSOLVED ORGANIC MATTER

Kattner, Ludwichowski, Ridder, Vogel (AWI), Falck (University of Bergen)

The determinations of nutrients and oxygen are closely connected with the physical and planktological investigations. The development of phytoplankton blooms is especially dependent on the available nutrients. On the other hand nutrients and oxygen are well suited as tracers for the identification of water masses. The change in nutrient and oxygen concentrations will be followed in the Fram Strait region and during the Greenland Sea transect, especially across the Greenland shelf and slope. In comparison with similar transects in former years, the seasonal and interannual variability will be determined. In the 1980s and 1990s water masses of Pacific origin occurred usually in the shelf and slope regions of the Fram Strait and further south of the Greenland Sea. The data from 2004, however, show almost no signal of water of Pacific origin. Especially the nitrate to phosphate ratio but also silicate are good tracers to follow the outflow of upper halocline Arctic surface water along the Greenland continental shelf and slope. Water masses may be especially rich in silicate compared to Atlantic waters. The data from this expedition will show whether there are further modifications of the water masses exiting the Arctic Ocean.

From water samples taken with the rosette sampler at different depth, the nutrients - nitrate, nitrite, phosphate and silicate - are determined immediately on board with an Autoanalyser-system according to standard methods. Oxygen is measured by the Winkler method.

In addition, dissolved organic matter (DOM) will be extracted from seawater at representative stations to follow the outflow of water masses transporting terrestrial organic matter from the huge Siberian river towards the Fram Strait. Sampling will be decided from results of the fluorescence profiles. 10 to 20 L of seawater will be extracted with different adsorbers. The chemical characterisation of DOM will be performed in the home labs at Bremerhaven.

6. SAMPLING OF PLANKTON FORAMINIFERA AND COCCOLITHOPHORES FOR PROXY VALIDATION STUDIES

Martinez Garcia, Martínez Boti (UAB)

6.1 Study of alkenones in the Nordic Seas

The aim of our sampling is to study the spatial variability of the concentration and distribution of algal lipids, namely alkenones, and coccolithophores across the main water domains in the Nordic Seas, and paying special attention to the transitions across the Arctic and Polar fronts.
This is for the purpose of further validation and in order to improve the calibration of biomarker proxies to reconstruct past sea surface temperature and salinity in high latitude oceanic settings.

Since it was first demonstrated that alkenone abundance ratios in sediments changed in a systematic way with inferred temperature, a great deal of research has been conducted with the aim of confirming and calibrating this relationship. The ratio of unsaturated ketons in the lipids of the micro organisms containing double (37:2) and triple (37:3) bonds is expressed as U^{K}_{37}'. Because the $C_{37:4}$ alkenone is often absent or not detectable in middle to low latitudes the ratio was simplified to U^{K}_{37}'. The general temperature dependent nature of the relative abundance of the $C_{37:2}$ and $C_{37:3}$ alkenones has been confirmed by culture, surficial sediment and water column particulate organic matter (POM) studies. Therefore, U^{K}_{37}' when measured in most modern sediments throughout the world ocean can be converted into realistic, seemingly reliable estimates of mean annual temperature at the sea surface (SST). Moreover, it appears that values of U^{K}_{37}' – once set biogeochemically by the algae – are not significantly altered by degradation in sedimentary processes. However, despite such positive results, the application of alkenone indices are not devoid of uncertainties. The initial U^K_{37}' - SST calibration derived from a culture of E. huxleyi (N.E. Pacific strain) by Prahl and Wakeham (1987) shows a clear linear relationship between U^K_{37}' and temperature in the range of 8 – 25°C. Interestingly, this linear regression equation is statistically the same as a regression between U^K_{37}' measured in global (60°N – 60°S) sediment core-tops and ocean-atlas mean annual SSTs. A number of recent studies highlight a degree of nonlinearity in the relationship of alkenones to SST at high (> 25°C) and low (<8°C) temperature extremes. Therefore it is apparent that in certain contexts or regions absolute temperatures derived from the "recommended" equations are unrealistic. It has been suggested that this may apply to the Nordic Seas region, where - based on an extensive core-top data set - considerable scatter is seen in the U^K_{37}' – SST relationship. In this region it is has been suggested that a calibration based on the original U^K_{37} index - which incorporates the $C_{37:4}$ compound – gives more accurate results down to 6°C. This contrasts with the cold waters of the southern ocean, where U^K_{37}' is well correlated to SST down to ~3°C, or in the South Atlantic where the correlation reaches 0°C. In the Nordic Seas, below 6°C neither the U^K_{37}' or U^K_{37} index – measured in surface sediments - is correlated to SST. This is frustrating for palaeoceanographic investigations, as the cold water regions of the Nordic Seas play a key role in the production of deep water masses, and in the wider global meridonal overturning circulation (MOC). Further investigation of alkenone distributions in the Nordic seas surface waters is necessary, as previous North Atlantic water column studies have reported no or very few results from the Arctic and Polar water masses. In previous studies we have we have reported alkenone distributions measured in sea surface (~6m depth) POM obtained from across the spectrum of property gradients (i.e. covering all the characteristic water masses) of the Nordic seas, during two cruises of the RRS *James Clark Ross* (JCR) in 1999 & 2000. The advantage of studying water column POM over the study of sediments is that alkenone distributions can be directly compared to *in situ* ocean parameters. In this study we obtained samples from the ships uncontaminated seawater supply at a fixed depth of 6m. This enabled us to filter large volumes of water from the mixed layer for a relatively large number of samples from a wide geographic area without stopping the ship for sampling. This sampling strategy was designed to gain an insight into the spatial variability of alkenone data. The approach only provides a brief temporal "snap shot" measurement of environmental conditions, rather than an integrated seasonal signal, as can be inferred from sediment traps or bottom sediments data. Hence the importance of repeating the sampling in subsequent years to appraise to some extent the interannual variability of the data.

We will be filtering large volumes of sea water (150-200L) while the ship is steaming using the ship's own underway seawater supply.

6.2 Mg/Ca in planktonic foraminifera

The paleoceanographic community is currently focusing on the trace element composition (primarily Mg/Ca) of planktonic foraminifera as a proxy of upper water column temperature. For paleo-reconstructions, the materials routinely come from microfossils preserved in the deep-sea sedimentary record. Calibration for the relationship between Mg/Ca and temperature is typically derived from uppermost sediments ("core-top" samples) or culture studies. One recent study used sediment trap samples to ascertain this relationship in the water column, but the foraminifera were not collected on a depth-discrete basis. Plankton tow samples are currently being used to further assess this on a depth-discrete basis, but these kinds of samples present other uncertainties, such as foraminifera calcifying at shallower depths than where they may be captured in the towing process. Plankton-pump samples of foraminifera will offer the advantage of true water column habitat (unlike core-tops or culture) without the uncertainty of calcification depth. Putting our important proxy systems to this sort of "test" with a relatively unique sampling approach will allow a series of developments. This effort will naturally build on several decades of work spent developing and refining these proxy systems, and fits right in with major objectives of several international programs, including the upcoming international GEOTRACES initiative.

We will be filtering plankton at 63 microns in order to capture surface-dwelling foraminifera from a range of temperature and nutrient conditions encountered during the cruise transect. These samples will ultimately be processed, picked, and cleaned before analysis for trace elemental (Mg/Ca and Sr/Ca) composition. The purpose is to refine the calibrations of these geochemical tracers against temperature, and potentially other variables.

7. QUANTIFICATION OF HIGHER TROPHIC LEVELS

Joiris, Briga, Gielen (VUB)

The aim is to quantify the at-sea distribution of seabirds and marine mammals in the Greenland Sea, as a function of the main hydrological parameters (water temperature, salinity) allowing to identify the main water masses (Atlantic water, polar water, pack ice) and fronts structures between water masses and ice edge.

Transect counts will take place when Polarstern is sailing, since at stations, seabirds can be massively attracted by ships.

This expedition is part of a long-term study in both polar regions - mainly the European Arctic seas - started in 1973.

Data will be discussed as reflecting food availability, i.e. the ecological structure of the whole water column. Another aspect will be the historical evolution in numbers since 1973 and the numerous expeditions in between, with special attention to climate change and possible changes in pack ice extent.

8. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

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AWI	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 12 01 61 27515 Bremerhaven
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RWTH Aachen	RWTH Aachen Templergraben 55 52056 Aachen
UAB	Institute of Environmental Science and Technology Universitat Autònoma de Barcelona Edifici CN, Torre C5 Parells Planta 4, Sala de Becaris 08193 Bellaterra BCN Spain
Uni Bergen	University of Bergen P.O. Box 7800 N-5020 Bergen
Uni Cambridge	University of Cambridge Dept. of Applied Mathematics and Theoretical Physics, Cambridge CB30WA, England
VUB Brüssel	Laboratory for Ecotoxicology and Polar Ecology Free University of Brussels (VUB) Pleinlaan 2, B-1050 Brussels, Belgium

9. FAHRTTEILNEHMER / PARTICIPANTS

Fahrtleiter: Gereon Budéus

Bremerhaven - Longyearbyen

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Briga	Michael	VUB Brüssel	Student
Budéus	Gereon	AWI	Scientist
Büchner	Jürgen	HeliTransair	Pilot
Buldt	Klaus	DWD	Technician
Erdmann	Hilger	DWD	Meteorolgist
Falck	Eva	Uni Bergen	Scientist
Friedrich	Jana	AWI	Geochemist
Fuhs	Elisabeth	HeliTransair	Inspector
Gielen	Robin	VUB Brüssel	Student
Greil	Florian	AWI	Student
Hans	Kerstin	AWI	Student
Heckmann	Hans Hilmar	HeliTransair	Pilot
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Kattner	Lisa	AWI	Student
Klassen	Niko	AWI	Apprentice
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Martinez Botí	Miguel Angél	UAB	Student
Martinez Garcia	Alfredo	UAB	Student

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Nauels	Alexander	AWI	Student
Plugge	Rainer	AWI	Technician
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Ridder	Theo	AWI	Student
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Wischnewski	Juliane	AWI	Student
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10. SCHIFFSBESATZUNG / SHIP'S CREW

Besatzungsliste	Reise ARK XXI/1a	
Name of Ship :	POLARSTERN	
Nationality :	GERMAN	Bremerhaven - Longyearbyen

No.	Name	Rank
01.	Schwarze, Stefan	Master
02.	Grundmann, Uwe	1.Offc.
03.	Farysch, Bernd	Ch. Eng.
04.	Fallei, Holger	2. Offc.
05.	Peine, Lutz	2.Offc.
06.	Wunderlich, Thomas	2.Offc.
07.	Uhlig, Heinz-Jürgen	Doctor
08.	Hecht, Andreas	R.Offc.
09.	Erreth, Gyula	2.Eng.
10.	Kotnik, Herbert	2.Eng.
11.	Minzlaff, Hans-Ulrich	2.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Nasis, Ilias	Electron.
14.	Feiertag, Thomas	Electron.
15.	Verhoeven, Roger	Electron.
16.	Schulz, Harry	Electron
17.	Loidl, Reiner	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Vehlow, Ringo	A.B.
20.	Hartwig-Labahn, Andreas	A.B.
21.	Winkler, Michael	A.B.
22.	Guse, Hartmut	A.B.
23.	Hagemann, Manfred	A.B.
24.	Schmidt, Uwe	A.B.
25.	Bäcker, Andreas	A.B.
26.	Lamm, Gerd	A.B.
27.	Preußner, Jörg	Storek.
28.	Ipsen, Michael	Mot-man
29.	Voy, Bernd	Mot-man
30.	Elsner, Klaus	Mot-man
31.	Hartmann,Ernst-Uwe	Mot-man
32.	Grafe, Jens	Mot-man
33.	Müller-Homburg, Ralf-Dieter	Cook
34.	Silinski, Frank	Cooksmate
35.	Völske, Thomas	Cooksmate
36.	Jürgens, Monika	1.Stwdess
37.	Wöckener, Martina	Stwdss/KS
38.	Czyborra, Bärbel	2.Stwdess
39.	Silinski, Carmen	2.Stwdess
40.	Gaude, Hans-Jürgen	2.Steward
41.	Möller, Wolfgang	2.Steward
42.	Huang, Wu-Mei	2.Steward
43.	Yu, Kwok Yuen	Laundrym.

ARK XXI / 1b

13.08.2005 - 19.09.2005

Longyearbyen - Bremerhaven

Fahrtleiter/ Chief Scientists:

Eberhard Fahrbach

Peter Lemke

ARK XXI/1b

1. ÜBERBLICK UND FAHRTVERLAUF

Der Fahrtabschnitt ARKXXI/1b führt für ozeanographische, geo- und biochemische, biologische und geologische Untersuchungen in den nördlichen Teil des Europäischen Nordmeers. Die Arbeitsgebiete liegen im Storfjord südlich von Spitzbergen, in der Framstraße entlang 79°N und nördlich davon, sowie auf dem Yermak-Plateau (Abb. 1).

Der Abschnitt beginnt am 13. August 2005 in Longyearbyen. Wir werden zunächst im Storfjord die Verteilung von submarin freigesetztem Methan im Meerwasser erfassen um damit den Einfluss der ozeanischen Zirkulation auf den Methanhaushalt zu untersuchen. Ergänzende hydrographische Messungen werden gleichzeitig im Rahmen des AWI-Schulprojekts von einer Schulklasse von dem Bildungslogger „Lovis" aus durchgeführt.

Anschließend wird Polarstern im „AWI-Hausgarten" und entlang einer ozeanographischen Verankerungslinie in der Framstraße arbeiten. Um die Dynamik von ökologischen Abläufen in der Tiefsee auf dekadischen Zeitskalen zu erfassen sind einmalige Erhebungen nicht ausreichend. Deshalb wird seit 1999 das polare Tiefseebenthos im „AWI-Hausgarten" kontinuierlich mit verankerten Systemen und durch jährlich wiederholte Beprobungen untersucht. Dazu wird entlang eines Schnitt zwischen 1000 m und 5500 m Wassertiefe mit Landern, Sedimentprobennahmegeräten sowie mit abbildenden oder messenden optischen Verfahren gearbeitet. Diesmal werden zusätzlich zu den Dauerbeobachtungen benthische Foraminiferen für eine Studie ihrer globalen genetischen Verteilung (Arktis vs. Antarktis) untersucht.

Die ozeanographischen Arbeiten haben zum Ziel, Änderungen des Wassermassen- und Wärmeaustauschs zwischen Nordpolarmeer und Atlantik und die Zirkulation in der Framstraße zu quantifizieren. Dafür werden Temperatur und Salzgehalt entlang eines Schnittes bei 79°N gemessen sowie Wasserproben genommen, um Spurenstoffe zu messen. Ozeanographische Verankerungen, die im letzten Jahr auf diesem Schnitt ausgelegt wurden, werden aufgenommen und mit neuem Gerät wieder ausgelegt. Damit wird eine mittlerweile sieben Jahre dauernde Langzeitmessung fortgesetzt.

Am 27. August wird in Longyearbyen ein Teil des wissenschaftlichen Personals ausgetauscht. Wir fahren anschließend nach Norden zum Yermak-Plateau, um dort für paleo-ozeanographische Untersuchungen Sedimentkerne zu gewinnen. Danach werden die ozeanographisch/ meereschemischen Arbeiten in der Framstraße fortgesetzt. Auf der Heimfahrt nach Süden wird beim Hakon-Mosby-Schlammvulkan eine „Temperaturlanze" abgesetzt, die dort über ein Jahr die Veränderungen des Temperaturprofils im Sediment messen soll.

Während des gesamten Abschnitts werden die bio- und geochemischen und die meeresoptischen Messungen, die Probennahmen zur Bestimmung von Biomarkern als paläontologischen Proxies, sowie die Beobachtungen von Seevögeln und marinen Säugetieren aus dem vorhergehenden Abschnitt fortgesetzt.

Nach Beendigung der Arbeiten wird Polarstern nach Bremerhaven zurückkehren und dort am 19. September 2005 einlaufen.

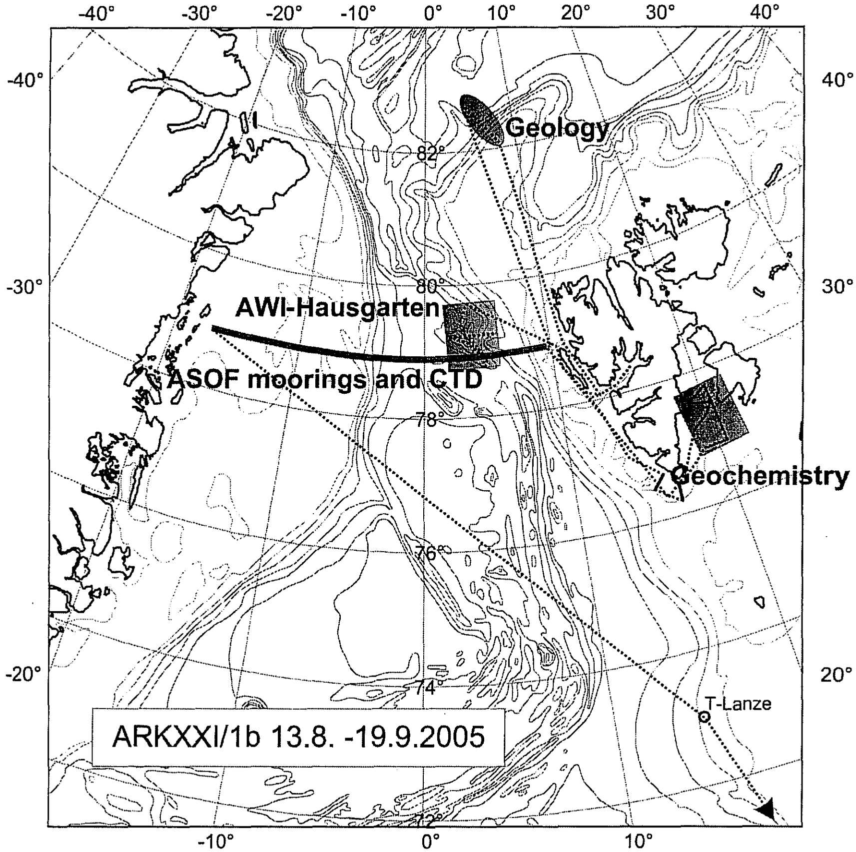


Abb. 1: Fahrtroute während ARK XXI/1b

Fig.1: Cruise track during ARK XXI/1b

SUMMARY AND ITINERARY

ARKXXI/1b starts at August 13 in Longyearbyen to perform oceanographic, geo- and biochemical, biological and geological investigations in the northern Nordic Seas. The working sites lie in Storfjorden south of Svalbard, in Fram Strait along 79°N and further north, and at the Yermak Plateau.

In Storfjorden we will measure the distribution of submarine released methane in the sea water to determine the influence of the ocean circulation on the methane budget. These measurements will be complemented through hydrographic observations performed by a school class onboard the sailing vessel "Lovis" in the frame work of the "AWI school project".

The biological program will focus on the dynamics of polar benthic deep-sea ecosystems. Since 1999, a long-term experimental transect between 1000 - 5500 m water depth (AWI-"Hausgarten") in the eastern Framstrait off Spitsbergen (Fig. 1) is revisited at least once a year to analyse seasonal and interannual variations in biological, geochemical and sedimentological parameters. This year, in addition to the long-term programs deep-sea foraminifera will be investigated to compare the diversity in Arctic and Antarctic seas and to address bio-geographical questions with respect to genetic differentiation.

The oceanographic work is dedicated to investigate the water mass and heat exchange between the Arctic and the North Atlantic with special emphasis on the interannual and decadal variability of the circulation in Fram Strait. Hydrographic measurements will be taken along 79°N, and water samples for tracer determination will be collected. 16 oceanographic moorings with current, temperature and salinity meters deployed last year will be recovered and re-deployed with new instruments to extend the existing time-series to 8 years.

On August 27, part of the scientific personal will be exchanged in Longyearbyen. Thereafter we will turn to the Yermak Plateau to obtain cores from sediment drift deposits that were documented during Polarstern cruise ARK-XX/2 and which are expected to give information about temporal changes in paleoclimate and paleoceanographic circulation.

During the entire leg the biogeochemical and optical measurements, the sampling for biomarker as paleo proxies as well as the observation and counting of sea birds and marine mammals from the previous leg will continue.

After the conclusion of the work programme R.V. Polarstern will return towards Bremerhaven and reach port on 19 September 2005.

2. OCEANIC FLUXES THROUGH FRAM STRAIT

Beszczynska-Möller, Greil, Hans, Hayek, Nauels, Schütt, Wisotzki (AWI),
Monsees, Graupner (Optimare)

Our aim is to measure the variability of the oceanic fluxes through Fram Strait on the long time scales - interannual and decadal. Due to a complex Ice-ocean-atmosphere interaction a vast amount of heat is carried northward by the global thermohaline circulation. From the North Atlantic the warm and saline water flows through the Nordic Seas and finally reaches the Arctic Ocean where it is modified by cooling, freezing and melting. As a result shallow fresh waters, ice and saline deep waters return to the south. The outflow from the Arctic Ocean to the Nordic Seas and further to the Atlantic Ocean provides the initial driving of the thermohaline circulation cell. Knowledge of these fluxes and understanding of the modification processes is a major prerequisite for the quantification of the overturning rate in the large circulation cells of the Arctic and Atlantic Oceans. It is also a basic requirement for understanding their role in climate variability on interannual to decadal scales.

The Atlantic water from mid latitudes enter the Arctic Ocean either through the Barents Sea or through Fram Strait. However, Fram Strait represents the only deep connection between the Arctic Ocean and Nordic Seas. The transfer of heat and freshwater is affected by the different ocean-atmosphere interaction over the deep passage of Fram Strait and shallow Barents Sea and the spreading of Atlantic water into the different pathways affects the climatic conditions in the Arctic. The Atlantic water inflow has a strong influence on the stratification and internal circulation in the Arctic Ocean and the outflow from the Arctic Ocean is either transferred south by the East Greenland Current or enters and affects the water mass modification in the Nordic Seas.

The complex topographic structure of Fram Strait leads to a splitting of the West Spitsbergen Current into at least three branches. One part follows the shelf edge and enters the Arctic Ocean north of Svalbard. This branch has to cross the Yermak Plateau, passing over the sill with a depth of approximately 700 m. A second part flows northward along the north-western slope of the Yermak Plateau and the third branch recirculates immediately in Fram Strait at about 79°N. The size and strength of the different branches largely determine the input of oceanic heat to the inner Arctic Ocean. The East Greenland Current carries water from the Arctic Ocean southward in a core concentrated above the continental slope, east of Greenland.

Since 1997 an array of up to 19 moorings provide high resolution measurements of currents, temperature and salinity in Fram Strait with the aim to estimate mass, heat and salt fluxes between the

Nordic Seas and Arctic Ocean. The year-round measurements of the moored instruments were combined with hydrographic sections taken during summer or autumn cruises. Until 2000 the observations were done in the framework of the European Union project 'VEINS' (Variability of Exchanges in Northern Seas). Since 2003 the work is carried out as a part of international programme 'ASOF' (Arctic-Subarctic Ocean Fluxes) and is partly funded by the EU in the project 'ASOF-N'.

In combination with regional models, the results of measurements will be used to investigate the nature and origin of the transport fluctuations on seasonal to decadal time scales.

The mooring array covers the entire deep part of Fram Strait from the eastern to the western shelf edge. In summer 2004 during ARK XX/2 19 moorings were deployed along 78°50'N, the twelve moorings in the eastern part are maintained by AWI and University of Hamburg. The observations are done in cooperation with the Norwegian Polar Institute. During ARK XXI/1b we are going to recover these moorings and to redeploy a new set of instruments at the same positions (Fig. 2).

The instrumentation of the new moorings remains similar as in the last year. For the second time an extended set of instruments will be deployed, including two moorings in the central part of the strait in the recirculation area and additional instruments at the depth of ca 750 m, the lower boundary of the Atlantic water. For sufficient vertical resolution, each mooring carries 3 to 8 instruments including current meters, two acoustic doppler current profilers (ADCP from RDI) and temperature and salinity sensors (Seabird). To increase a consistency of measured data, from 2005 on all deployed current meters will be Aanderaa instruments, RCM7/8 or RCM11. Two deep-sea pressure gauges (Seabird) will be installed at moorings to register changes in the sea surface inclination to estimate the barotropic component of the flow. Three moorings are combined with inverted echo sounders (PIES) which allow to distinguish between the changes of the sea level gradient caused by barotropic flow variations and by the variations of the water density. All moorings will be equipped with Posidonia transponders, which will allows optimal localization and thus decreases the potential risk of loss.

Hydrographic stations and ship-borne ADCP measurements will be conducted along the mooring line to supply temperature, salinity and velocity with much higher spatial resolutions than given through moorings. Depending on ice conditions, the section will be continued westward beyond the shelf edge to the Greenland coast. For the hydrographic measurements we will use a CTD system SBE 9/11+ in combination with a SBE 32 Carousel Water Sampler (Seabird). The in-situ oxygen sensor and fluorometer will be used with the CTD system. Water samples will be collected for on-board calibration of the conductivity and oxygen sensors. The salinity samples will be analysed with Autosal 8400A salinometer (Guildline) and the oxygen concentration will be measured with the automated precise Winkler titration.

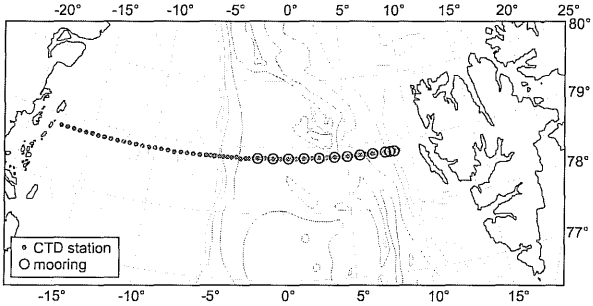


Fig 2 : Location of moorings and CTD stations in Fram Strait planned during ARK XXI/1b.

3. BIOGEOCHEMISTRY

3.1 Recent change in the Arctic: feedbacks to geochemical pathways in seawater

Damm, Helmke, Vöge, Lichte (AWI)

see chapter 3 of ARK XXI/1a

3.2 Nutrients, oxygen and dissolved organic matter

Ludwichowski, Vogel, Wolff (AWI), Falck (Uni Bergen)

see chapter 5 ARK XXI/1a

4. BIO-OPTICS

Schwarz, Corella (AWI)

see chapter 4 ARK XXI/1a

5. INTERDISCIPLINARY RESEARCH AT A DEEP-SEA LONG-TERM STATION IN THE ARCTIC OCEAN

Bauerfeind, Bergmann, Dannheim, Feseker, Kanzog, Kolar, Sablotny, Schewe, Volkenandt, Wegner (AWI), Pusceddu (University of Ancona)

Due to its enormous dimensions and inaccessibility, the deep-sea realm remains the world's least known habitat. Even today, numerous of deep ocean processes and their relevance to global climate and ecosystem issues are not sufficiently understood.

Until a few years ago, deep-sea research simply meant the assessment of the pre-sent status in a distinct, unexplored region of the world's oceans. Single sampling campaigns or measurements, however, generate only snap shots, not allowing ex-trapolation on temporal variabilities. Consequently, ecological assessments are largely confined. Only long-term investigations at selected sites offer the opportunity to identify environmental settings determining the structure, complexity and the development of deep-sea communities. There is strong evidence that ongoing industrialisation affects the marine environment, including the deep sea. Hence, basic data are urgently needed to assess anthropogenic impacts on the deep-sea ecosystem. Long-term investigations at selected sites provide the information necessary to assess the present status, and to describe changes due to anthropogenic impacts. The opportunity to measure processes on sufficiently long time scales will finally help to differentiate spatial and temporal variability from (natural) long-term trends.

A comprehensive ecosystem analysis needs investigations on interactions between abiotic and biotic components. Thus, close cooperation between all disciplines working in the marine domain is a prerequisite.

Following a pre-site study using the French Remotely Operated Vehicle (ROV) "VICTOR 6000" in summer 1999, we established the first long-term station in polar deep-sea regions in the eastern Framstrait off Spitsbergen (Fig. 3). Beside a central experimental area at 2500 m water depth (AWI-

"Hausgarten"), we defined 9 stations along a depth transect between 1000 - 5500 m, which were extended during the past years by six 2500 m stations on a north-south transect. These stations are revisited at least once a year to analyse seasonal and interannual variations in biological, geochemical and sedimentological parameters.

Organic matter produced in the upper water layers or introduced from land is the main food source for deep-sea organisms. To characterise and quantify organic matter fluxes to the seafloor, we use moorings carrying sediment traps. The ex-change of solutes between the sediments and the overlaying waters as well as the bottom currents will be studied to investigate major processes at the sediment-water-interface. Virtually undisturbed sediment samples were taken using a multiple corer. Various biogenic compounds from the sediments will be analysed to estimate activities (e.g. bacterial exoenzymatic activity) and total biomass of the smallest sediment-inhabiting organisms. Results will help to describe the eco-status of the benthic system. The quantification of benthic organisms from bacteria to megafauna will be a major goal in biological investigations.

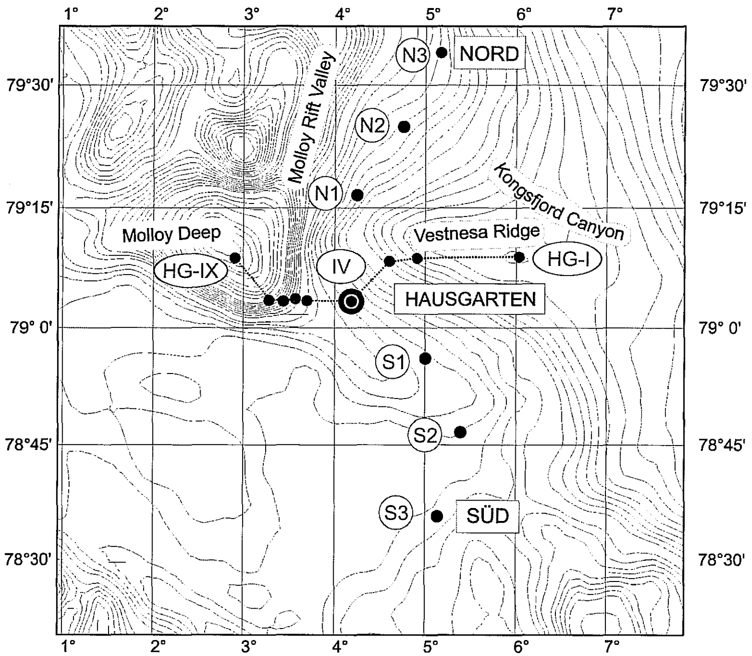


Fig. 3: Deep-sea long-term station AWI-"Hausgarten"

5.1 Particle flux to the deep seafloor

Bauerfeind (AWI)

Sedimenting organic matter represents food for benthic organisms. To estimate vertical particle flux funnel-shaped sediment traps with automatic sampling were de-ployed for about one year. During the expedition three arrays with three traps, each will be exchanged. Our main goal is to understand seasonal, regional, and interannual fluctuations of particle formation, modification, and sedimentation in relation to the benthic response, and to the impact of global change.

5.2 Activity and biomass of the small benthic biota

Kanzog, Kolar, Schewe, Volkenandt (AWI)

Quantitative assessment of meiofauna organisms, bacteria and the analysis of a series of biogenic sediment compounds representing (vertical and/or lateral) organic matter input from primary production (sediment-bound chloroplastic pigments), heterotrophic activity (bacterial exo-enzyme activity) and biomass of the smaller benthic infauna (phospho-lipids, particulate proteins) will allow to obtain substantial information on the eco-status of the benthic system.

Sediment sampling will be done with a multiple corer (MC), i.e. an instrument which allows the collection of almost undisturbed sediment samples especially for biochemical analyses at the sediment-water interface. The MC will be equipped with a video camera for online control. Meiofauna and bacteria samples will be preserved and later sorted at the home laboratory. Biochemical analyses for estimating heterotrophic activity in the uppermost centimetres of the sediments have to be done on board to avoid losses in activity during storage. Sediment samples for the determination of chloroplastic pigments and benthic biomass will partly be analysed on board or stored in deep freezers for later analyses at the home institute.

5.3 Impact of organic enrichments of sediments on hydrolytic potentials and growth of benthic bacterial deep-sea communities: in situ experiments and long-term investigations

Kanzog (AWI)

Particulate organic material (POM) that has settled from the euphotic zone serves as the main food source of benthic organisms. In the deep-sea, the processes of organic matter (OM) degradation are dominated by bacteria. The sporadic input of nutrients may affect the diversity and activity of bacterial

deep-sea communities. Results from an in-situ experiment which began during ARK XX/1 will help to under-stand how and to what extent the bacterial communities react to such events. Benthic colonization trays were deployed, which contained different types of artificial sediments and different concentrations of chitin and algae detritus. During ARK XXI/1, the trays will be sampled in order to measure enzymatic activities, applying various microbiological and molecular biological techniques.
To investigate the composition and colonization rate of bacterial communities deep-sea sediments will also be sampled using a multi-corer on three different stations at the AWI-Hausgarten (2300 m, 2500 m, 2700 m water depth). In the laboratory, these sediments will then be used for long-term incubation experiments with chitin and algae detritus.

5.4 The influence of “foodfalls” on benthic populations

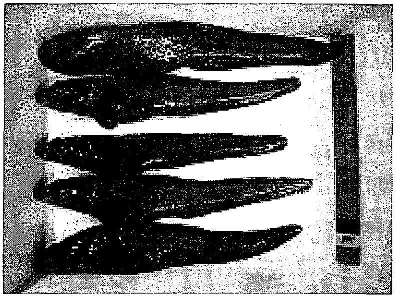
Schewe, Sablotny (AWI)

The food-supply of benthic deep-sea organisms is mainly contingent on the primary production of the euphotic zone. Dead planktonic algae are subject of various conversion- and decomposition-processes during their sedimentation to the seafloor. Just a small fraction of the detritus, grown within the primary production, reaches the deep-sea floor. However, if detritus particles agglutinate to larger conglomerates they gain a much higher sedimentation-velocity. Ice-algae growing at the lower side of Arctic ice floes, build up large algal mats. If suchlike mats or large perished animals drop to the deep-sea floor, such events represent an abnormal strong and patchy food-input, which is formally known as a “large foodfall”. Although these are natural processes within the oceans, they fulfill conditions, which conform, by our definition, to natural disturbances at the seafloor. Suchlike foodfalls are hard to locate within the deep-sea realm because of their relatively low dimensions. For that reason, we will deploy artificial foodfalls equipped with transmitters at the seafloor. In detail, we will deploy a large carcass and an algal matt at the central “Hausgarten-station” in 2500 m and at the Molloy Hole a single carcass in 5000 m. These artificial foodfalls will be accessed and investigated after one month by help of the remotely operated vehicle (ROV VICTOR 6000) during a later expedition.

5.5 Ecology and habitat requirements of Arctic demersal deep-sea fishes

Bergmann (AWI)

Fig. 4
Trap-caught Lycodes frigidus *from AWI-Hausgarten IV (water depth: 2400m)*



The planned research aims to expand our knowledge about the distribution and ecology and the functional ecological role of demersal deep-sea/shelf fish of the Arctic. During ARK XXI/1b, we will assess the importance of habitat type and depth for the distribution and ecology of demersal fish at the 'AWI-Hausgarten'. This long-term observatory comprises a sequence of nine stations along a depth gradient from 1250 to 5500 m. It provides a unique opportunity to assess the distribution of fish and their habitats along a depth gradient. Although underwater camera footage from this area has shown that demersal fish belonging to the genus Lycodes (eelpout) (Fig. 4) are abundant in this area no research has yet been undertaken to study their distribution, ecology and their functional ecological role. Remote-sensing techniques allow us to study habitat preferences and patterns in the distribution of fish at a large scale. However, such techniques do not allow us to infer the cause for such behaviour and to establish direct links between the fish and their environment. During this expedition, we will sample fish and mega-epifauna directly with a large Agassiz-trawl and fish traps attached to a benthic lander to study their ecology and for "ground-truthing" of our data from video analyses.

Planned work:

1. Agassiz-trawling to sample Lycodes spp. at the AWI-Hausgarten.
2. Determine species composition of demersal fish and mega-epifauna for "ground-truthing" of video analyses.
3. Assess length, weight, age and sex of each fish to calculate condition index, size frequencies and sex ratio.

4. Tissue samples for radio stable isotope (15N) to assess the trophic level of fish.
5. Stomach contents analysis to establish direct dietary links between fish and their environment and to study their functional ecological role as potential predators in the benthic food web.
6. Determine the weight of livers for the calculation of the hepatosomatic index and the liver lipid content as an indicator of habitat quality.
7. Describe reproductive biology: quantify the number of eggs & egg size in relation to fish length and age to gain an estimate of the age of sexual maturity.

5.6 Long-term temperature observation at Hakon Mosby mud volcano

Feseker (AWI)

Warm fluids escaping at seeps create heat flow anomalies which in turn, when detected and quantified, provide information on the nature and strength of fluid venting at those seeps. Measurements of temperature at several depths below the seafloor allow the determination of temperature gradients. Heat flow is defined as the simple product of the vertical temperature gradient and sediment thermal conductivity measured either in-situ or on core samples. A main goal is to use heat flow anomalies to constrain models of fluid flow at of Hakon Mosby mud volcano.

A temperature lance will be deployed at the center of the mud volcano for a long-term temperature observation. The lance will remain in the sediment and record temperatures for about one year in order to obtain a more profound insight into the temporal variations of the activity of the mud volcano. The temperature lance is a modified gravity corer, which is equipped with 8 temperature loggers mounted on outrigger holders. In order to facilitate the re-location of the lance during assessment and recovery, a buoy and/or a sonar reflector will be attached to the weight.

The lance will be deployed during the expedition ARK XXI/1b. After penetration into the sediment an acoustic releaser unit equipped with a POSIDONIA positioning system will be used to detach the temperature lance from the ship's cable. During an expedition with RV L'Atalante in September 2005, the position of the temperature lance will be assessed and documented with the help of the ROV Victor 6000. The lance will be recovered during the HERMES/VICKING expedition in June 2006.

6. BIOGEOGRAPHIC PATTERNS AMONG DEEP-WATER BENTHIC FORAMINIFERA, MOLECULAR VERSUS MORPHOLOGICAL APPROACHES

Pawlowski, Longet (University of Geneva), Cornelius (NOC)

Benthic foraminifera are a dominant faunal element in deep-sea and high-latitude settings. Many deep-sea foraminiferal morphospecies are widely distributed across tropical, temperate and high latitude localities. However, these morphology-based studies may not accurately reflect genetic variation. It is possible that widely separated populations have diverged genetically but not morphologically, or that the similarity has arisen from convergence. In the case of shallow-water foraminifera, there is some preliminary molecular evidence for genetic divergence between morphologically identical Arctic and Antarctic populations. By comparing the diversity of Arctic and Antarctic deep-sea foraminifera we will address the following questions: Do deep-sea species typically have small or large geographical ranges? Does morphological differentiation accurately reflect genetic differentiation?

To answer these questions, we have already collected samples from the Weddell Sea during "Polarstern" cruise ANT XIX-4 (2002) and cruise ANT XX11/3 (Jan-April 2005). Additional samples have been collected from Svalbard coastal waters during "Jan Mayen" cruise (2001) and "Oceania" cruise (2004), and from under Ross Ice Shelf and McMurdo Sound, Antarctica (1998-2003). Analysis of Weddell Sea material allows description of two new species. Preliminary survey of Svalbard foraminifera was reported in Gooday et al. (2005). Our studies of Antarctic foraminifera reveal exceptionally high morphological and molecular diversity of 'primitive' monothalamous (single-chambered) species. These species were show to be of crucial phylogenetic importance as modern representatives of lineages that originated within the initial radiation of early foraminifera in the Neoproterozoic period.

During R/V Polarstern cruise ARK XXI/1, we intend to isolate benthic foraminifera from different water depths and seafloor habitats using multicore samples. Samples for molecular studies will be sieved immediately and living foraminifera picked under a binocular microscope. Some specimens will be photographed and their DNA extracted. Others will be deep-frozen for further morphological and molecular analysis. Some multi-core samples for morphospecies analyses will be preserved in buffered 10% formalin. The molecular diversity will be examined using ribosomal DNA genes, amplified with foraminiferan specific primers, cloned and sequenced following protocol described in Pawlowski (2000).

Using material collected during this cruise, we aim to (1) obtain rDNA data for broad taxon sampling of Arctic foraminifera, (2) establish phylogenetic relationship and determine the genetic distance between Arctic and Antarctic species (3) search for cryptic species in common deep-sea taxa, (4) describe new species on the basis of morphological and molecular criteria. This work will complement studies on the diversity of polar foraminifera developed in collaboration with Drs. S. Bowser, A. Habura (Albany), W. Majewski (Warsaw), T. Hromic (Punta Arenas), T. Cedhagen (Aarhus), M. Hald (Tromso) and S. Korsun (Moscow).

7. PALEOCEANOGRAPHY AND SEDIMENTARY PROCESSES OF DRIFT DEPOSITS IN THE FRAM-STRAIT/YERMAK-PLATEAU AREA

Bardenhagen, Krauß, Lensch, Müller (AWI)

Studies of sediment drift deposits may give important information about changes in paleoclimate and paleoceanographic circulation patterns through time. During the Polarstern Expedition ARK-XX/2 (2004) major sediment drifts were documented in PARASOUND and multichannel seismic profiles from the Fram Strait/Yermak Plateau area (Stein, 2005). Unfortunately, no sediment cores could be obtained during this expedition. During the Polarstern Expedition ARK-XXI/1b, we plan to revisit two of the sediment drift locations (Fig. 5, Drifts 1 and 2) to take long sediment cores and near-surface sediments. The exact location of these cores is known (see below). Thus, no additional time for a site survey is needed.

Major objectives are:

- Study of the history and formation processes of sediment drifts on the Yermak Plateau.
- Establishing of a stratigraphic framework including sediment cores, acoustic profiles and well-constrained chronology (e.g., AMS14C and stable isotopes).
- High resolution reconstruction of the paleoclimatic and paleoceanographic circulation patterns in the Arctic gateway area, using sedimentological and geochemical methods.
- Study of past (bottom) water mass exchange between the Arctic and North Atlantic oceans.

This study is also an important survey for an IODP proposal for future scientific drilling in this area (Jokat, Stein et al., "Arctic Ocean – North Atlantic Gateway: Tectonic and paleo-oceanographic evolution of the Fram Strait and Yermak Plateau area during Cenozoic times").

In the two areas (Fig. 5, Drifts 1 and 2), a total of 13 geological stations will be carried out (two gravity cores and one GKG per station). The water depths are between 820 and 1200 m. Within the two working areas, the distance between the geological stations is between about 0.3 and 3 km.

Location of geological stations:

Latitude (N)	Longitude (E)	Station
81,100070	8,596360	drift-1-1
81,100290	8,511000	drift-1-2
81,100400	8,427480	drift-1-3
81,100430	8,100430	drift-1-4
81,100140	8,323590	drift-1-5
81,100220	8,303090	drift-1-6
81,100200	8,156590	drift-1-7
81,600180	6,167800	drift-2-1
81,600330	6,285490	drift-2-2
81,600380	6,390790	drift-2-3
81,600320	6,422080	drift-2-4
81,600240	6,464080	drift-2-5
81,600200	6,496150	drift-2-6

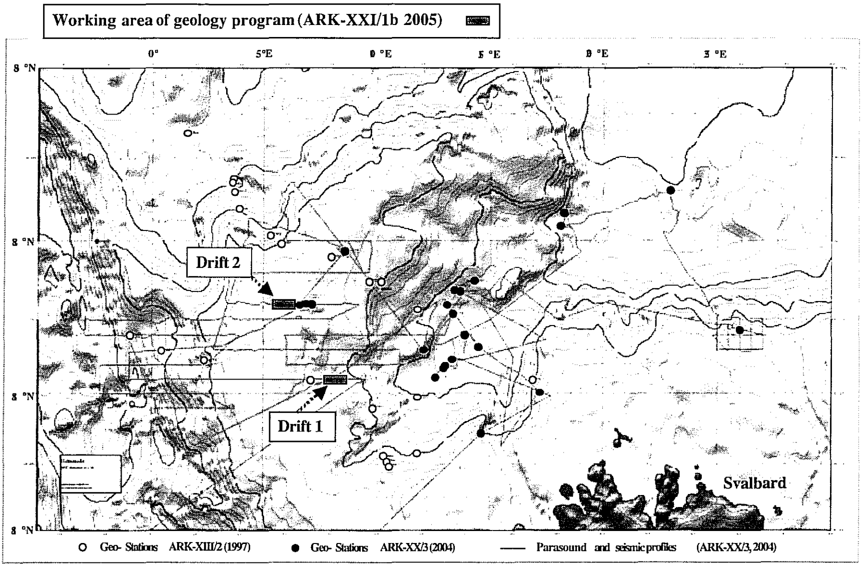


Fig. 5: Working area of ARK-XXI/1b geology program. Geological stations (ARK-XIII/2 and ARK-XX/3) and Parasound/seismic profiles (ARK-XX/3) of previous Polarstern *expeditions are also shown*

8. CHARACTERIZATION OF THE MAIN WATER MASSES WITHIN FRAM STRAIT WITH RESPECT TO PLUTONIUM (PU) ISOTOPES

Martinez Garcia (UAB)

Arctic sea ice has been proposed as a means of transportation for contaminants across the Arctic Ocean. In particular, the fate of Plutonium has been investigated for different reasons. First, it is a contaminant by itself that gets widely dispersed away from its source regions through incorporation into sea ice and subsequent transport with the Transpolar Drift, thereby reaching and affecting otherwise pristine regions. Second, its physical and chemical properties make it a suitable tracer: it is particle-reactive, i.e. it adsorbs relatively easily onto particle surfaces like mineral grains. On average, about 10% of total Plutonium activities are found in the particulate fraction. It can thus be transported in both the dissolved and the particulate form over long distances.

The half-lives of ^{239}Pu and ^{240}Pu (24100 and 6560 years, respectively) are long enough to not alter their activities during the 3 to 6 years transit time across the Arctic Ocean. Finally, the isotopic composition, expressed as ^{240}Pu/^{239}Pu atomic ratios, yields valuable information on the source regions and the different input mechanisms affecting the sea ice melting areas. Knowledge of the difference in atomic ratios for the various Plutonium sources provides information on the origin of sedimentary material, transport paths and scavenging processes taking place in the Arctic Ocean (Masqué et al. 2003).

Sea ice within the Arctic Basin is known to carry substantial amounts of particulate material which gets incorporated during ice formation especially on the shallow Siberian shelves through processes like suspension freezing, river spilling or aeolian input (Barnes et al. 1982, Reimnitz et al. 1992, Nürnberg et al. 1994). The incorporated material can carry Plutonium activities being transported to the Arctic via the large Siberian rivers. The sedimentary fraction of the ice will ultimately be discharged in ablation areas, notably the Fram Strait. Release of particulate material from melting sea ice will further enhance scavenging of Plutonium and its rapid removal from the water column into the sediment in this area.

So far, no data exist on the Plutonium content of sea ice itself, whether activity can be trapped during the freezing process or if ice can act as an adsorber with respect to particle-reactive elements.

^{137}Cs, a further anthropogenically released isotope, provides an excellent tracer for the study of water provenance in the North Atlantic. Its main origin for this region is the reprocessing plant of Sellafield in the Irish Sea.

The aim of the study is geochemical characterization of the in- and outflowing water masses in terms of their ^{240}Pu/^{239}Pu ratios and ^{137}Cs concentrations including the sea ice that leaves the Arctic via Fram Strait.

We will be sampling vertical water profiles along 79°N in order to characterize the main water bodies of the Fram Strait with respect to their isotopic composition of Pu and their ^{137}Cs content. For each sample, a precipitation of $Fe(OH)_3$ will be performed from 60 – 100 l of sea water which leads to scavenging of the Pu by the precipitate. The supernatant will then be taken of in order to perform a second precipitation that concentrates Cs. Both steps are done in the presence of a suitable yield tracer that allows later processing and measurements to correct for efficiency. Samples will be measured in the home laboratory by alpha-spectrometry or ICPMS for Pu and by gamma-spectrometry for ^{137}Cs.

Shiptime permitting, we will also sample different sorts of sea ice for the Pu and Cs content. Lumps of ice will be melted, filtered and the water treated as described for sea water samples.

9. SAMPLING OF PLANKTON FORAMINIFERA AND COCCOLITHOPHORES FOR PROXY VALIDATION STUDIES

Martinez Boti (UAB)

see chapter 6 of ARK XXI/ 1a

9.1 Study of alkenones in the Nordic Seas

Martinez Garcia, Martínez Boti (UAB)

see chapter 6.1 ARK XXI/1a

10. QUANTIFICATION OF HIGHER TROPHIC LEVELS

de Grave, Raty (VUB)

see chapter 7 ARK XXI/1a

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NOC.	Southampton Oceanography Centre European Way Southampton SO14 3ZH Great Britain

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12. FAHRTTEILNEHMER / PARTICIPANTS

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Longyearbyen - Bremerhaven

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Bardenhagen	Janine	AWI	Geologist
Bauerfeind	Eduard	AWI	Oceanographer
Bergmann	Melanie	AWI	Biologist
Beszczynska-Möller	Agnieszka	AWI	Oceanographer
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Cornelius	Nils	NOC .	Student
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Dannheim	Jennifer	AWI	Biologist
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Falck	Eva	Uni Bergen	Scientist
Feseker	Thomas	AWI	Geologist
Fuhs	Elisabeth	HeliTransair	Inspector
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Hayek	Wolfgang	AWI	Student
Heckmann	Hans Hilmar	HeliTransair	Pilot
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Lensch	Norbert	AWI	Technician
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Sablotny	Burkhard	AWI	Engineer
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Wegner	Jan	AWI	Engineer
Wisotzki	Andreas	AWI	Oceanographer
Wolff	Marthi	AWI	Technician

13. SCHIFFSBESATZUNG / SHIP'S CREW

Besatzungsliste Reise ARK XXI/1b
Name of Ship : POLARSTERN
Nationality : GERMAN Longyearbyen Bremerhaven

No.	Name	Rank
01.	Schwarze, Stefan	Master
02.	Grundmann, Uwe	1.Offc.
03.	Farysch, Bernd	Ch. Eng.
04.	Fallei, Holger	2. Offc.
05.	Peine, Lutz	2.Offc.
06.	Wunderlich, Thomas	2.Offc.
07.	Uhlig, Heinz-Jürgen	Doctor
08.	Hecht, Andreas	R.Offc.
09.	Erreth, Gyula	2.Eng.
10.	Kotnik, Herbert	2.Eng.
11.	Minzlaff, Hans-Ulrich	2.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Nasis, Ilias	Electron.
14.	Feiertag, Thomas	Electron.
15.	Verhoeven, Roger	Electron.
16.	Schulz, Harry	Electron
17.	Loidl, Reiner	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Vehlow, Ringo	A.B.
20.	Hartwig-Labahn, Andreas	A.B.
21.	Winkler, Michael	A.B.
22.	Guse, Hartmut	A.B.
23.	Hagemann, Manfred	A.B.
24.	Schmidt, Uwe	A.B.
25.	Bäcker, Andreas	A.B.
26.	Lamm, Gerd	A.B.
27.	Preußner, Jörg	Storek.
28.	Ipsen, Michael	Mot-man
29.	Voy, Bernd	Mot-man
30.	Elsner, Klaus	Mot-man
31.	Hartmann,Ernst-Uwe	Mot-man
32.	Grafe, Jens	Mot-man
33.	Müller-Homburg, Ralf-Dieter	Cook
34.	Silinski, Frank	Cooksmate
35.	Völske, Thomas	Cooksmate
36.	Jürgens, Monika	1.Stwdess
37.	Wöckener, Martina	Stwdss/KS
38.	Czyborra, Bärbel	2.Stwdess
39.	Silinski, Carmen	2.Stwdess
40.	Gaude, Hans-Jürgen	2.Steward
41.	Möller, Wolfgang	2.Steward
42.	Huang, Wu-Mei	2.Steward
43.	Yu, Kwok Yuen	Laundrym.