EXPEDITIONSPROGRAMM NR. 80

FS POLARSTERN

ARK- XXIII/1

ARK- XXIII/2

ARK- XXIII/3

Koordinator
Dr. E. Fahrbach

Fahrtleiter

ARK- XXIII/1
Gereon Budéus

ARK- XXIII/2
Gerhard Kattner

ARK- XXIII/3
Wilfried Jokat

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MITGLIED DER HERMANN VON HELMHOLTZ-GEMEINSCHAFT DEUTSCHER FORSCHUNGSZENTREN E.V. (HGF)

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EXPEDITION PROGRAMME No. 80

RV POLARSTERN

ARK- XXIII/1
12 June 2008 - 2 July 2008
Bremerhaven - Longyearbyen

ARK- XXIII/2
4 July 2008 - 10 August 2008
Longyearbyen - Reykjavik

ARK- XXIII/3
12 August 2008 - 19 October 2008
Reykjavik - Bremerhaven

Coordinator
Eberhard Fahrbach

Chief Scientists

ARK- XXIII/1:	**Gereon Budéus**
ARK- XXIII/2:	**Gerhard Kattner**
ARK- XXIII/3:	**Wilfried Jokat**

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ARK- XXIII/1

12 June 2008 - 2 July 2008

Bremerhaven - Longyearbyen

Greenland Sea

Chief scientist
Gereon Budéus

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Gereon Budéus (AWI)

Der erste Fahrtabschnitt der 23. *Polarstern*-Expedition in die Arktis beginnt am 12.6.2008 in Bremerhaven. Das Forschungsschiff *Polarstern* wird direkt Kurs nehmen auf die grönländische Küste bei 74°N und dort dicht vor der grönländischen Küste in eisbedeckte Gewässer laufen. Als erste Forschungsaktivität werden geodätische Arbeiten auf dem grönländischen Festland stattfinden. Per Helikopter werden Messstationen ausgebracht, die die Vertikalbewegung des Festlandes bestimmen, welche durch die abnehmende Eislast verursacht wird. Auf drei Breiten zwischen 74°N und 76°N wird je eine Station in Küstennähe sowie eine Station etwa 100 km weiter landeinwärts ausgebracht. Diese Stationen benötigen Messzeiten von einigen Wochen und werden auf dem nachfolgenden Fahrtabschnitt wieder geborgen.

Auf die geodätischen Arbeiten folgt ein hydrographischer Schnitt über die Grönlandsee. Dieser Schnitt verläuft von der Küste Grönlands bis zur Bäreninsel. Er wird unterbrochen durch die Auswechslung von autonom profilierenden Tiefsee-Verankerungen und einer speziell zur Untersuchung des Süßwassereintrags konzipierten Flachwasserverankerung. Der Schnitt entlang 75°N ist Teil eines Langzeitprojektes, dessen Ziel die Erfassung und Erklärung der hydrographischen Veränderungen im Becken der Grönlandsee und seinen Randströmen ist. Man hat erkannt, dass auch die arktischen Gewässer durch hohe Dynamik gekennzeichnet sind und dass die komplexen Veränderungen, bedingt durch Konvektion und Austausch mit den Randwassermassen, nur mit Hilfe langer Zeitreihen konsistenter Qualität richtig erklärt werden können. In den vergangenen Jahren zeigte sich ein verstärkter Einstrom von atlantischen Wassermassen, der weitreichende Implikationen besitzt. Dieser ist mit dafür verantwortlich, dass die Grönlandsee mittlerweile im Winter üblicherweise eisfrei bleibt. Während dieses Schnitts wird das Schiff überwiegend auf Station sein, da einer Dampfstrecke von etwa einer Stunde jeweils eine Station von circa 2 Stunden Dauer folgt. Verschiedene chemische Analysen der gewonnenen Wasserproben werden teils direkt an Bord, teils später im Labor durchgeführt.

Während die hydrographischen Arbeiten die gesamte Wassersäule bis zum Meeresboden beproben, nutzen Studien zur paläontologischen Proxy-Validierung unter Verwendung von Foraminiferen und Coccolithophoren die Seewasserversorgung des Schiffes, um die Hauptwassermassen und Fronten entlang des Schiffsweges zu bestimmen. Ein weiteres Ziel dieses Projektes ist eine Verbesserung des Verständnisses der Interaktion zwischen Ökosystem und Umweltbedingungen in der Subarktis, insbesondere im Hinblick auf die Fähigkeit des Biosystems zur Anpassung an die aktuellen und vorhergesagten klimatischen Veränderungen. Mit ARK-XXIII/1 wird erstmals eine interannuelle Vergleichsstudie in diesem Gebiet durchgeführt.

Die Verteilung von Seevögeln und marinen Säugern unterliegt ebenfalls den klimatischen Veränderungen, besonders im Hinblick auf die wechselnde Ausdehnung der eisbedeckten Flächen. Der besondere Wert der Quantifizierung dieser Tiere auf ARK-XXIII/1 liegt dementsprechend ebenfalls in ihrem Charakter als Langzeitstudie, die bereits 1973 begonnen wurde. Die Verteilung der Walvorkommen im Nordatlantik zeigt bereits eine deutliche Veränderung aufgrund der Modifikation der Eisbedeckung in der Arktis. Die Zählungen werden entlang des gesamten Schiffsweges bestimmt.

Am 2.7.2008 wird *Polarstern* den Fahrtabschnitt beenden und in Longyearbyen einlaufen.

OVERVIEW AND ITINERARY

The start of the first leg of the 23rd *Polarstern* expedition to the Arctic is scheduled for 12 June 2008. The ship will be heading directly to the east Greenland coast at 74°N and enter ice-covered waters between Jan Mayen and the Greenland coast. Geodetic work on Greenland will be the first research activities. GPS receivers will be installed on land with the use of helicopters. The receivers determine the vertical movement of the land masses which are caused by the decreasing ice load. At three latitudes between 74°N and 76°N receiver pairs will be installed, one close to the coast, and the second about 100 km inland. The instruments need a measuring period of some weeks and will be recovered during the next cruise leg.

After the geodetic work a hydrographic transect across the Greenland gyre will be performed. This transect extends from the Greenland coast to Bear Island. It is interrupted by the exchange of autonomously profiling deep sea moorings and a shallow water profiling mooring which is specifically designed to assess the fresh water introduction into the gyre. The zonal transect at 75°N is part of a long-term project the aim of which is to observe and explain the hydrographic modifications in the Greenland basin and its bounding currents. It has been recognised that the Arctic Waters experience highly dynamic changes, and that the complex modifications by convection and the exchange with the surrounding waters can be correctly explained only with the aid of quality-consistent long-term time series. During recent years, an increased input of Atlantic waters has been perceived which has far reaching implications. The increased input essentially contributes to the fact that the Greenland Sea remains usually ice free in winter nowadays. While performing this transect, the ship will keep its position most of the time, as 2 hour station times alternate with 1 hour steaming. Various chemical analyses of the collected water samples will be accomplished either directly on board or later in the lab.

While the hydrographic investigations 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. A major aim of this research is to contribute temperature and ice-cover reconstructions of the Holocene to the existing climate databases. A second aim is to improve current understanding of environment-ecosystem interactions and to estimate to which extent Arctic biota can absorb the currently predicted climate changes. With ARK-XXIII/1, an interannual comparative study will be performed in this area for the first time.

The distribution of higher trophic levels (seabirds and marine mammals) is also dependent on climatic changes, in particular with respect to the changing size of ice covered areas. The specific quality of the quantification of these species during ARK-XXIII/1 is due to its long term approach which started already in 1973. The distribution of certain whale species in the North Atlantic has already shown a marked modification which results from the reduced ice cover in the Arctic. The observations will be carried out along the ship's entire pathway.

On 2 July we will finish the cruise leg and call at the port of Longyearbyen.

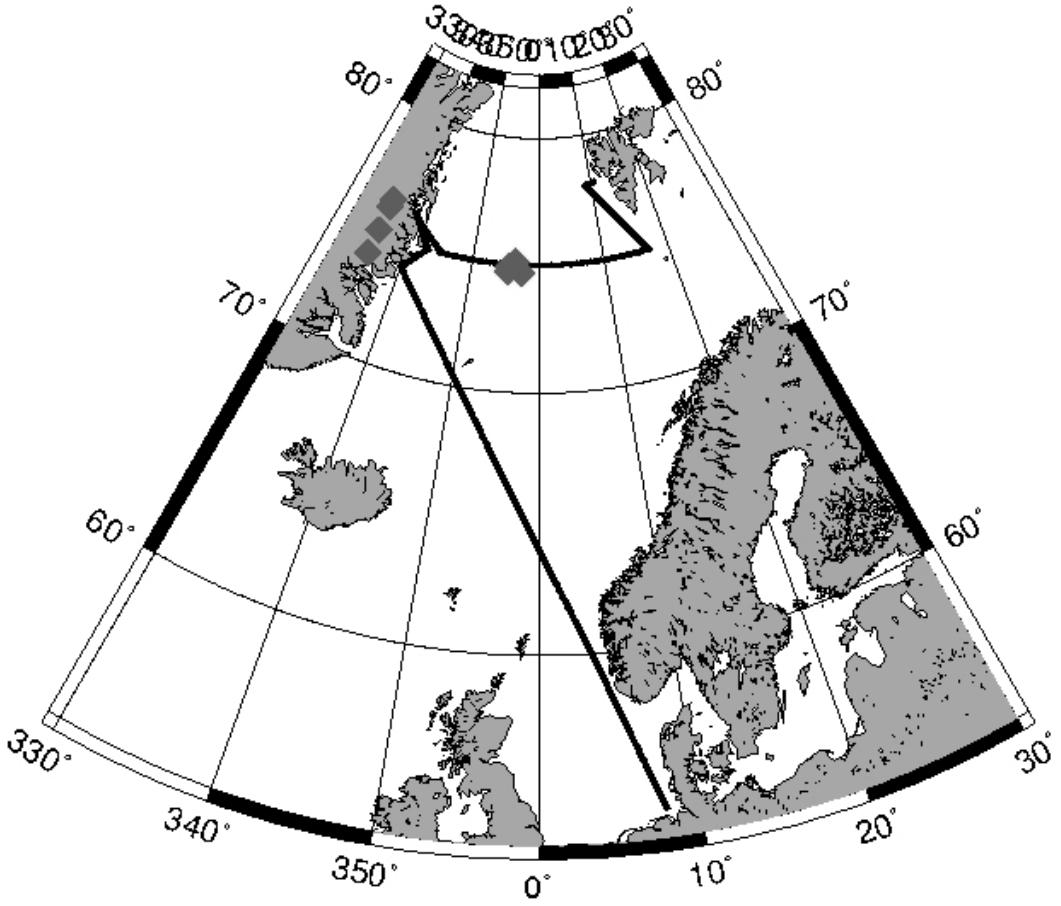

Fig. 1: Cruise track (black line) and specific work areas (diamonds) during ARK-XXIII/1. Marked work areas on Greenland tag geodetic work sites, those in the Greenland Sea tag oceanographic moorings.

2. LONG-TERM VARIABILITY OF THE HYDROGRAPHIC STRUCTURE, CONVECTION AND TRANSPORTS IN THE GREENLAND SEA (LOTEVA-GS)

G. Budéus, T. Dammrich, J. Jacob, L. Kattner, V. Mohr, R. Plugge, H. Weber, O. Zenk (AWI), H. Botnen, E. Falck (University Bergen) , H. Rohr (Optimare), H. Pulz (IPY teacher)

Introduction and Objectives

Physical processes in the entire 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. The changes here represent the first example of a basin-wide structural modification due to increased fresh water input. Today it is clear that the straightforward idea of regular, repeated bottom water renewal in winter is not correct at present and that the previously proposed concepts for deep convection do not adequately describe the actual 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. The doming structure of the 80s has been superseded by a marked two layer structure which has formed a slight depression in the gyre centre recently. In this situation, bottom water properties change towards higher temperatures and salinities. This can to a large part be explained by a 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.

Work during the recent years has shown 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 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 of the early 1980s.

Recently, suprisingly long-lived submesoscale 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 1,000 m greater than in the background (some 2,600 m vs. 1,600 m). These eddies seem to survive a number of years by a repeated homogenisation during winter. It is in the centres of these eddies where winter convection is expected to meet the ocean bottom first. In order to assess the importance of the SCVs, they deserve a small scale survey which investigates their structure if one is met accidentally or after a search pattern.

In all depth levels, the Greenland Sea represents a highly dynamical environment with considerable temporal changes. Our present knowledge about the relevant hydrographic processes does not allow to predict the future hydrographic development (including

convective activity and transports) and consequently most of the analysis relies on field measurements. In order to assess the changes correctly and to gain an adequate perception of the processes, a longer time series is necessary. It has to comprise continuous and consistent observations including the water mass end members on the shelves. As convection history is established by comparisons between subsequent years, a disruption of the time series is adverse to its analysis (a one year gap leading to a loss of convection determination of two years).

Within the project, a unique hydrographic time series is being established by an annually repeated zonal transect across the Greenland gyre center and by measurements of autonomous profilers (EP/CC-Jojo, 2-daily profiles, full depth, 1 year exchange cycle) which give unprecedented insight to winter convective activity as well as to advective modifications. The major aim is to detect and quantify the interannual and seasonal physical/chemical changes in the Greenland gyre interiour as well as in the surrounding large currents and to identify the responsible processes for the former.

Work at sea

Due to the large spatial gradients and relatively small spatial scales involved (Rossby radius about 20 km) it is indispensable to perform measurements with a comparatively small station spacing and in a sufficient number. Otherwise spatial and temporal differences, which are of the same order in this region, cannot be distinguished and any derived trend is most likely heavily biased. Furthermore, SCVs have to be identified, distinguished from the background, and skipped from the background trend analysis. According to this, the transects are performed with a station spacing of 10 nautical miles or less, which results in about 60 CTD stations on a zonal transect at 75°N. A double sensor set is used for temperature and conductivity and various additional sensors will be operated. The most important of these is the electical oxygen sensor.

In addition to the electrical measurements, water samples are taken by a carousel water sampler. The water samples serve as *in-situ* calibration material and are used to determine oxygen content according to the Winkler method.

Three autonomously profiling EP/CC moorings will be exchanged. They are equipped with modified SBE-16 CTDs with Digiquartz pressure sensors. They deliver complete profiles every other day, travelling between the parking position at roughly 100 m and the ocean bottom at 3,700 m. In order to assess the annual fresh water cycle in the Greenland gyre, a specialized profiling shallow water yoyo CTD has been installed in 2007. This mooring reveals profiles between 160 m and the surface proper, and will be exchanged, too.

3. ARCTIC CLIMATE AND MARINE EXPORT PRODUCTION: A MULTIPROXY APPROACH

B. Hambach, S. Fietz (University Barcelona)

Objectives

Despite recent rapid advances in climate research, the predictions and observations on temperature and ice cover changes in the Arctic are still fragmentary and large discrepancies between model outputs exist. These models still need to be supported and validated. The

most accurate way to determine global and regional changes and their impacts is based on modern instrumental records. These monitorings are naturally too short in time to assess natural variability at multi-decadal or millennial time scales. The long-term perspective can be, however, reproduced by palaeo-environmental and -climate studies. Hence a major aim of our research group is to contribute temperature and ice-cover reconstructions of the Holocene to the existing climate databases. A second aim is to improve current understanding of environment-ecosystem interactions and to estimate to which extent Arctic biota can absorb the currently predicted climate changes. Temperature and ice cover primarily drive the biological processes, e.g., benthic-pelagic coupling, in the Arctic. Current understanding is that, upon warming and ice cover decline, the relative importance of sea-ice biota, pelagic communities and benthic assemblages will likely shift from a ´sea-ice-organisms/benthos-dominated´ to a ´pelagic/zooplankton-dominated´ mode.

For these studies we use proxies for temperature (alkenone unsaturation-index UK37', TEX86-index from archaebacterial tetraether lipids and Mg/Ca ratio in foraminifers), for ice cover (branched isoprenoids, exopolymers, coccolite species, $\delta^{18}O$ in coccolites and foraminifers), as well as for primary and export productivity and food web structure (alkenones, photosynthetic pigments, sterols, fatty-acids, coccolites and foraminifers). Refining and calibration is required for all these fossil markers in the Arctic. Sediment cores to assess long-term changes have been collected in a precedent cruise in 2007 with the RV *Maria S. Merian* (MSM 05/05) as well as first water samples for distribution study and calibration purposes. To integrate the interannual variability in our studies and to include novel proxies we want to retrieve further samples and data on *Polarstern* cruise ARK-XXIII.

Work at sea

Along the transect Bremerhaven-Greenland we will filter seawater pumped through the clean seawater system from the ocean surface in regular intervals. One of the great advantages to plankton pumping is that it does not involve any additional ship time. Ideally, we will connect two water flows, one directly into four in-line filter systems and a second to plankton net. Salinity and temperature data will be monitored with the thermosalinograph at the same time. Collected water from the CTD rosette will be filtered by a fixed filter ramp with connected vacuum pump. At each anchoring station off the Greenland coast as well as in regular intervals along the transect at 75º N (Greenland – Svalbard; approx. 10 stations) we will collect water samples from the CTD rosette bottles at least from two depths, i.e. from chlorophyll maximum and bottom water. The chlorophyll maximum will be determined with a fluorescence probe attached to the CTD transmitting real-time data. Ideally (and according to other participants' needs), 12 bottles are used per depth. This will allow us to determine the biomarkers with separate filters and in duplicate. During the CTD stations water samples shall be collected in parallel using the clean seawater pump. Water from the surface pump will be also used for filtering water through a plankton net. Hence, at each station we will get data at least from surface, chlorophyll maximum and bottom water. At two deep-water stations along the 75º N transect we will collect water from the CTD rosette bottles along a depth profile.

4. AT-SEA DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

R.M. Lafontaine, B. B. Tessens, B. Pecceu (PolE)

Objectives

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) which characterise the main water masses (Atlantic water, polar water, pack ice), of front structures between these water masses and of the ice edge. The 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 extend.

This expedition is part of a long-term study in both polar regions with emphasis on the European Arctic seas. The data gained during this cruise will be integrated into the time series running since 1973 (Greenland Sea), and this series will be used to detect possible evolution in numbers (populations) for the last 30 years. Very important data have been recently collected on board *Polarstern* in conditions of extremely low ice coverage in the Greenland Sea, with strong decrease of breeding little auks – the main species with 1.3 million pairs breeding on Svalbard – in the southern limit of their range. Such effects obviously deserve more study.

Another example of recent analysis is a major increase of large cetacean numbers in the Greenland Sea which was noted in summer 2007. The following species were concerned, in decreasing importance of changes: bowhead *Balaena mysticus,* blue whale *Balaenoptera musculus,* humpback *Megaptera novaeangliae,* fin whale *Balaenoptera physalus* and sperm whale *Physeter macrocephalus.* The most striking increase was noted for the bowhead: one observation during more than 2,500 hours of transect counts from 1979 to 2005, *versus* 57 in 2007, during less than 100 hours. Observations of the other species mentioned increased by one order of magnitude and more between 2005 and 2007. Such increases can obviously not be explained by population growth when taking their low reproduction rate into account. The proposed interpretation is that Northeast Atlantic and North Pacific stocks of these species, separated formerly by pack ice off Siberia and Canada, came in contact through the Northeast and/or Northwest Passages, which became accessible to cetaceans as a consequence of decreasing pack ice coverage. These exchanges resulted in a drastic increase in numbers in the Northeast Atlantic, since its stocks used to be much smaller than the North Pacific ones. It also means that the previously separated stocks merged into one single population.

Work at sea

Transect counts will take place when *Polarstern* is sailing, since seabirds can be massively attracted by ships during station work.

5. VERTICAL AND HORIZONTAL DEFORMATIONS OF THE EARTH'S CRUST AS DETERMINED BY GPS OBSERVATIONS IN NORTH-EAST GREENLAND

M. Scheinert, A. Groh, R. Rosenau (TU Dresden), K. Engsager (NSI Copenhagen)

Objectives

The only continental ice sheet outside Antarctica still exists in Greenland. It plays an important role for the global climate. Although it only contains 10 % of the global fresh-water storage in comparison to the Antarctic ice sheet, it reacts in a very sensitive way to changes in the environmental and climate conditions due to its location at high- and sub-polar latitudes. Therefore, the Greenland ice sheet has been subject to intensive geophysical and glaciological investigations for almost one century.

Changes of the ice sheet are indirectly visible at deformations of the surface of the earth. Ice mass changes can be regarded as changing surface loads, which cause – due to the rheological properties of the upper layers of the earth – long-term visco-elastic or immediate elastic reactions. Hence, in the observable, vertical deformation of the earth's crust we can find the integral effect of all ice-mass changes during glacial history *and* in present times.

In North-East Greenland, however, no observations of the vertical deformation of the earth's crust have been carried out yet. Nevertheless, this region is characterized by a high variability of the ice edge with regard to its location and mass change as well as of a visco-elastic signal due to glacial history, which reaches maximum values in entire Greenland. Additionally, deformations of tectonic origin cannot be excluded, which will be tested analysing the horizontal components.

Satellite-based positioning by means of GPS allows a precise geodetic determination of coordinates and, with repeated observations, the determination of precise changes for the horizontal as well as for the vertical components with an accuracy in the sub-centimeter level. In order to ensure a high accuracy of repeated measurements, a stable base for the GPS marker has to be chosen. Therefore, the stations will be set-up at ice-free bedrock locations.

The scientific goal of the project is to identify and observe about 15 new GPS-locations in the ice-free regions of North-East Greenland. *One GPS station will serve as a reference station for the entire time period of both cruises.* The geodetic net configuration shall include a west-east component (stations at the ice edge and at the coast), and shall cover the entire north-south extension of the working area between 74°N and 81.5°N.

From the analysis of repeated GPS observations we will come up with deformations respectively rates, which serve as an independent source of information for the validation and improvement of models of the glacial history and the recent mass balance of North-East Greenland. While testing the significance of horizontal deformations we will contribute to an improved analysis of the tectonic regime in the working area.

This project is part of the internationally coordinated project POLENET (Polar Earth Observatory Network) of the International Polar Year 2007/08 (IPY). Linked to this international coordination we plan a close cooperation with Danish and American partners (cf. Project partners).

Work at sea

The locations, which have been identified during the preparation of the project, will be reached by helicopter. The reconnaissance will serve to chose the optimum position due to exposure, geological conditions and free visibility over the horizon. GPS stations will be set up and remain at the location for permanent observations of a minimum of 5 to 10 days. Additionally, geodetic-photogrammetric images of selected glacier streams will be taken using a digital camera. It is planned, that all stations, which will have been set up during cruise ARK-XXIII/1, will be re-collected during cruise ARK-XXIII/2.

Further geodetic stations will be observed in close cooperation and coordination with the Danish and US partners (Dr. Finn Bo Madsen of the Danish National Space Center, Copenhagen and Prof. Michael Bevis of the Ohio Station University, Columbus, USA). It is anticipated to optimize the choise of all stations with regard to position and co-location.

Tab. 5.1: Coordinate list of the planned GPS locations in North-East Greenland

ID	Länge	Breite	geographische Region
TUD-801	-18.5177	81.0340	Kronprins Christian Land CN
TUD-702	-21.5300	80.2770	Kronprins Christian Land CS
TUD-701	-16.3642	80.2386	Holm Land SE
TUD-603	-24.2635	80.0570	Kronprins Christian Land SW
TUD-602	-22.4652	79.6319	Kronprins Christian Land S
TUD-601	-18.4107	79.7136	Hovgaard Ø S
TUD-502	-22.0378	79.2698	Lambert Land W
TUD-501	-20.7889	79.0400	Lambert Land S
TUD-402	-23.2601	78.0433	Bildsøe Nunatakker
TUD-401	-18.4938	78.5639	Franske Øer
TUD-303	-23.0907	76.8564	Storstrømmen W (Dronning Luise Land)
TUD-302	-21.9794	76.5806	L Bistrup Bræ NE
TUD-301	-18.6203	76.0970	Store Koldewey S
TUD-202	-22.0803	75.2743	Kong Wilhelm Land S
TUD-201	-17.4879	75.1197	Shannon E
TUD-102	-23.9598	74.1763	Ole Rømer Land
TUD-101	-20.3268	73.8601	Hold with Hope NE

NE North-East
CN Centre-North
etc.

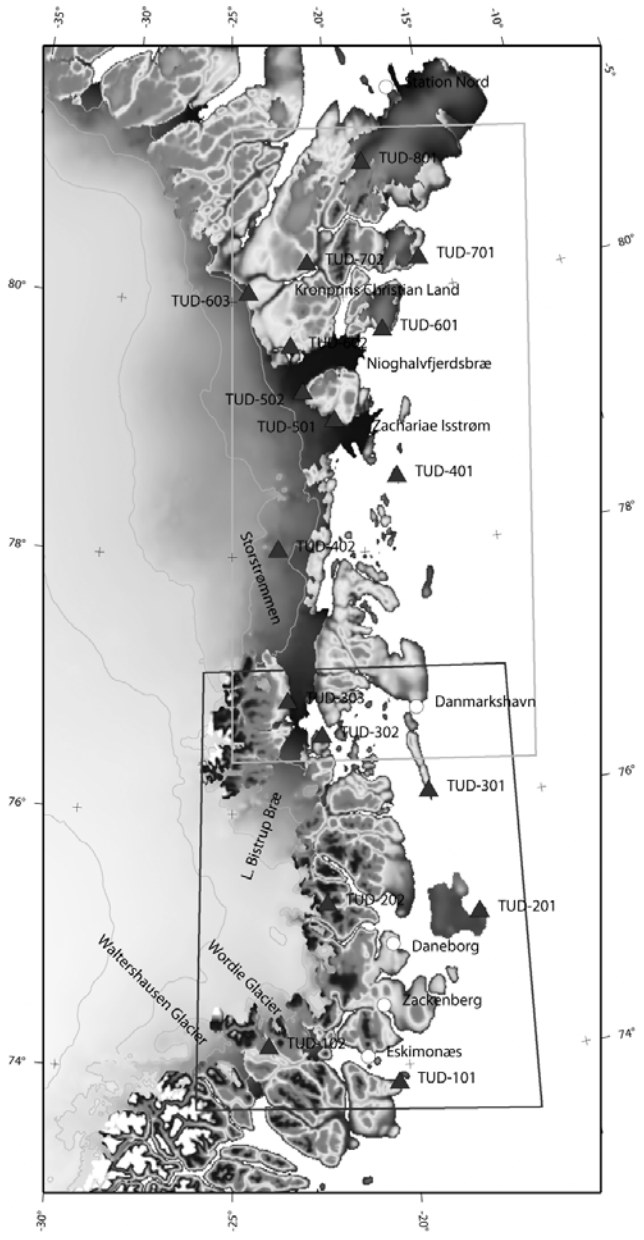

Fig. 5.1: Working area and planned GPS stations

ARK-XXIII/1

ARK-XXIII/2

6. BETEILIGTE INSTITUTE/ PARTICIPATING INSTITUTES

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University Barcelona	Universitat Autonoma de Barcelona (UAB) Institut de Ciencia i Tecnologia Ambientals (ICTA) Bellaterra E - 08193 Barcelona Spain
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8. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
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05.	Hering, Igor	2.Offc.
06.	Janik, Michael	3.Offc.
07.	Lambrecht, Wolfgang	Doctor
08.	Koch, Georg	R.Offc.
09.	Kotnik, Herbert	2.Eng.
10.	Schnürch, Helmut	2.Eng.
11.	Westphal, Henning	2.Eng.
12.	Holtz, Hartmut	Elec.Tech.
13.	Rehe, Lars	Electron.
14.	Dimmler, Werner	Electron.
15.	Fröb, Martin	Electron.
16.	Feiertag, Thomas	Electron.
17.	Clasen, Burkhard	Boatsw.
18.	Neisner,Winfried	Carpenter
19.	Kreis, Reinhard	A.B.
20.	Schultz, Ottomar	A.B.
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23.	Moser, Siegfried	A.B.
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25.	Hartwig-L., Andreas	A.B.
26.	Kretzschmar, Uwe	A.B.
27	Beth, Detlef	Storekeep.
28.	NN	Mot-man
29.	Fritz, Günter	Mot-man
30.	Krösche, Eckard	Mot-man
31.	Dinse, Horst	Mot-man
32.	Watzel, Bernhard	Mot-man
33.	Fischer, Matthias	Cook
34.	Tupy,Mario	Cooksmate
35.	Völske, Thomas	Cooksmate
36.	Dinse, Petra	1.Stwdess
37.	Hölger, Irene	Stwdss/KS
38.	Streit, Christina	2.Steward
39.	Hischke, Peggy	2.Stwdess
40.	Wartenberg, Irina	2.Stwdess
41.	Hu, Guo Yong	2.Steward
42.	Sun,Yong Sheng	2.Steward
43.	Yu, Chung Leung	Laundrym.
44.	Pagels, Christian	Appr.
45.	Keller, Maik	Appr.

ARK- XXIII/2

4 July 2008 - 10 August 2008

Longyearbyen - Reykjavik

Fram Strait

Chief scientist
Gerhard Kattner

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Gerhard Kattner (AWI)

Der Fahrtabschnitt ARK-XXIII/2 beginnt am 4. Juli in Longyearbyen und endet am 10. August in Reykjavik. Das Untersuchungsgebiet umfasst das nördliche Europäische Nordmeer, in dem sich die Forschungsarbeiten in der Framstraße zwischen Spitzbergen und Grönland sowie in der Nordost Wasser Polynja an der nordöstlichen Spitze von Grönland konzentrieren werden (Abb. 1). Ozeanographische, biologische, chemische und geophysikalische Arbeiten bilden die Schwerpunkte dieses Fahrtabschnitts.

Die Forschungsarbeiten werden mit ozeanographischen Untersuchungen kurz nach Auslaufen von Longyearbyen beginnen. Dieses Programm gehört zu einem Projekt, in dem die langfristigen Veränderungen des Wassermassen- und Wärmeaustauschs zwischen dem Atlantischen Ozean und dem Nordpolarmeer bestimmt und quantifiziert werden. Entlang der Fahrtroute auf 78°50'N werden in regelmäßigen Anständen Temperatur, Salzgehalt und Sauerstoff gemessen, sowie Wasserproben für die Bestimmung von Spurenstoffen genommen. Die für die ozeanographischen Langzeitmessungen ausgelegten Verankerungen, die 1-2 Jahre gemessen haben, werden aufgenommen und wieder ausgelegt bzw. durch neue Geräte ersetzt.

Für die biologischen Arbeiten im sogenannten AWI-*Hausgarten* wird der ozeanographische Schnitt unterbrochen. In diesem seit 1999 laufenden Projekt werden schwerpunkmäßig die benthischen Lebensgemeinschaften untersucht. Eine deutliche Abnahme und Veränderung in der Zusammensetzung der Fauna konnten bereits festgestellt werden. Neben dem Austausch von Verankerungen werden optische Systeme zur Erfassung der Besiedlung des Bodens eingesetzt sowie Netzfänge und Sedimentproben genommen.

Nach Abschluss der Verankerungsarbeiten wird *Polarstern* nach Norden fahren, damit die Geräte für die seismischen und geodätischen Arbeiten ausgebracht werden können, so dass ausreichende Messzeiten für diese Untersuchungen zur Verfügung stehen. Die Geräte für die seismischen Untersuchungen werden per Helikopter auf großen Eisschollen installiert. Erdbeben von extrem geringer Stärke in einem Gebiet, das sich nur sehr langsam ausdehnt, sollen so erfasst werden. Anschließend an diese Arbeiten werden GPS-Sensoren, ebenfalls per Helikopter, auf Grönland aufgebaut, um die vertikalen und horizontalen Bewegungsraten der Erdkruste zu bestimmen. Diese Geräte werden auch während des 1. Fahrtabschnitts weiter südlich installiert. Alle Geräte müssen am Ende des Fahrtabschnitts wieder aufgenommen werden.

Nach Ausbringen der Sensoren werden in der Nordost-Wasser-Polynja vor Grönland hydrographische, chemische und biologische Untersuchungen durchgeführt. Dieses Gebiet wurde bereits 1993 in einer mehrmonatigen internationalen Polynjastudie untersucht, so dass hier ein Vergleich der Ökosysteme unter den sich verändernden klimatischen Bedingungen möglich ist. Das Mesozooplankton wird in hoher Auflösung mit einem neu entwickelten optischen System bestimmt. Die chemischen Arbeiten konzentrieren sich auf die Produktion von Methan und Dimethylsulfide (DMS), beides wichtige Gase in der Atmosphäre. Anhand der Nährsalzkonzentrationen wird der Anteil pazifischen Wassers auf dem grönländischen Schelf, das durch die Beringstraße in den Arktischen Ozean gelangt, bestimmt. Diese Messungen werden seit vielen Jahren durchgeführt. So wurde bis zum Jahr

2004 immer pazifisches Wasser auf dem Schelf gefunden, aber danach konnte so gut wie kein Ausstrom von pazifischen Wassermassen mehr festgestellt werden. Während des gesamten Fahrtabschnitts werden die Beobachtungen von Seevögeln und Säugetieren, die während des 1. Fahrtabschnitts begonnen wurden, fortgesetzt.

Nach Abschluss der Arbeiten in der Polynja werden die Sensoren auf den Eisschollen und auf Grönland wieder aufgenommen und die hydrographischen Untersuchungen in der Framstraße fortgesetzt und beendet. Auf der Rückreise werden die GPS-Sensoren, die auf dem 1. Fahrtabschnitt auf ca. 75°N installiert wurden, wieder geborgen, bevor die Expedition am 10. August 2008 endet in Reykjavik.

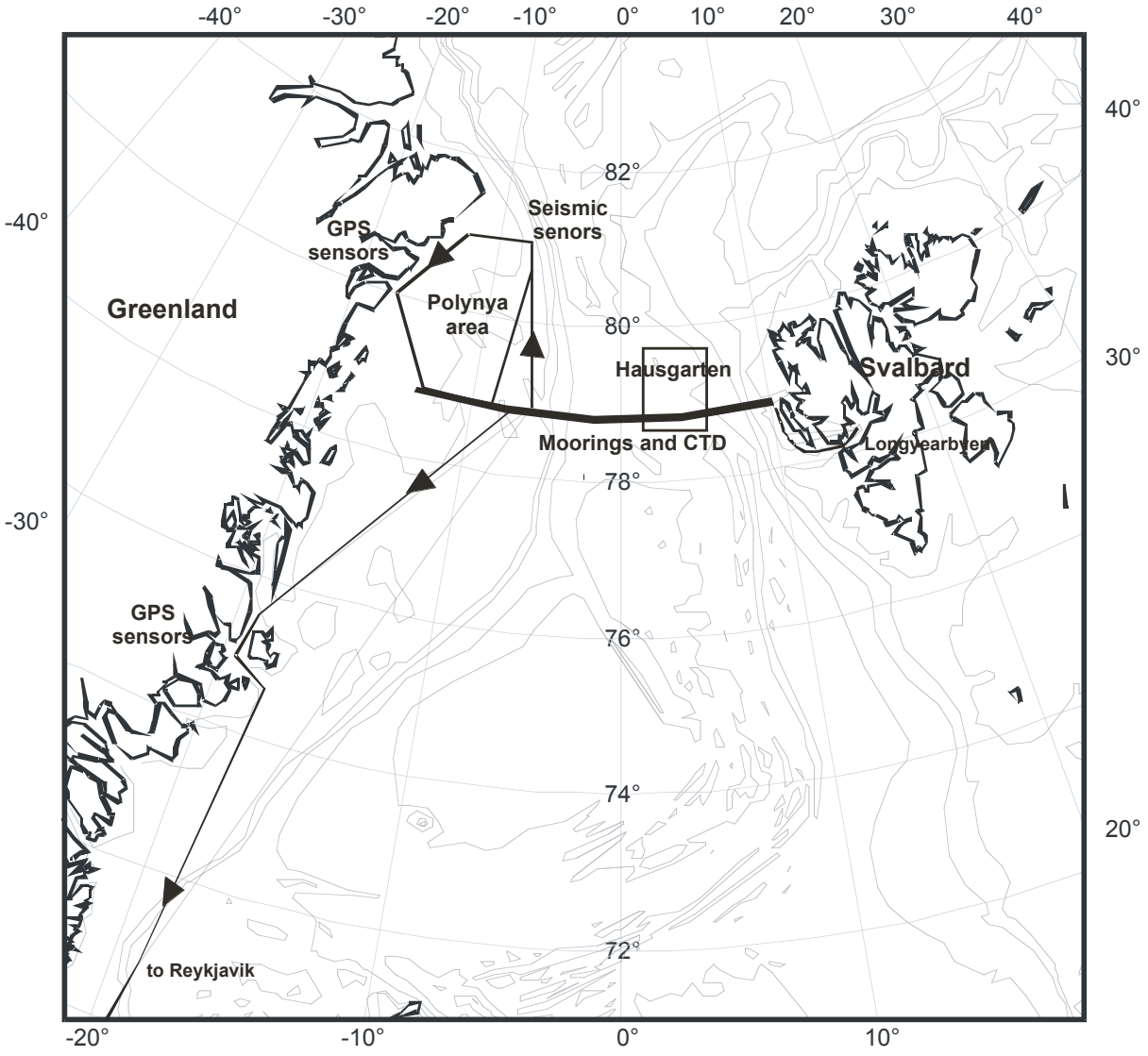

Abb. 1: Fahrtroute während ARK-XXIII/2
Fig. 1: Cruise track during ARK-XXIII/2

SUMMARY AND ITINERARY

The cruise leg ARK-XXIII/2 starts in Longyearbyen on 4 July and ends in Reykjavik on 10 August. The research areas are the northern Nordic Seas. The main working sites are the Fram Strait which is located between Svalbard and Greenland and the Northeast Water Polynya at the northeastern tip of Greenland (Fig. 1). Oceanographic, biological, chemical and geophysical investigations are the main objectives during the leg ARK-XXIII/2.

The oceanographic programme will be performed at the beginning of the cruise. The aim is to quantify the interannual to decadal variation of volume, heat and salt fluxes through Fram Strait. Since 1997 an array of moorings has been maintained to measure currents, temperature and salinity. The moorings, which have been measured for 1 to 2 years, will be recovered and redeployed. The year-round measurements will be combined with hydrographic sections measuring temperature, salinity, and oxygen. In addition, water samples for the determination of trace compounds are taken.

The biological studies in the so-called AWI *Hausgarten* will be coordinated with the hydrographic transect. The main focus of this programme, which has been started in 1999, is to study the changes of the polar benthic deep-sea ecosystem. Recent data show a significant decrease in total megafaunal densities and individual species. In the *Hausgarten* area moorings will be exchanged and optical systems as well as net sampling, trawls and sediment coring are applied for recording the bottom fauna assemblages.

After completion of the mooring work, *Polarstern* will steam northward to deploy sensors for the seismic and geodetic studies so that there is a period of at least one week for measurements. The instruments for the seismic studies, transported by helicopter, will be placed on large ice floes. Micro earthquakes in this region with ultraslow spreading ridges will be recorded with an array of seismometers. The GPS stations for the geodetic measurements are set up on Greenland with the helicopters. They will allow the very precise determination of changes for the horizontal and vertical components of deformation of Greenland's earth crust. GPS stations are also deployed during the first leg. The seismic and geodetic instruments will have to be recovered at the end of the leg.

The time until recovering of the sensors will be used to study the Northeast Water Polynya off Greenland. Hydrographic, chemical and biological studies will be performed. This region has already been intensively studied in 1993 as part of the International Arctic Polynya Programme so that it is possible to compare this special ecosystem in view of the changing climatic conditions. A newly developed towed optical system will be used to study the vertical and horizontal variability of mesoplankton distribution. The chemical studies focus on the production of methane and dimethylsulfide (DMS), both important gases in the atmosphere. The determination of nutrients will allow us to determine the proportion of Pacific water, which flows from the Bering Strait through the Arctic Ocean and exists on the Greenland Shelf into the Atlantic Ocean. However, the nutrient data from 2004 onwards show almost no signal of water of Pacific origin on the Greenland shelf. During the entire leg observations and counting of sea birds will be continued which will start already during the first leg.

After finishing the polynya studies the seismic and GPS sensors will be recovered, and the hydrographic work in Fram Strait will be completed. During our trip back to Reykjavik the

GPS stations, deployed during the first leg, will also be recovered before the cruise will end on 10 August 2008.

2. VARIABILITY OF OCEANIC FLUXES THROUGH FRAM STRAIT

A. Beszczynska-Möller, A. Wisotzki, O. Strothmann, A. Behrendt, A. Jha, L. Schönborn (AWI), M. Monsees (Optimare)

Objectives

Our aim is to investigate the variability of the oceanic fluxes through Fram Strait. This work contributes to long-term studies addressing the response of the various Arctic subsystems to the rigorous climatic changes of the last decades.

The spread of warmth to high latitudes in the Atlantic Ocean is part of the global thermohaline circulation. From the North Atlantic warm and saline water flows to the Arctic Ocean, where it is modified by cooling, freezing and melting and where huge amounts of river runoff is added. Shallow fresh waters, ice and saline deep waters return to the North Atlantic. 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. Atlantic water enters the Arctic Ocean either through the shallow Barents Sea or through Fram Strait which represents the only deep connection between the Arctic Ocean and the Nordic Seas. Just as the freshwater transport from the Arctic Ocean is of major influence on convection in the Nordic Seas and further south, the transport of warm and saline Atlantic water affects the water mass characteristics in the Arctic Ocean which has consequences for the internal circulation and possibly influences also ice and atmosphere.

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

The aim of the oceanographic work is to quantify the interannual to decadal variation of volume, heat and salt fluxes through Fram Strait. Since 1997 an array of moorings has been maintained to measure currents, temperature and salinity. The year-round measurements are combined with hydrographic sections taken during summer cruises. Until 2005 the observations were done in the framework of the European Union projects 'VEINS' (Variability of Exchanges in Northern Seas, 1997-2000) and 'ASOF-N' (Arctic-Subarctic Ocean Fluxes, 2002-2005). Since 2006 the work has been carried out as a part of 'DAMOCLES' EU Integrated Project.

An array of 18 moorings covers the entire deep part of Fram Strait along 78°50'N from the eastern to the western shelf edge. Twelve of these are maintained by AWI and 6 moorings in the western part of the strait by the Norwegian Polar Institute.

Work at sea

During ARK-XXIII/2 cruise 12 moorings will be exchanged in the central and eastern Fram Strait. Four of these moorings had been deployed in 2006 and not exchanged in 2007 due to the cancelled cruise, thus they have remained in the water for two years. Recovery of these moorings is of the highest priority because they will not endure the next year. The remaining 8 moorings deployed in September 2007 will be exchanged according a to one-year turnover period of moorings in Fram Strait. For sufficient vertical resolution, each mooring carries 3 to 8 instruments (current meters from Aanderaa, acoustic doppler current profilers (ADCP) from RDI and temperature and salinity sensors from Seabird). One AURAL sound recorder will be deployed in mooring F9. The deep-sea pressure gauges (Seabird) register changes in the sea surface inclination which will be used to estimate the barotropic component of the flow. In 2007 three moorings in the eastern Fram Strait were equipped with the low-frequency modems to test underwater acoustic data transfer. These modems will be recovered. In addition, the central communication mooring with the central data unit, underwater winch and profiling top will be deployed next to the mooring F6. Four inverted echo sounders with pressure sensor (PIES) were deployed in Fram Strait next to the moorings' positions in summer 2006 and could not be recovered in 2007 due to the lack of ship time. These PIES will be recovered, refurbished and redeployed during ARK-XXIII/2. Data collected by PIES will allow to distinguish between the changes of the sea level gradient caused by barotropic flow variations and by the variations of the water density.

Hydrographic stations with a CTD system SBE 9/11+ in combination with a SBE 32 Carousel Water Sampler (Seabird) and an *in-situ* oxygen sensor and ship-borne ADCP measurements will be conducted along the mooring line to supply temperature, salinity and velocity at higher spatial resolution than given by the moorings. Depending on ice conditions and time, the section will be continued westward toward the Greenland shelf. Water samples will be analyzed for salinity with an Autosal 8400A salinometer (Guildline).

The Seaglider, an autonomous buoyancy driven profiling vehicle equipped with pressure, temperature, conductivity, oxygen sensors as well as with RAFOS hardware and a sound source will be also deployed in Fram Strait during ARK-XXIII/2. The Seaglider will be operated from the pilot station in Bremerhaven during a ca. 2 months long mission, aimed in profiling the upper 1,000 m layer along hydrographic sections in Fram Strait.

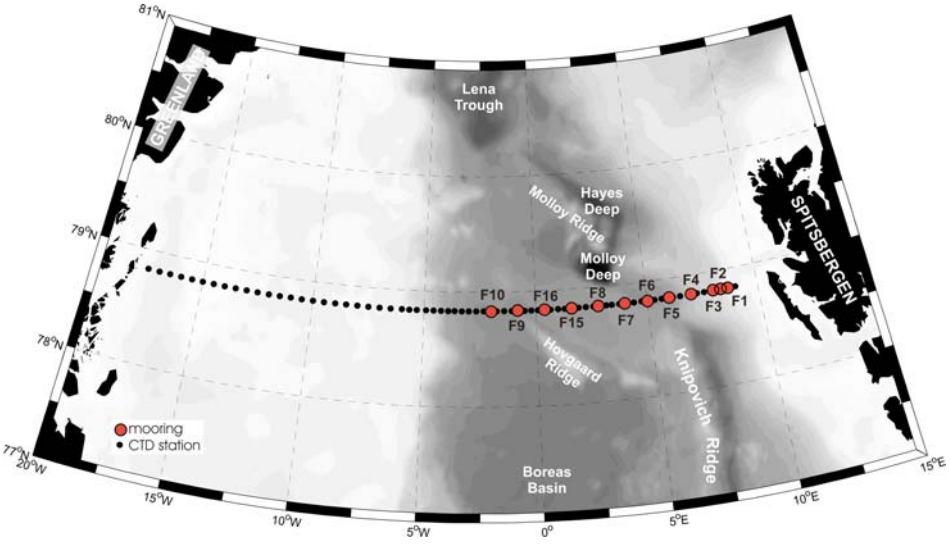

Fig. 2: Positions of moorings and CTD stations in Fram Strait

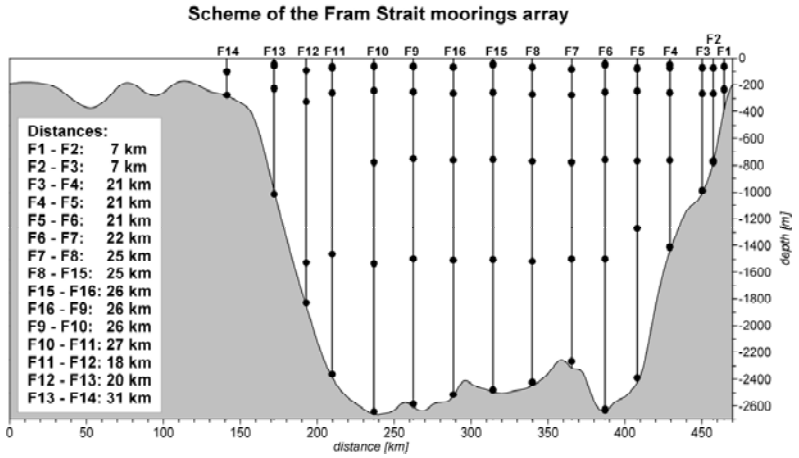

Fig. 3: Scheme of instrumentation at the Fram Strait moored array (moorings F1 to F10 will be exchanged during ARK-XXIII/2)

3. CHEMICAL OCEANOGRAPHY

M. Graeve, K.U. Ludwichowski, A. Schröer, G. Kattner (AWI), H. A. Botnen, E. Falck (University Bergen)

Objectives

The determinations of nutrients and oxygen are closely connected with the physical and biological investigations. Nutrients and oxygen are well suited as tracers for the identification of water masses. The changes in nutrient and oxygen concentrations will be followed in the Fram Strait region and especially across the Greenland slope and in the Northeast Water

Polynya which will be revisited and compared with a detailed investigation performed in 1993.

Northeast Water (NEW) Polynya has been already intensively studied as part of the International Arctic Polynya Programme in 1993. The NEW Polynya is located on the continental shelf off northeast Greenland and covers the area between the Norske Øer Ice Shelf in the south and the Ob Bank Ice Shelf in the north; the eastern boundary is given by the slope of the East Greenland Shelf. Polynyas are ice-free before the usual opening of the ice coverage and therefore receive light earlier, so that primary production can start earlier in the year than in other polar regions. The productivity, however, is basically limited by the nutrients available for the primary producers when environmental conditions are favourable for phytoplankton growth. The hydrography of the NEW shows a two layered water structure of relative fresh and cold water in the upper 50 to 150 m of depth, denominated as East Greenland Shelf Water because of its local character and an anticyclonic circulation. Below this layer warmer and saltier waters, influenced by Atlantic Water are located. Polynyas are assumed to be areas of high production.

In comparison with similar transects in former years to the Fram Strait region and the Greenland shelf, the seasonal and interannual variability of nutrients and oxygen 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. 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.

Work at sea

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

4. IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE COMMUNITY STRUCTURES AND FOOD WEBS

I. Schewe, E. Bauerfeind, M. Bergmann, B. Sablotny, S. Simon (AWI), C. Cathalot (CNRS), J. Przytarska (IOPAS), A.-K. Siegmund (University Göttingen), T. Schott (Oktopus)

Introduction

Long-time series of marine fauna and flora in the Arctic are rare. This is not surprising since the area is only accessible by means of expensive modern infrastructure and instrumentation. However, since the 1970's, Norwegian scientists have investigated both

jointly with other international partners and independently the fjords and coastal areas of the arctic archipelago of Svalbard and surrounding seas. More recently, these research co-operation activities have been formalised through participation in the ARCTOS network.

The Alfred Wegener Institute for Polar and Marine Research (AWI) established the *Hausgarten* in 1999 as the first and only long-term deep-sea observatory at high latitude. It comprises 15 permanent sampling stations along a bathymetric transect from the Vestnesa Ridge to the Molloy Hole (1,200 - 5,500 m) and a latitudinal transect along the 2,500 m isobath. These transects cross at the central *Hausgarten* station, which serves as an experimental area for long-term experiments. Long-term investigations at *Hausgarten* comprise various compartments of the ecosystem, including the water column and the deep seafloor. Repeated sampling and the deployment of moorings and long-term free-falling systems (bottom landers) have been conducted on an annual basis since 1999 and yielded an unrivalled time-series data set. *Hausgarten* has seen major changes over the monitoring period: the most prominent one is that both the surface and the deep waters have warmed by 0.025°C between 2001 and 2004 concurrent with a decrease in the phytodetrital flux to the seafloor and sediment-bound organic matter. A decline in organic matter input will affect the entire deep-sea ecosystem, which - in the absence of light - relies on the carbon flux from the euphotic zone and shelf. Indeed, recent data indicate a decline in the microbial biomass of sediments and changes in meiofaunal densities at some stations over the sampling period. Recently, a comparison of seafloor images from 2002 and 2004 showed a significant decrease in total megafaunal densities and individual species (unpublished data). These findings indicate that serious changes are already taking place at various levels of biological organisation. The AWI Deep-Sea Research Group has thus gained extensive expertise in multi-disciplinary research and collation of time-series data at deep high-latitude locations.

Concurrent with the efforts made by AWI the research groups of ARCTOS have access to the best available data to assess past changes in shallow Arctic pelagic and benthic ecosystems. In particular, this long-term co-operation has provided good baseline data from Kongsfjorden (site of large-scale Norwegian and EU research facilities). In 1996, a transect of ten stations (NPI) was established from the inner part of the Kongsfjorden to outside the shelf break at five discrete depth strata, and has been sampled several times a year. The data have been continuously processed until summer 2006. Additionally, a large data set has been gathered on fatty acid trophic markers and stable isotopes of zooplankton, fish and marine birds. The state of the Kongsfjorden ecosystem has been reviewed by several authors and the potential effect of climate swings.

It has been hypothesized that one major impact of global change is a shift in the quantity and quality of food available. For example, some models project increased pelagic productivity and recycling in the Arctic while benthic systems become impoverished due to a decline in nutrients reaching the seafloor coupled with a retreating ice edge. If we see a decline in key species, the trophic level of their predators may change as they starve or switch to other prey. To assess how changes at one level impinge on other compartments of the ecosystem, we began to optimise the scientific outcome of the two sampling programmes by combining the Kongsfjorden and *Hausgarten* transects. By chance, the shallowest AWI sampling station lies only some 25 nautical miles northwest of the deepest station of the Kongsfjorden transect. This collaboration between AWI and ARCTOS yields a more complete data set spanning from shallow to deep water stations.

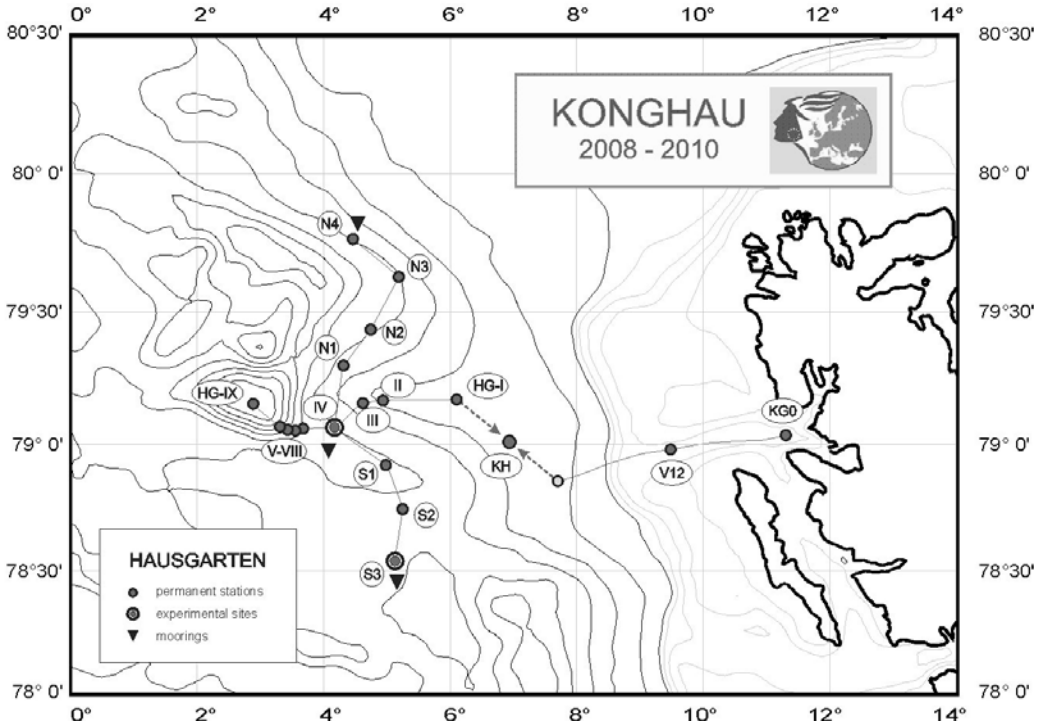

Fig. 4: Deep-sea long-term station AWI-Hausgarten

4.1 WATER COLUMN SAMPLING

Arctic *Calanus* species are the most important animals in high latitude seas because they convert low energy diet to high energy. The herbivorous copepods of the genus *Calanus* spp. comprise up to 70 - 80 % of the zooplankton biomass in Arctic seas and constitute the key link between primary production and higher trophic levels. In this programme, we will study the timing of the bloom on the seasonal and diel migration and the effect through different trophic levels in a high Arctic ecosystem, as well as the timing and productivity of key herbivore and carnivore species. Data on algal biomass, zooplankton community structure and abiotic environmental data, high-resolution mooring data of fluorescence and zooplankton seasonal and diel vertical migration will give information on “timing”. Pelagic data will be gained from plankton net hauls and moored sedimentation traps (see below).

Organisms inhabiting the deep sea chiefly rely on the input of organic material from the shallow and productive layer of the ocean. Therefore, estimates on the vertical particle flux are an important component of the sampling activities at *Hausgarten*. At high latitude, sedimentation and composition of settling particles is governed to a great extent by ice conditions and variations in ice coverage. However, sedimentation is also affected by the structure of zooplankton communities in the epi- and mesopelagic zone leading either to a retention or a sedimentation regime. At *Hausgarten*, the vertical particle flux has been

studied by year-round deployments of moored sediment traps since 2000. These moorings are also equipped with current meters.
Data from the shallow traps (~300 m) are available until 2005. First analyses of the data indicate a co-variation of the total particulate matter flux (TPM) and share of biogenic matter in TPM-flux with the ice conditions. A more detailed microscopic analysis of the intercepted particles is currently under way to evaluate the share and variation of ice-related organic matter in the sedimented particle pool. Here, we propose to extend the biochemical and microscopic analyses to samples from deep sediment traps from *Hausgarten* that could not be processed hitherto.

The sediment trap samples regularly contain varying amounts of zooplankton (swimmers). This material has been archived. A detailed analysis of these organisms (species composition, life stages) will allow us to gain insights into the structure of the zooplankton communities during winter, a period for which we usually lack zooplankton samples from this area. This analysis enables us to trace changes in community composition caused by the changing environmental conditions in the northern north Atlantic.

4.2 BENTHIC SYSTEM SAMPLING

4.2.1 Sediments

The sampling programme at *Hausgarten* comprises biochemical analyses to estimate the input of organic matter from phytodetrital sedimentation. Plant pigments are a good indicator for the input of phytodetritus to the seafloor and can rapidly and accurately be measured by fluorometry. To determine the nutrients available to benthic biota the total organic carbon content of sediments is also assessed. To obtain biomass estimates for benthic micro-organisms (bacteria, yeasts, fungi, protozoa and metazoan meiofauna) sediment-bound phospholipids which are indicative of cellular membranes are determined. Data are available for all these parameters from 2000 to 2006.

We will extend our *Hausgarten* sampling programme to selected stations of the Kongsfjorden transect. Sediment samples will be taken by a video-guided multiple corer or, depending on the sediment characteristics, by a box corer. We propose to analyse the total organic carbon content, phaeopigment concentrations, phospholipids quantities and granulometry of sediment samples.

On board oxygen microprofiles will be performed on collected cores from selected stations in order to improve the understanding of the relations, and eventually define parameters (and model) between meiofauna community and the sediment biogeochemistry (physical and biological environmental parameters). Focusing on the relationship at small scale sediment respiration and infauna-linked structures, we will study the horizontal distribution of oxygen profiles around biological structures on retrieved cores.

4.2.2 Benthic megafauna

Benthic megafauna plays an important role in benthic ecosystem function as they control the population dynamics of smaller biota through predation and bio-engineering and recycling of organic matter. Megafauna creates mounds, pits and tracks which increase habitat heterogeneity and the diversity of smaller-sized inhabitants (bacteria, meiofauna). Sponges and stalks of sea lilies enhance three-dimensional habitat complexity and present hiding places and secondary habitats to a host of organisms. Sessile organisms, which often belong to the suspension feeders, may be most vulnerable to environmental change since they

cannot escape. As megafauna plays an important role in ecosystem function and their densities are already in decline (unpublished data) it is of paramount importance to record changes in their abundance, composition and functional diversity over time. The composition and density of megafaunal assemblages can be assessed by analysis of footage from towed underwater cameras. The organisms present on images are identified to species or morphotypes and classified according to life style and feeding behaviour (e.g. sessile suspension feeder, mobile predator). This rather time-consuming process may be accelerated by the use of promising automated image analyses tools developed during the Statoil-funded CORAMM project. Voucher samples taken by trawl or box corer complement camera observations as they allow a direct taxonomic identification (ground-truthing) and thus assessment of diversity. A comparison of images from successive years allows us to assess changes in species' densities.

Scanned images taken by an Ocean Floor Observation System are already available for *Hausgarten* station IV from the years 2002, 2004 and 2007 which are currently analysed by a PhD student at AWI. More images were obtained from other *Hausgarten* stations in 2002, but still await analysis. Megafaunal samples for ground-truthing were obtained in 2004 and 2005 at most stations. Owing to time constraints we have been unable to carry out the repeated camera tows along the bathymetric *Hausgarten* transect required for a time series study. Here, we propose to assess the composition and density of megafaunal assemblages at selected stations along the proposed Kongsfjorden-*Hausgarten* transect by analysis of footage from towed underwater cameras.

4.2.3 Trophic level & food web

Traditional approaches to trophic studies rely on stomach content analysis together with field and laboratory observations. These approaches are somewhat problematic when working in the deep sea due to restricted access and technical problems: live organisms for experiments are difficult to obtain and stomach content analyses are hampered by specimen being damaged by sampling and pressure effects. Furthermore, it is difficult to identify the gut contents of species that macerate their prey. In addition, the prey found in stomachs represents only a snapshot in time. In recent years, stable isotope analysis has been established as an alternative approach to determine relative trophic positions of organisms. Naturally occurring stable isotopes of nitrogen (N) show a stepwise enrichment between prey and consumer tissue during assimilation processes. Selective metabolic fractionation leads to a preferential loss of lighter isotopes during excretion which is conventionally expressed as $\delta^{15}N$, the ratio of ^{15}N to ^{14}N. Grazing animals thus show ^{15}N enrichment relative to the plants they consume; predators show further ^{15}N enrichment relative to their prey species. This mechanism allows us to establish the relative trophic positions of members of a food web.

Over the past three years, stable isotope analysis has been done at most *Hausgarten* stations on demersal fish, meio-, macro- and megafaunal organisms, particulate organic matter from surface and bottom waters and sediments. Here, we propose to conduct stable isotope analysis at selected station(s) along the proposed Kongsfjorden-*Hausgarten* transect to understand the links between the water column and the benthic ecosystem. Benthic sampling (multiple and/or box corer and/or trawl) will provide the material required for measurements by continuous flow isotope ratio mass spectrometry. The $\delta^{15}N$ ratio of primary producers from surface waters and bottom particulate organic matter sampled by water samplers provides a reference point for other ecosystem compartments. A combination of our results with those from the water column by the NPI will enable us to collate a unique data set and understand the links between the pelagic and the benthic system.

5. TAXONOMY PHYLOGENY, PHYLOGEOGRAPHIC AND ECOLOGICAL ASPECTS OF NORTHERN POLAR DEEP-SEA PORIFERA (SPONGES) COMPARED WITH THE SPONGE FAUNA OF THE SOUTHERN OCEAN

D. Janussen, Senckenb.

Objectives

So far, only few data are available on the bathymetric and phylogeographic distribution of deep-sea sponge taxa at polar latitudes, and almost nothing is known about their colonization history, evolution and phylogenetic relationships. The aim of this proposed research project, planned in close cooperation with Prof. Dr. Gert Wörheide (Göttingen/Munich), Dr. Ole Secher Tendal (ZMUC Copenhagen) and other sponge specialists, is to resolve the systematic and phylogenetic relationships of selected key taxa of the sponge communities in Arctic and Subarctic areas. We want to reconstruct their phylogeographic history in comparison with sponge faunas from the Atlantic Sector of the Antarctic Ocean (notably the Weddell Sea, e.g. Janussen & Tendal 2007). An integrative approach of molecular techniques combined with morphological and palaeontological data will be applied, in order to achieve a better understanding of the colonisation and history of diversification of Polar Porifera, as a key-component of benthic communities in the Arctic and Antarctic Seas. We aim to resolve phylogenetic status of alledgedly cosmopolitan genera (such as *Acanthascus*, *Bathydorus*, *Caulophacus, Polymastia*, *Suberites*, *Tentorium*, *Asbestopluma*, *Chondrocladia*) and also of so-called “bipolar species” (e. g. *Anoxycalyx ijimai*, *Tentorium papillatum*). Furthermore to investigate, how the radiation of different sponge taxa may be linked with special adaptations, e. g. regarding nutrition and reproduction, to the extreme conditions of polar and deep-sea environments.

Work at sea

Sorting of the catches from benthic gears, particularly AGT and GKG, and immediate photographic documentation of all sponges. Furthermore, the sponges need to be preliminarily identified and sorted according to taxa very quickly, in order to make adequate decisions for each specimen concerning the types of fixation, especially in case of limited material priority decicions are required. Provided the biomass is sufficient, samples will be taken of each sponge taxon for: Histology and skeletal preparations, electron microscopy, genetics and biochemical and isotope investigations. Fragments of all sponges will be preserved in RNAlater (Sigma) to allow for a variety of subsequent molecular approaches, and the meio-infauna of the larger sponges will be collected and preserved for later identification.

Work at the home lab

After return of the cruise the sponges will be prepared for electron microscopy and histology at the home lab, and according to morphology they will be taxonomically identified, documented and described. The reconstruction of molecular phylogenetic relationships will be done predominantly by probabilistic methods, such as Maximum Likelihood and Bayesian Methods. We intend to sequence 18S and partial 28S rDNA sequences from selected demosponge and Hexactinellid species according to standard methods established (e.g. Dohrmann et al., 2008). Our taxonomical and phylogenetic studies will be flanked by the

analysis of stable isotopes ^{15}N und ^{13}C of species from representative sponge taxa. Our studies will be done in close cooperation with other WGs on board, and with collegues from AWI and DZMB.

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6. ZOOPLANKTON

K. Barz, A. Basilico (AWI)

In the northern North Atlantic, several large species of copepods dominate the water column and determine secondary production and vertical carbon flux. The three hydrographic domains (Atlantic, Arctic, and polar) are inhabited by different species which are distinguished by size and life cycle strategies. Shifts in species distributions will have dramatic effects on higher trophic levels such as birds and planktivorous fish which select for prey size. Although there are large interfaces between the hydrographic domains, at present these copepod species are contained within their different domains. When exported with currents they are expatriated and not able to maintain self-supporting populations. Thus, the troughs on the East Greenland Shelf are areas of expatriation of Atlantic species advected onshelf with the Return Atlantic Current. However, only little is known on the factors constraining biogeographic shifts. Temperature and/or timing of food availability are possible controls. Predicting shifts in species distributions require detailed knowledge on physiological and behavioural constraints. In addition, both direction and velocity of advection depend on vertical distribution pattern which may change on a dial and seasonal scale. Therefore high resolution sampling is required to describe the vertical distribution of zooplankton in relation to the physico-biological environment. LOKI is a newly developed towed optical system that will be used to study vertical and horizontal variability of mesoplankton distribution on scales < 1 m. Each image of an organism has the complete information on environmental parameters (temperature, salinity, depth, fluorescence, oxygen, position).

Objectives

The goal of our work during this cruise is to describe with a high resolution the habitat of key mesozooplankton species in their source regions (Greenland Sea gyre, Greenland shelf) and where water masses overlap (e.g. the East Greenland Polar Front and the Return Atlantic Current), to understand the magnitude and temporal scale of environmental stress they are exposed to.

7. METHANE *IN-SITU* PRODUCTION AND ITS RELATIONSHIP WITH DMSP CATABOLISM DURING A PHYTOPLANKTON BLOOM IN THE NEW POLYNYA (GREENLAND)

E. Damm, E. Lichte (AWI)

Methanogens form methane via various pathways commonly classified with respect to the type of carbon precursor utilized, e.g. the methylothrophic pathway indicates the intact conversion of a methyl group to methane. The contribution of methylated substrates is potentially large in the surface ocean, and methylothrophic methanogenis is considered to be a principal pathway from which methane is readily formed by microbial activity. However, direct evidence of the role of methylated substrates in aerobic seawater is still lacking.

DMSP is an abundant methylated substrate in the surface ocean and large amounts are produced annually by marine phytoplankton. DMSP (dimethylsulfoniopropionate) turnover plays a significant role in carbon and sulphur cycling in the surface ocean. DMSP degradation occurs via a demethylation pathway and a cleavage pathway. Cleavage of DMSP can be carried out by bacteria or by phytoplankton, and leads to formation of DMS (dimethylsulfide).

DMS partly escapes to the atmosphere where it is oxidized to sulphuric acid and methanesulfonic acid. These sulphur-containing aerosols serve as cloud condensation nuclei altering the global radiation budget. Thus, DMS may exert a cooling (negative) effect on earth's climate. However, bacteria in the water column oxidize a large amount of the DMS before it can be released to the atmosphere. Anaerobic metabolism of DMS results in the production of methane. Hence, the DMSP catabolism may also have a positive effect on the earth's climate due to the formation of the greenhouse gas, methane.

Because of the relatively small and semi-enclosed area of the Northeast Water (NEW) polynya (Greenland) water exchange is restricted, and the pathways of these climate-relevant biogases can be studied in detail. The carbon isotopic ratio of methane will be used to trace the *in-situ* production and the subsequent consumption processes because both processes alter the isotopic composition of the initial source material. Thus, a direct insight into the formation of a local methane cycle in surface water is likely to provide promising information. Furthermore, DMSP and its degradation products will be measured as potential precursors for methane.

Objectives

With this expedition we expect to expand our knowledge about the recent marine methane cycle. The aim of the investigations is to estimate the balance between the production/consumption pathways and the resultant isotopic fractionation processes during polar summer conditions. Furthermore, we intend to study the sea to air flux of excess methane related to background concentrations.

Work at sea

The investigations are a continuation of the work on methane distribution in the water column performed in the Barents Sea during ARK-XXI and ARK-XXII in 2005 and 2007. Water samples will be collected in Niskin bottles mounted on a rosette sampler at discrete depths throughout the water column on several stations along transects. The dissolved gases will be immediately extracted from the water and analysed for methane on board ship, using a gas chromatograph equipped with a flame ionization detector (FID). Gas samples will be stored for analyses of the $\delta^{13}C_{CH4}$ values in the home laboratory. Furthermore, samples for the analysis of DMSP will be taken at each station and analyzed in the home lab.

8. SEISMOLOGY: RECORDING THE SEISMICITY OF LENA TROUGH WITH SEISMOMETERS ON DRIFTING ICE FLOES

C. Riedel, C. Läderach, E. Korger (AWI)

Objectives

Ocean basins are formed by seafloor spreading at active mid-ocean ridges. Mantle material is upwelling under the ridges and melts to produce magma which erupts onto the sea floor and crystallises at depth to produce new oceanic crust. Crustal generation and plate separation rate keep pace over a wide range of spreading rates and produce oceanic crust with a uniform thickness of about 7 km. Models predict that at spreading rates below about 20 mm/y, the mantle looses heat by conduction and only small amounts of melt are produced at large depths. Consequently, magmatism and crustal thickness should decrease with decreasing spreading rate. Volcanic eruptions should be unlikely at ultraslow spreading ridges (<20 mm/y). Until recently, very little data from ultraslow-spreading ridges were available to verify this theory because these ridges are located in remote ocean basins like the ice covered Arctic Ocean. Contradicting the common theory, the Arctic Mid-Ocean Ridge Expedition (AMORE2001) showed that the ultraslow-spreading Gakkel ridge is divided into segments with pronounced volcanism and segments lacking any signs of mantle melting, their distribution being independent of the spreading rate. New models are therefore necessary to describe the processes of crustal generation at ultraslow-spreading ridges.

Micro earthquakes image the active tectonic and magmatic processes at mid-ocean ridges and therefore help to understand crustal generation. At ultraslow-spreading ridges the microseismicity is hardly explored. The Emmy Noether junior research group MOVE studies in various projects the seismicity of ultraslow-spreading ridges. In 2001 and 2007, we recorded micro earthquakes at three geologically different sites of the Gakkel ridge. The measurements proved that recording mico earthquakes with arrays of conventional land seismometers installed on drifting ice floes works sufficiently well to characterise the seismicity of the survey sites, provided that up to 3 arrays record for a time period of at least 7 - 10 days. Whereas sufficient data could be acquired in magmatically active regions of Gakkel ridge to analyse active tectonic and volcanic processes there, only 4 days of data are available for amagmatic segments. In order to comparatively analyse and understand the

contrasting properties of the seismicity of magmatic and amagmatic segments, further data are necessary for amagmatically spreading segments of ultraslow spreading ridges.

Lena trough represents a logistically better accessible survey area to study amagmatic spreading than Gakkel ridge. Therefore, we want to complete our microseismicity data set with the same type of measurements at Lena trough. Whereas spreading is perpendicular to the ridge axis at Gakkel ridge, Lena trough opens obliquely and has a complicated tectonic setting. Until now, it is poorly understood, whether Lena trough is an amagmatically rifted continental margin or has reached a state of ultraslow seafloor spreading. We hope that the new microseismicity data will shed light onto the active processes at this ridge and help to understand its tectonic regime.

Work at sea

Work at sea consists of installing seismometers on ice floes and leaving them as long as the expedition schedule allows. By helicopter we will fly into a survey area which lies roughly between 80.5° and 81.5°N and at about 3°W and look for a multiyear ice floe with a size of about 1 km. We will install 3 seismometers in a triangle of about 800 m side length on the ice floe. Each seismometer has a battery powered data logger and a sensor which has to be covered by a snow heap of about 1 m height to shelter the seismometer against temperature changes and wind. Two seismic stations will additionally have ARGOS transmitter which will regularly send the position of the seismometers to *Polarstern* so that the ice floe can be reliably tracked and the seismometers recovered at the end of the survey period. One such seismological array can be transported in one helicopter flight together with two scientists to mount the equipment. This takes roughly one and a half hours per ice floe plus the flight time between ship and ice floe. Three such arrays at a distance of 10 - 15 km between the arrays shall be installed. A total of 6 flights will therefore be necessary to install and recover the entire seismological equipment.

A reconnaissance flight to the survey area prior to the installation of the seismometers will help to identify suitable ice fields for the seismometer installation. A compromise will have to be found between a survey area with sufficient ice cover as close as possible to the ship to ensure a long recording period and the geologically most desirable survey position. The ice conditions and ambient ice drift during the survey time will strongly influence this position.

In preparation of the seismometer installation, we will test our equipment on board *Polarstern* and let the GPS receivers accustom to the shifted position. The batteries will be recharged and the equipment packed in red Zarges boxes for field installation. When the seismometers are installed, we will monitor their position to decide on the time of safe recovery depending on weather and expedition schedule. After retrieval of the instruments, the equipment will have to be dried, stored for transport and the data downloaded, copied and archived.

9. GPS OBSERVATIONS IN NORTH-EAST GREENLAND TO DETERMINE VERTICAL AND HORIZONTAL DEFORMATIONS OF THE EARTH'S CRUST

M. Scheinert, R. Rosenau (TU Dresden)

See chapter 5 ARK-XXIII/1 on page 14.

10. HIGHER TROPHIC LEVELS: SEABIRDS AND MARINE MAMMALS

C. Joiris, H. Robert (PolE, Belgium)

See chapter 4 ARK-XXIII/1 on page 13.

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4.	Bratz, Herbert	2.Offc.
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8.	Koch, Georg	R.Offc.
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25.	Hartwig-L., Andreas	A.B.
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28.	NN	Mot-man
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30.	Krösche, Eckard	Mot-man
31.	Dinse, Horst	Mot-man
32.	Watzel, Bernhard	Mot-man
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35.	Völske, Thomas	Cooksmate
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45.	Keller, Maik	Appr.

ARK- XXIII/3

12 August 2008 - 19 October 2008

Reykjavik - Bremerhaven

East Siberian Sea

Chief scientist
Wilfried Jokat

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Wilfried Jokat (AWI)

Die Expedition ARK-XXIII/3 wird am 12. August 2008 in Reikjavik (Island) beginnen und endet am 19. Oktober 2008 in Bremerhaven. Das Forschungsgebiet dieser Expedition liegt in der Ostsibirischen See. Hierfür soll bei der Anfahrt die Nordwestpassage (Nordkanada) und bei der Rückfahrt die Nordostpassage befahren werden. Der Schwerpunkt des wissenschafltichen Programmes liegt auf geowissenschaftlichen Experimenten an der Schnittstelle des Mendelejew-Rückens mit dem ostsibirischen Schelfs. So weit es die Eisverhältnisse erlauben werden, sollen hier umfangreiche reflexionsseismische Daten erhoben werden, um einen Beitrag zum besseren Verständnis der tektonischen Entwicklung dieser Region zu leisten. Im idealen Fall sollen lange Profile vom Kanada-Becken über den Mendelejew-Rücken in das Makarov Becken erhoben werden, um Hinweise auf die relativen Alter des Rücken zu den beiden Becken zu erhalten. An der Schnittstelle des Rückens mit dem Schelf sind Gebiete mit hohen Sedimentationsraten von besonderem Interesse, um neue Erkenntnisse über die jüngere geologische Vergangenheit hinsichtlich der Meereisbedeckung zu erhalten. Sowohl die kurzen Kerne als auch die seismischen Profile sollen letztendlich verwendet werden, um einen eingereichten IODP Bohrvorschlag weiter zu stützen. Mit Hilfe der geowissenschafltichen Daten sollen neue Bohrlokationen bestimmt werden. Falls die seismischen Daten Hinweise auf alte Schichtabfolgen liefern, die am Meeresboden aussbeissen, soll eine Beprobung mit einem Schwerelot versucht werden. Ozeanographische Experimente (CTD) sollen parallel zu den geologischen Stationen durchgeführt werden, um die Änderungen in der Zusammensetzung der Wassermassen in der Arktis weiterhin zu dokumentieren. Zusätzlich sollen XCTD vom Helikopter und fahrendem Schiff aus eingesetzt werden. Im östlichen Nansen-Becken sollen fernerhin Driftbojen auf Eisschollen installiert werden, die für ca. 12 Monate Informationen über Salzgehalt, Temperatur etc. über eine Satellitenverbindung senden sollen. Ebenfalls in Verbindung mit den geologischen Stationen bzw. Transekten sollen biologische Arbeiten mit einem Multinetz durchgeführt werden, um die Verteilung der Copepode *Oithona simili* im Arktischen Ozean zu dokumentieren. Weitere biologische Untersuchungen zur Biodiversität entlang der Mendelejew und Gakkel Rücken sind geplant. In Ergänzung des biologischen Programmes werden vogelkundliche Beobachtungen während der gesamten Expedition durchgeführt, um die Artenverteilung insbesondere in der Hocharktis zu erfassen.

Geochemische Arbeiten (Isotopen Analysen) sind vorgesehen, um die Transportwege der unterschiedlichen arktischen Wassermassen zu beschreiben. Hierfür wird kontinuierlich das wissenschaftliche Pumpensystem des Forschungsschiffes *Polarstern* sowie Wasserproben der ozeanografischen Rosette verwenden, die parallel zu den CTD Messungen genommen werden.

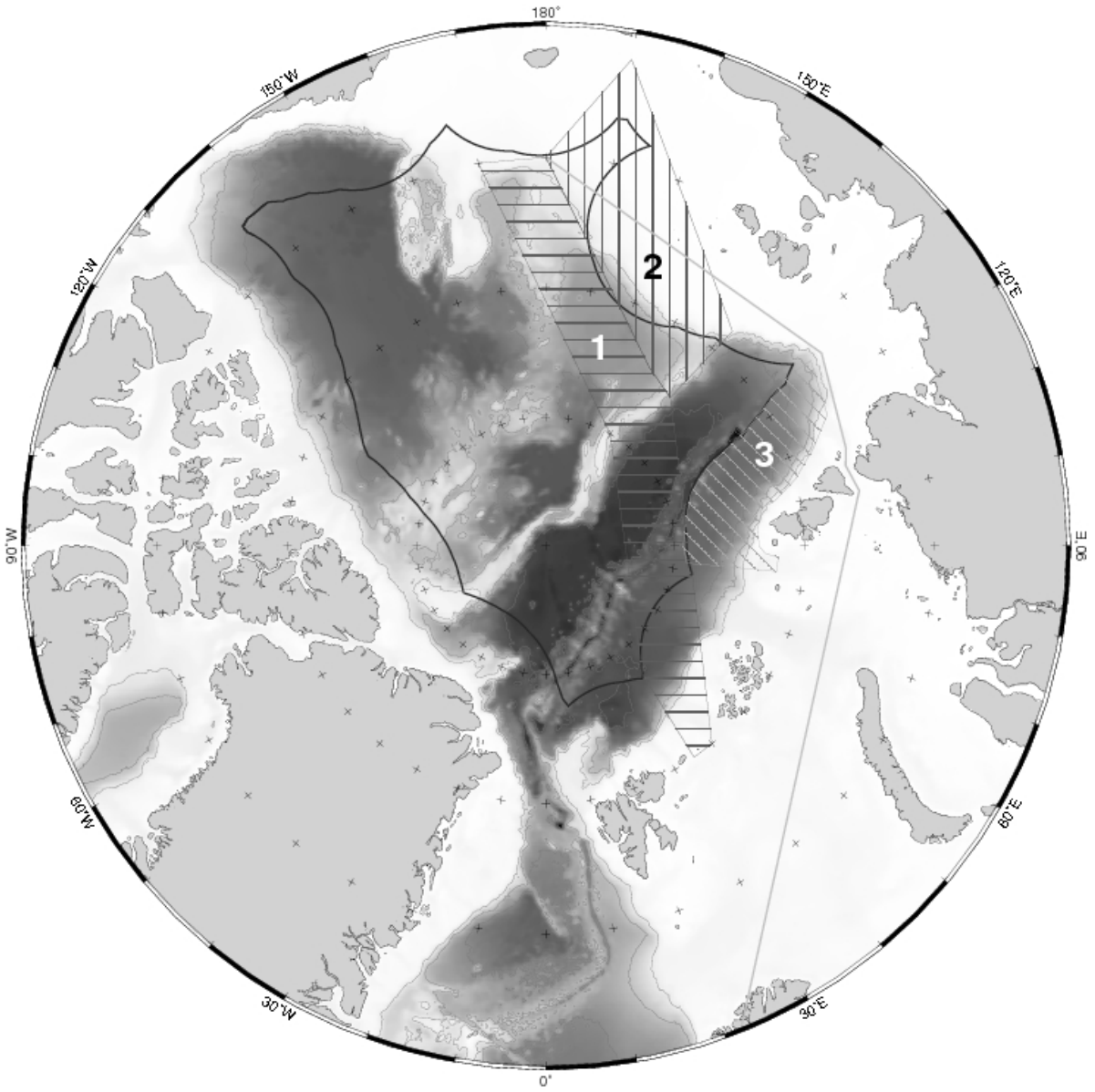

Fig. 1: The main research area is located at 170°E at the junction of the Mendeleev Ridge with the East Siberian Shelf. The line along the NE passage indicates the route from the research area back to Bremerhaven. The number mark the proposed research regions:
1- This corridor will be investigated in case of favourable ice conditions in 2008. The eastern part is identical with our main research area.
2- Research area on the East Siberian shelf,
3- Area where autonomous buoys will be deployed on ice floes.

SUMMARY AND ITINERARY

The expedition ARK-XXIII/3 will start on 12 August 2008 in Reikjavik (Iceland) and will terminate on 19 October 2008 in Bremerhaven. In order to reach the East Siberian Sea *Polarstern* will transit through the NW Passage into the research area, and will leave it via the NE Passage. Research activities will concentrate on geoscience at the junction of the Mendeleev Ridge with the East Siberian Shelf. Depending on the sea ice conditions, it is planned to conduct seismic investigations at the junction of the ridge with the shelf to investigate the tectonic evolution of this feature. In an optimum case several long profiles from the Canada Basin across the Mendeleev Ridge into the Makarov Basin would provide clues on the relative ages of the basins and the ridge. In the shallow part of the ridge areas with high sediment accumulations rates the target will be to unravel the climate history with cores. Thus, special attention will be given on the definition of potential drill sites for an already submitted IODP pre-proposal.

In conjunction with the geophysical activities the geological programme aims to retrieve cores from the ridge and the basins to gather information on the younger glacial history of the Amerasia Basin. Furthermore, wherever the seismic reflection data provide information on outcropping older geological units, we will try to core them. The oceanographic investigations will concentrate to collect CTD profiles in conjunction with geological stations to document the actual changes in the water mass composition. In addition, XCTD will be deployed from a helicopter. In the eastern Nansen Basin meteorological/oceanographic buoys will the deployed on ice floes to monitor via satellite the ice movements, salinity and temperature of the water. Biological investigations will use a multi-net to investigate the abundance of the copepod Oithona simili. Biodiversity studies will be performed in addition along the Mendeleev and Gakkel ridges. Finally, tracers in the water column will be investigated with the pumping system of *Polarstern* and the water bottle of the CTD casts to track geochemically the transport paths in the water column of the Arctic Ocean.

If ice conditions permit we will try to penetrate as deep as possible into the Canada Basin to investigate core sites on the Alpha Ridge, where Mesozoic sediments were recovered in the 50's and 60's from drifting ice islands.

2. MARINE GEOPHYSICS

J. Matthiessen, J. Müller, B. Naafs, F. Niessen, M. Schreck, I. Schulte-Loh, R. Stein, (AWI), V. Shevchenko (IORAS)

The Mesozoic-Cenozoic tectonic and paleooceanographic history of the Alpha Mendeleev Ridge Complex, Arctic Ocean

Introduction

Since the Swedish palaeobotanist Alfred Nathorst discovered in 1883 leaves and fruit of the tropical breadfruit tree in Cenomanian fluvio-deltaic sediments from west Greenland, it has become apparent that the Late Cretaceous climate of the northerly high latitudes – at least during certain intervals – was far warmer than it is today. The description of glendonites

(pseudomorphs of the low-temperature hydrated form of calcium carbonate, ikaiite) in lower Valanginian and upper Aptian sediments from the Sverdrup Basin in Arctic Canada (70 - 80ºN palaeolatitude), however, implies that Early Cretaceous seawater temperatures were at times close to freezing. Almost certainly these cooler temperatures record global changes because, in the case of the Late Aptian at least, coeval glendonites are also known from the Southern Hemisphere, being found in the Eromanga Basin in Australia at a palaeolatitude of 65º. The implication of these isolated occurrences is that, even in a so-called 'greenhouse' period, the Arctic Cretaceous climate was not uniformly warm and equable but experienced considerable variation. Other palaeontological data support the general contention that the mid-to Late Cretaceous Arctic climate was generally rather mild: the presence of deciduous trees, and leaves with characteristic morphologies, at 80 - 85º N, the presence of crocodiles beyond 60°N and, most specifically, the discovery of champosaurs (cold-blooded reptiles) in the Turonian of the Sverdrup Basin at 72°N palaeolatitude. The palaeobotanical data from the Arctic Cretaceous, however, are not in agreement with global climatic trends established from other parts of the world from oxygen-isotope ratios of microfossils and bulk pelagic carbonates. In a study of Arctic floras authors suggest a thermal maximum in the Coniacian. However, oxygen-isotope data from ODP cores in both the southern and northern hemispheres suggest that the global maximum (or maxima) was/were developed between the Cenomanian/Turonian boundary and the Late Turonian. In the northwest circum-Pacific region, oxygen-isotope ratios of aragonitic ammonites and bivalves suggest relative thermal maxima in the early Late Santonian and early Late Campanian: in this area a Campanian surface-water temperature of ~26 ºC at 40º N paleo-latitude has been calculated. Only by coring, recovering and analysing the Cretaceous of the Arctic the paleo-temperature evolution of this 'sensitive tip' of the planet can be accurately determined. Did the Cretaceous globe warm and cool relatively uniformly across a range of latitudes, or were local factors dominant in governing temperature at specific locations? And, given the claims for Cretaceous eustatic sea-level changes, is there evidence for high-latitude ice in the northern hemisphere during this interval?

The area to test these hypotheses and observations in the Arctic is the Alpha Mendeleev Ridge complex located in the Amerasia Basin. It is a 450 km wide, irregular transpolar bathymetric feature, which rises over 2,700 m above the adjacent abyssal plain to known water depths of about 1,000 m and is believed to be formed during the Late Cretaceous times. The ridge section north of Canada was named after US ice station Alpha, which made the first crossing in 1957/58. The complementary ridge north of the Siberian margin was named after the Soviet chemist Mendeleev. The complex horst and graben ridge topography of volcanic rocks is covered by 0.5 - 2 km of sediments. The magnetic anomaly pattern over the ridge is partly irregular and generally correlated with ridge topography. A number of hypotheses have been forwarded to explain the origin of the Alpha Mendeleev Ridge:

- a continental fragment
- an extinct axis of seafloor spreading
- a compressional feature representing an incipient island arc or subduction complex
- an inactive transform fault
- a submarine volcanic plateau
- a hot spot trace.

Two samples of basalt represent the only fragment of basement of the Alpha Ridge available to date. The CESAR sample consists of tholeiitic basalt, is weathered and documents the volcanic origin of Alpha Ridge. No dating was possible. The ARCTIC-98 sample has a similar composition and was dated to 83-100 Ma. Together with seismic data, which indicate that a

more or less continuous sediment record, it is obvious that information on the geological and climate history of the Mesozoic Arctic can be achieved by deep drilling.

The geoscientific data base over the Alpha Mendeleev Ridge Complex

The existing data base from the Alpha and Mendeleev ridges relevant for scientific drilling is mainly from the pioneering seismic reflection survey and sediment sampling effort from U.S. ice drift station T-3. In several instances, the drift tracks include close parallel as well as crossing lines, which may warrant target definitions. More recently, a two-ship experiment with the Russian nuclear icebreaker *Arktika* and *Polarstern* probed the central part of Alpha Ridge. In total 320 km of multichannel seismic data were acquired along three profiles supplemented by four sonobuoys. The sediment velocities range from 1.6 to 2.7 km/s and the sediment thicknesses vary between 500 m - 1,200 m. The units lie conformably on the basement. Only minor faulting is visible in the area of Lyons Seamount. In general, the sediments can be divided in two units. Their age is quite hypothetical: the upper unit is most likely of Cenozoic, the lower of Cretaceous age. The interpretation of the seismic velocities suggests oceanic basement. The basement velocities range from 4.3 to 6.7 km/s. In combination with a recovered basalt sample there is little doubt of the oceanic origin of Alpha Ridge, at least in its western sector. During the same expedition, undisturbed, up to 7.2 m long sedimentary records were obtained on the Alpha Ridge, probably representing the last about 3 Ma .

In late summer of 2000 geoscientific investigations were carried on Mendeleev Ridge aboard RV *Akademik Fedorov*. Deep seismic soundings accompanied by geological sampling, reflection and gravity observations were performed along a 500 km longitudinal profile crossing the crest of MR at 82°N. In conjunction with the seismic investigations, the total of 41 geological stations were obtained (23 gravity cores, 14 grabs and 4 dredges). In the vicinity of a prominent steepsided bathymetric knob abundant large-sized, semi-angular rock fragments were recovered and appeared composed of uniform lithologies dominated by fossiliferous sedimentary rocks of Middle-Upper Palaeozoic age.

Work on Sea

We would like to perform seismic reflection, refraction, gravity and magnetic experiments in the indicated research area. The main purposes are to gather 1-3 geophysical transects across the Alpha Mendeleev Ridge deep into both basins (Canada and Makarov basins) to outline the full extend of the ridge complex. Currently the interpretation of this area is biased by the poorly known bathymetry. Most of the ridge might still be hidden by sediments in the Canada and Makarov basins. Furthermore, we intend to find sites where shallow and deep coring can be performed. The location of the transects across the ridge is completely unknown and will depend on the actual ice conditions. Ideally, one transect should be located close to the East Siberian Shelf, one in the middle and one as close as possible to the Canadian margin. If the sea ice cover in the central part of the Canada Basin does not allow any seismic investigations, we will concentrate our investigations at the junction of the Mendeleev Ridge with the East Siberian Shelf to identify structures, which are promising for deep drilling within the IODP programme. The seismic data will be gathered with a streamer with a variable length of 300 - 3,000 m depending on the sea ice conditions. Helicopter-borne magnetic data will be gathered just in limited areas to better resolve certain known anomalies. However, this depends on the fact that the ship will operate sufficiently long in that area to gather a critical amount of data for a later interpretation.

3. MARINE GEOLOGY PROGRAMME

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Introduction

The overall goals of the marine-geological research programme are (1) high-resolution studies of changes in paleoclimate, paleoceanic circulation, paleoproductivity, and sea-ice distribution in the central Arctic Ocean and the adjacent continental margin during Late Quaternary (especially postglacial-Holocene) times, and (2) the long-term history of the Mesozoic and Cenozoic Arctic Ocean and its environmental evolution from a warm to an ice-covered polar ocean. In areas such as the Alpha Mendeleev Ridge, pre-Quaternary sediments are cropping out, which could even be cored with coring gears aboard *Polarstern*, and which would allow to study the Mesozoic/Tertiary history of the (preglacial) Arctic Ocean. Especially the data for the reconstruction of the long-term paleoclimatic history of the Arctic Ocean are very rare and only based on very short sediment cores taken from drifting ice islands (see above). Furthermore, the results will be related to our results obtained from previous expeditions into the central Arctic and the Eurasian continental margin area.

The main objectives include

Stratigraphic analyses of the sediment sequences
As basis for all further reconstructions of paleoenvironmental changes, a stratigraphic framework as precise as possible has to be established. This work will include magnetostratigraphy, oxygen and carbon stable isotopes, absolute age dating, biostratigraphy, natural radionuclides (^{10}Be, ^{234}Th), magnetic susceptibility, cyclostratigraphy (manganese cycles, physical properties, XRF scanning), and correlation to other existing (dated) Arctic Ocean records.

Terrigenous sediment supply
The terrigenous sediment supply in the Arctic Ocean is controlled by river discharge, oceanic currents, sea-ice (and iceberg) transport, down-slope transport, and eolian input. Most of these mechanisms also influence biological processes in the water column as well as at the sea floor (i.e. surface-water productivity, particle fluxes through the water column, benthic activities at the sea floor, organic carbon export and burial, etc.).

The research will concentrate on the quantification, characterization and variability of terrigenous sediment discharge to the Alpha Mendeleev Ridge and adjacent continental margin areas. This study will allow estimates of chemical and sedimentary budgets, identifications of major transport processes, and reconstructions of oceanic currents. Of major interest is a detailed sedimentological, geochemical, mineralogical, and micropaleontological study of surface sediments and sediment cores. Methods should include determinations of grain size, clay minerals, heavy minerals, major, minor, trace and rare earth elements, organic carbon fractions, and physical properties. Mapping of sediment echotypes from Parasound profiles will allow an extrapolation of point information from core data into spatial facies pattern.

Analytical techniques to be used include X-ray diffraction (XRD), X-ray fluorescence (XRF), inductivity-coupled plasma mass spectrometry (ICP-MS), and microscopy of coarse fraction. Furthermore, MSCL-logging and XRF-scanning records will be determined.

Geochemical and micropaleontological tracers: Organic-carbon flux and water-mass characteristics

One of the major goals is to quantify the flux of organic carbon and to characterize the mechanisms controlling organic carbon deposition and their changes through late Quaternary and Mesozoic/Cenozoic times. Here, the oxygenation of water masses, surface-water productivity, surface-water temperature, sea-ice cover, and terrigenous input are of special interest. Analytical techniques to be used include LECO ($CaCO_3$, TOC, C/N), Rock-Eval pyrolysis, gas chromatography (GC), gas chromatography/ mass spectrometry (GC/MS),and high-performance liquid chromatography/mass spectrometry (HPLC/MS), XRF, ICP-MS, and microscopy as well as XRF scanning.

Of major interest are

- to determine the amount, composition, and maturity of the organic carbon fraction, i.e., (sub-) recent marine and terrigenous organic carbon, reworked fossil material (coals), using organic-geochemical bulk parameters (TOC, C/N, HI values), biomarkers (e.g., *n*–alkanes, sterols, GDGTs, BIT index), maceral assemblages, and stable carbon isotopes of organic matter;
- to quantify the flux of marine and terrigenous organic carbon (accumulation rates), its change through space and time and its relationship to changes in sea-ice distribution and paleoclimate;
- to estimate the (paleo-) productivity from various productivity proxies: marine organic-carbon flux, biomarker composition (e.g., *n*-alkanes, sterols, fatty acids, alkenones, etc.); stable carbon and nitrogen isotopes of organic matter; barium; biogenic opal; diatom and dinoflagellate assemblages;
- to reconstruct sea-surface temperature and sea-ice cover from biomarker composition (alkenones, TEX_{86}; HBIs, IP_{25});
- to reconstruct water-mass oxygenation using organic carbon/sulfur and organic carbon/iron/sulfur relationships, redox-sensitive trace elements (e.g., Mo, V, U. Ag, Cd, Zn, Re), and specific biomarkers (isorenieratane);
- to compare the Alpha Mendeleev Ridge data with similar data sets from the eastern central Arctic and Eurasian continental margin areas.

Foraminifers and stable isotopes

The distribution and variability of planktonic and benthic foraminifers and their stable isotope signal will be determined to reconstruct changes in paleoenvironment such as watermass properties, surface-water productivity etc. through time.

Palynological proxies

The temporal distribution of organic-wallled microfossils (dinoflagellate cysts, acritarchs, freshwater algae) will be used to establish a biostratigraphic framework of Neogene to Mesozoic sediments and to provide information on sea-surface conditions through time.

Work at Sea

Coring strategy

Coring should be performed on transects from the East Siberian continental margin towards the adjacent deep sea, and from the Canada Basin across the Alpha Mendeleev Ridge into the Makarov Basin, using the Kastenlot (KAL), gravity corer (SL), giant box corer (GKG), and multicorer (MUC). Of interest are areas of high sedimentation rates for the high-resolution studies of late Quaternary (postglacial-Holocene) paleoenvironment and areas where older strata are cropping-out (for studying Mesozoic/Cenozoic sequences of paleoenvironmental change). Coring positions have to be collected carefully using detailed bathymetric mapping and sub-bottom profiling systems (i.e., Hydrosweep and Parasound, respectively) to avoid areas of sediment redeposition (turbidites and slumps) and erosion, and to identify areas where preglacial sediments are cropping out.

Prior to opening, all sediment will be logged using the Multi-Sensor-Core-Logger (MSCL). Then, cores will be opened and described, sediment slices for X-ray photographs be taken, colour scanning carried-out. Smear-slide and coarse-fraction analyses will be done to get information about sediment composition, X-ray photographs will be studied for amount of ice-rafted debris (IRD). Furthermore, discrete sampling will be done on a selected number of coarse for later shore-based studies.

Pore-water programme

Pore waters of marine sediments give valuable information about biogeochemical processes related to the early diagenetic degradation of organic matter. As these processes can potentially alter the geochemical and geophysical characteristics of the sediment, and can have an impact on preservation of certain microfossils as well, their study is of broad interest. In particular, for detailed investigation of the Quaternary manganese cycles known to occur in Arctic sediments, it is necessary to decipher the redox zonation of the upper sediment column through combined solid phase and pore water analyses. Additionally, in case of recovery of Mesozoic black shales cropping out close to the sea floor, it is important for any paleoenvironmental interpretation to know the degree of post-depositional and especially recent diagenetic alteration (e.g. oxygen „burndown“, sulfate reduction, sulfate-methane transition).

For this purpose, a pore water programme will be conducted onboard *Polarstern* (in addition to later shore-based inorganic-geochemical sediment analyses). Pore water samples will be taken with so-called rhizon samplers, which have proven to be an easy, effective and largely non-destructive method. Certain parameters will be determined onboard, shortly after core recovery and pore water sampling (pH, redox potential, ammonia, alkalinity, phosphate, hydrogen sulfide). Subsamples will be acidified and preserved for further shore-based analyses of anions (e.g. sulfate, phosphate, silicic acid, chloride, fluoride, nitrate) and cations (e.g. manganese, iron, calcium, various trace elements).

Sampling of sea ice

A sampling of („dirty“) sea ice will be carried-out to study the amount and composition of sediments entrained in modern sea ice. Here, selected ice floes will be visited using a helicopter.

4. OCEANOGRAPHY

D. Kalmbach, A. Nauels, B. Rabe (AWI), T. Kikuchi (JAMSTEC)

Objectives

Observations from the past decades revealed the Arctic Ocean and its ice cover to be a sensitive indicator of climate change. Arctic sea ice extent was at a minimum in September 2007 and is likely to vanish in summer completely – possibly as a consequence of a feedback in the ice/ocean radiation budget. In the same time the Arctic Ocean is strongly affected by advection from the North Atlantic and Pacific. These imported water masses changed as well considerably over the past decades. In the Arctic, the ocean waters are subject to conversions through cooling, freezing and melting. Thus, when returning to the North Atlantic, Arctic water masses directly or indirectly influence the Atlantic-wide meridional overturning circulation. Huge amounts of fresh water, supplied to the Arctic Ocean by continental runoff (10 % of the global runoff), precipitation, and Pacific water inflow, play a considerable role in these conversions by shielding the ocean from direct atmospheric influence. Furthermore, the fresh water underwent strong variations in supply, storage and circulation pattern during the past decades.

In order to understand the processes behind the changes and to distinguish climate trends from variations that follow the atmospheric oscillation patterns, the changes have to be surveyed at sufficient spatial coverage. To do so an international joint effort is undertaken during IPY to conduct a quasi-synoptic Pan-Arctic survey. In 2007, several cruises covered large parts of the Arctic, and the central Eurasian basins were surveyed during ARK-XXII/2. During this cruise this work is extended towards the East-Siberian regions.

Work at Sea

The oceanographic work will consist of CTD sections and the deployment of ice-tethered platforms.

Profiles of ocean temperature, salinity and oxygen will be measured along sections between the basins north of the East Siberian and the Laptev seas. The casts will be carried out with a CTD (Conductivity Temperature Depth)/rosette system with Seabird components (SBE9+ and SBE32) with double temperature and conductivity sensors. Water samples will be taken only occasionally for salinity and oxygen sensors calibration.

To increase the spatial resolution of the sections and to extend the sections in regions with heavy ice we will use XCTDs (eXpendable CTD). The XCTD data acquisition and processing equipment can measure temperature and conductivity (i.e. salinity) from sea surface to 1,100 m depth in only five minutes. The XCTD system is manufactured by The Tsurumi-Seiki Co., LTD, Japan. The system is transportable so that XCTDs will not only be launched from the steaming ship, but it can also be transported by helicopter and then XCTDs will be launched from ice floes.

Along the transects, the velocity field of the upper 400 m will be measured with a ship-borne 150-kHz broadband ADCP.

In order to extend the measurements of ocean temperature, salinity and velocity in time and space, ice-tethered platforms (ITPs) with various instrumentation will be deployed:

Three ITPs (Ice-Tethered Profilers), respectively POPS (Polar Ocean Profiler), both equipped with Seabird CTDs that will sample temperature and salinity profiles once per day between the surface and 800 m water depth.

One ITAC (Ice-tethered Acoustic Current profiler) consisting of a RDI ADCP (75 kHz, Long Ranger) that measures the velocity profile of the upper 500 m once every two hours.

These platforms contribute to the "International Arctic Ocean Observation System" (iAOOS). The oceanographic work is supported through contributions from the European Union-funded Integrated Project "DAMOCLES" (Developing Arctic Modelling and Observing Capabilities for Long-term Environment Studies), the BMBF-funded Project "North-Atlantic", the US National Science Foundation and the Japan Agency for Marine-Earth Science and Technology.

5. ISOTOPE TRACER ANALYSES

R. Letcher (RSMAS)

Objectives

We will apply an isotopic tracer technique for investigation of the rate of exchange between the Arctic shelves and the Arctic Ocean interior, and apply the results to further our understanding of the decay of terrigenous (dissolved organic carbon (DOC) in the system. This work has been successfully carried out in the western Arctic with results published in the journal SCIENCE (Hansell et al., 2004). It was found that a relatively long retention time of river water within the western Arctic allowed degradation of DOC to be observed. The purpose of the work here is to expand our results to the eastern Arctic, where different time scales of shelf-basin exchange and surface water residence times are likely. The tracer technique utilizes the measurement of the water column ratio of two naturally occurring radium isotopes ($^{228}Ra/^{226}Ra$) and will be performed with measurement of DOC in the upper Arctic Ocean. With the Ra data, we will determine the time-since-shelf residence of Arctic surface water; that is, the aging of water with respect to the elapsed time since contact with shelf sediments. This will allow further constraints to be put on circulation patterns of the upper waters, and on rates of transformation of shelf-derived species as they transit the central Arctic basin. Specifically, we will apply these ages to measurements of DOC to explore the residence time of terrigenous DOC (tDOC) in the Eastern Arctic Ocean.

With our data, we will obtain further constraints on circulation patterns of the upper waters, and on rates of transformation of shelf-derived species as they transit the central Arctic basin. Specifically, we will apply Ra-derived ages to measurements of dissolved organic carbon (DOC) to explore the residence time of terrigenous DOC (tDOC) in the Eastern Arctic Ocean.

Work at Sea

We will be collecting approximately 200 liter surface samples from the ship's seawater intake for radium filtration. Analysis will be done in our lab in Miami. Small aliquots (~50ml) will be taken for DOC, and for oxygen isotopes. We will request 50 ml samples from CTD casts for DOC samples as well, if water is available.

6. BIOLOGY

6.1 BIOLOGY OF *OITHONA SIMILIS* (COPEPODA: CYLOPOIDA) IN THE ARCTIC OCEAN

N. Fischer (AWI), B. Wend (University of Oldenburg)

Objectives

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

Work at sea

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

On board experiments with living animals will be conducted dependent on the numbers of animals found at each station. These experiments aim on the determination of egg production, egg development, nauplii hatching and stage durations as well as the feeding behaviour. Half of the individuals taken for experiments will be preserved in ethanol and the remaining part in formalin. This procedure allows to check whether cryptic species exist.

6.2 PHYTOPLANKTON ECOLOGY IN THE WATER COLUMN

N. Fischer (AWI), B. Wend (University of Oldenburg)

Objectives

Since the nineties phytoplankton investigations on biomass, species composition, productivity and related biochemical parameters, i.e. chlorophyll *a*, have been carried out in arctic waters mainly in the Fram Strait area. During the years 1993 – 1996, and 2007 sampling was also conducted above Amundsen and Nansen basins. During this cruise, the same investigations will be done for comparison with the old data and 2007 to understand eventually existing changes due to a changing environment.

Work at Sea

Water will be sampled with the rosette sampling system attached to the CTD. Subsamples will be taken from the surface layer at 4 different depths (appr. 5, 20, 50, 75 m) for species abundances (water samples, ca. 200 ml fixed with buffered formalin), chlorophyll *a* and

phaeopigments (0.5 to 1 liter of water will be filtered on Whatman GF/C glass-fibre filters) to be analysed later in the home laboratory.

7. INVESTIGATIONS ON THE BENTHIC FORAMINIFERAL AND MICROBIAL FAUNA OF THE AMERASIAN BASIN AND AT THE HÅKON MOSBY MUD VOLCANO

T. Dufek, A. Hegewald, R. Isbert, L. Jensen, W. Jokat, F. Jurisch, T. Kalberg, S. Kessling, J. Kollofrath, H. Martens, P.V. Pulm, M. Urlaub, F. Winter (AWI)

Since 1991 the benthic foraminifera fauna of extensive surface sediment samples from the Eurasian Basin was collected and analyzed. Multiple faunistic and isotopic analyzes provided us with a comprehensive knowledge on benthic-pelagic coupling, and the influence of physical and geochemical parameters on the analyzed benthic fauna. The modern findings were and are basis of palaeo-ecological and palaeooceanographic interpretations on long sediment cores. Now we intend to extend our investigations to the Amerasia Basin, its oceanic ridges, continental margins and shelves. Since we lack data from these areas, it is important to collect as many cores as possible along strategic profiles across ridges or from shelf to abyssal areas. Joint analyzes with our geological and micro-palaeontological colleagues will ensure high qualitative data sets for future analyzes on the long-term sediment record.

During this expedition our interest on the Håkon Mosby Mud Volcano is restricted to the collection of sediment cores from a pogonophora site inhabited by Sclerolinum contortum. The sediment cores to collect are essential for the continuation of our running culture experiments on benthic foraminifera from this locality.

The microbial population and running microbial processes in the central Arctic Ocean are little known. This applies as well for surface waters, including sea ice, as for sediments, especially in the deep-sea realm. So far, our microbiological investigations were largely restricted to the Yermak Plateau and 81/82°N-profile across Fram Strait. Here, we found low bacterial productivities, with bacterial communities tightly related to the water column above. In contrast to these western sites, we observed extremely high bacterial primary productivities associated with volcanism in the central part of the Gakkel Ridge. The observed bacterial communities were specifically adapted to the different energy sources and highly diverse. The very different results of the sites analyzed so far, reveal that it is essential to significantly extend our microbiological analyzes on samples from the central Arctic Ocean. The material collected during this years cruise will allow more concrete assumptions about general productivity, methane consumption and the impact of global change on the central Arctic Ocean microbiota.

Work at Sea

Mulitcorer samples and material from other geological sampling techniques will be used.

8. AT-SEA DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

C. Joiris (PoIE)
See Chapter 4 of ARK-XXIII/1 on page 13.

9. POLLEN AND SPORE FLOW IN THE AIR OF THE ARCTIC SEA

M. Herrmann (Senckenb)

Objectives
We analyse to what extent pollen and spores can be transported over the Artic Sea, in order to better understand the palynological record in Arctic sediments and cores as well as the colonization of the Artic islands by plants after the last glaciation. For that purpose we will use a Burkard pollen trap, which allows to determine the pollen/spore flow in a well-defined air volume. Using modelling techniques the source of the pollen/spores identified can be determined.

Work at Sea
First we have to install a Burkard-pollen trap on the deck and run the trap over the whole expedition period. Daily work on board will be to empty the trap every day at the same time and then to prepare pollen slides with hourly resolution. Using a light-microscope the pollen/spores will be identified, counted and documented with photographs. Considering the ships position and the weather conditions during the time of pollen collection it will be able to reconstruct the transport pathway of the palynomorphs. For that purpose backward trajectories have to be calculated using the HYSPLIT-Method (Draxler & Hess, 1997).

Expected Results
The project will allow to identify the pollen/spore flow over the Arctic Sea as it varies with the distance to possible source areas and the weather conditions. These results will help to better interpret palynological data from Cenozoic Arctic sediments; moreover it will allow to determine which pteridophytes and mosses could have been transported by wind over long distances to colonize Arctic islands.

10. BETEILIGTE INSTITUTE/ PARTICIPATING INSTITUTES

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11. FAHRTTEILNEHMER / PARTICIPANTS

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Dufek	Tanja	AWI	Student, bathymetry
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Wend	Britta	University of Oldenburg	Biologist
Winter	Felicia	AWI	Student, geophysics

12. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Schwarze, Stefan	Master
02.	Spielke, Steffen	1.Offc.
03.	Farysch, Bernd	Ch. Eng.
04.	Peine Lutz	2. Offc.
05.	Fallei, Holger	2. Offc.
06.	Dugge, Heike	3.Offc.
07.	NN	Doctor
08.	Hecht, Andreas	R.Offc.
09.	Minzlaff, Hans-Ulrich	2.Eng.
10.	Sümnicht, Stefan	2.Eng.
11.	Schaefer, Marc	3.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Nasis, Ilias	Electron.
14.	Verhoeven, Roger	Electron.
15.	Muhle, Helmut	Electron.
16.	Himmel,Frank	Electron
17.	Loidl, Reiner	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Guse, Hartmut	A.B.
20.	NN	A.B.
21.	Winkler, Michael	A.B.
22.	Vehlow, Ringo	A.B.
23.	Hagemann, Manfred	A.B.
24.	Schmidt, Uwe	A.B.
25.	Bäcker, Andreas	A.B.
26.	Wende, Uwe	A.B.
27.	Preuflner, Jörg	Storek.
28.	Ipsen, Michael	Mot-man
29.	Voy, Bernd	Mot-man
30.	Elsner, Klaus	Mot-man
31.	Hartmann,Ernst-Uwe	Mot-man
32.	Pinske, Lutz	Mot-man
33.	Müller-Homburg, Ralf-Dieter	Cook
34.	Silinski, Frank	Cooksmate
35.	Martens, Michael	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.
44.	Pagels, Christian	Appr.
45.	Keller, Maik	Appr.

FS POLARSTERN

ARK-XXIII/1	**12.06.2008 - 02.07.2008**	**Bremerhaven - Longyearbyen**
ARK-XXIII/2	**04.07.2008 - 10.08.2008**	**Longyearbyen - Reykjavik**
ARK-XXIII/3	**12.08.2008 - 19.10.2008**	**Reykjavik - Bremerhaven**