EXPEDITIONSPROGRAMM NR. 83

FS POLARSTERN

ARK-XXIV/1

ARK-XXIV/2

ARK-XXIV/3

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EXPEDITION PROGRAMME No. 83

RV POLARSTERN

ARK-XXIV/1
20 June 2009 - 10 July 2009
Bremerhaven - Longyearbyen

ARK-XXIV/2
10 July 2009 - 03 August 2009
Longyearbyen - Reykjavik

ARK-XXIV/3
05 August 2009 - 25 September 2009
Reykjavik - Bremerhaven

Coordinator
Eberhard Fahrbach

Chief Scientists

ARK-XXIV/1:	**Gereon Budéus**
ARK-XXIV/2:	**Michael Klages**
ARK-XXIV/3:	**Wilfried Jokat**

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ARK-XXIV/1

20 June 2009 - 10 July 2009

Bremerhaven - Longyearbyen

Greenland Sea and Fram Strait

Chief scientist
Gereon Budéus

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1. ÜBERBLICK UND FAHRTVERLAUF

Gereon Budéus (AWI)

Der erste Fahrtabschnitt der 24. *Polarstern* Expedition in die Arktis wird am 20. Juni 2009 beginnen. Das Schiff wird von Bremerhaven auslaufen, um in der Grönlandsee und der Framstraße Forschungen durchzuführen.

Das genannte Gebiet steht seit einigen Jahrzehnten verstärkt im Fokus des wissenschaftlichen Interesses, da sich dort Schlüsselprozesse im Ozean abspielen. Der Transfer zwischen Atmosphäre und Ozean bezüglich mechanischer Energie, Wärme und Süßwasser ist hoch, insbesondere während der kalten Wintermonate. Wassermassen aus niedrigen und hohen Breiten treffen dort aufeinander und interagieren durch Vermischung an Fronten, Überschichtungen, Einmischungen und Winterkonvektion. Meereis wird gebildet in den nördlichen und westlichen Teilen des Gebiets und Eis wird gen Süden transportiert mit den kalten und salzarmen Oberflächenwassermassen im ostgrönländischen Strom. Es werden Wassermassen hoher Dichte erzeugt, die einen wesentlichen Beitrag zur tiefen meridionalen Zirkulation im Atlantik leisten. Dies alles macht die Region ausgesprochen empfindlich gegenüber klimatischen Veränderungen, wobei Rückkopplungsmechanismen bezüglich des nordeuropäischen Klimas besondere Beachtung verdienen. Es ist selbstverständlich, daß solch großräumige klimatische Betrachtungen auf hochwertigen regionalen Beobachtungen lokaler Veränderungen aufbauen müssen.

Die hydrographischen Arbeiten auf diesem Fahrtabschnitt etablieren einen weiteren Mosaikstein zweier Langzeit-Meßreihen, wie sie für die klimabezogene Forschung unverzichtbar sind. Sowohl in der Grönlandsee als auch in der Framstraße hat das Alfred-Wegener-Institut bereits eine beachtliche Forschungshistorie aufzuweisen, welche die Quantifizierung solch wichtiger Vorgänge wie die des meridionalen Wärmeflusses, der winterlichen Konvektionstiefen, der Speicherung von Wärme und Salz im Ozean und dergleichen mehr gestattet, sowie die Variabilitäten und Trends der mit diesen verbundenen physikalischen Parametern bestimmbar macht. In den Projekten werden Stationsarbeiten durchgeführt und es finden sowohl konventionelle als auch innovative autonome selbstprofilierende Verankerungen ebenso wie autonome Unterwasserfahrzeuge Verwendung.

Die Validation von Paläoproxies ist ein weiteres Thema des Fahrtabschnitts. Hierzu werden Foraminiferen und Coccolithophoren aus der Seewasserversorgung des Schiffs auf dem gesamten Schiffsweg gesammelt und analysiert. Ein Hauptanliegen ist dabei, die Rekonstruktion der Temperaturen und der Eisbedeckung während des Holozäns in den existierenden klimatischen Szenarien zu verbessern. Des weiteren soll das Verständnis der Interaktionen zwischen Umwelt und Ökosystem verbessert werden, sowie abgeschätzt werden, inwieweit spezielle Teile der arktischen Biota die zu erwartenden klimatischen Veränderungen überstehen. Mit dem vorliegenden Fahrtabschnitt wird eine erfolgreiche und neuartige interannuelle Vergleichsstudie fortgesetzt.

Es besteht kein Zweifel, daß die im globalen Kontext rapidesten Veränderungen der Umweltbedingungen in der Arktis auch Auswirkungen auf die marine Fauna haben werden. Die Forschungen zum arktischen Ökosystem auf diesem Fahrtabschnitt umfassen die gesamte Größenskala von der Mikrobiologie bis hin zu den weltgrößten Lebewesen. Temperatur- und CO_2-bedingte Effekte auf die Produktion, Diagenese und Aggregation von

organischem Material werden mit Hilfe von Inkubationexperimenten untersucht. Ein wesentliches Ziel ist es, zu einem besseren Verständnis von Richtung und Stärke der biogeochemischen und mikrobiologischen Rückkopplungsprozesse im Ozean der Zukunft beizutragen. Das Vorkommen und das Verhalten von marinen Säugern, insbesondere aber nicht ausschließlich von Walen, ist Gegenstand zweier weiterer Projekte, in denen modernste akustische und optische Methoden Verwendung finden. Die sich verändernde Eisbedeckungsstruktur in der Arktis führt bereits heute zu veränderten Vorkommen einiger Arten und die zu erwartende Zunahme des Geräuschpegels im Ozean durch die Nutzung der nördlichen Schiffsrouten schon in der näheren Zukunft impliziert die Notwendigkeit, verlässliche Bestandsänderungsabschätzungen unverzüglich in Angriff zu nehmen.

Der Fahrtabschnitt wird am 10. Juli 2009 in Longyearbyen auf Spitzbergen enden.

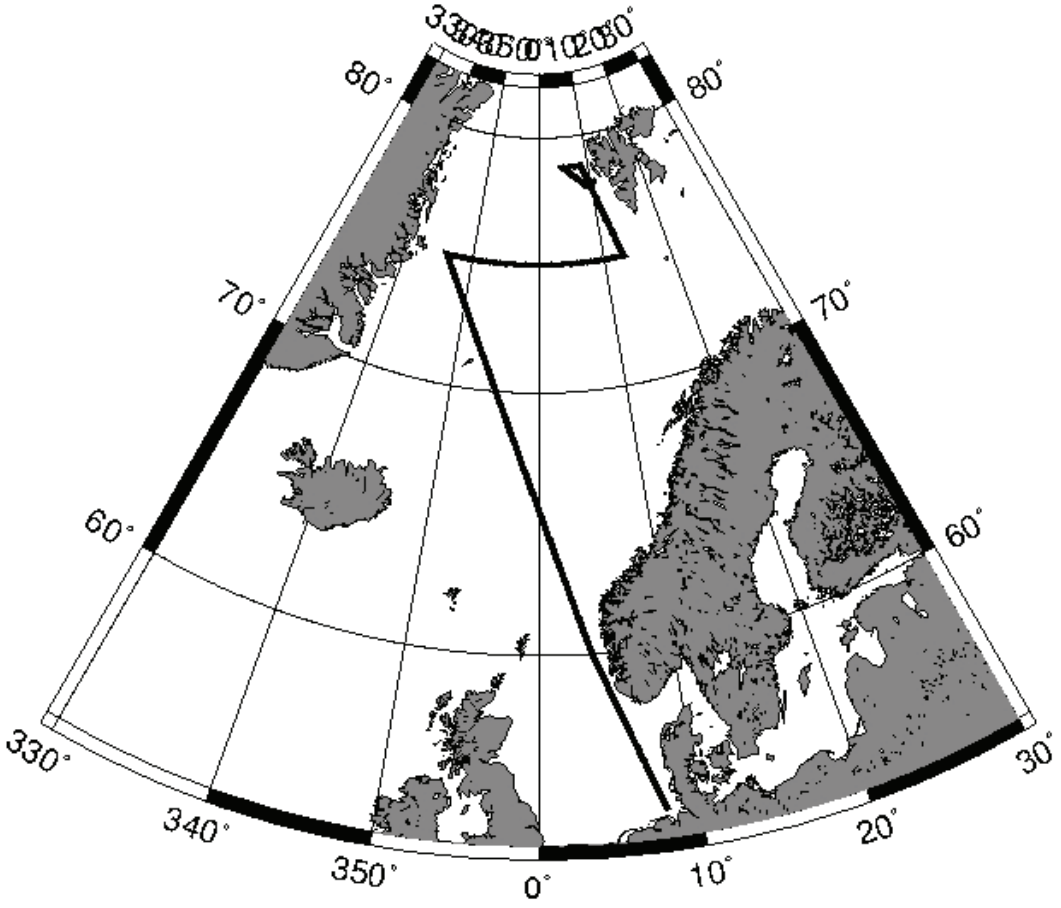

Fig. 1: Cruise track during ARK-XXIV/1

SUMMARY AND ITINERARY

The start of the first leg of the 24th *Polarstern* expedition to the Arctic is scheduled for the 20th of June 2009. The ship will depart from Bremerhaven and do research in the Greenland Sea and in Fram Strait.

This region attains increased scientific attention during the recent few decades due to a number of key properties. The atmosphere-ocean transfers of momentum, heat and freshwater are strong, particularly during the cold winter months. Water masses from low and high latitudes meet and interact by means of mixing at fronts, subduction, entrainment, and winter convection. Sea ice is formed in the northern and western parts and is transported southward with the cold and fresh surface waters in the East Greenland Current (EGC). Dense waters are formed which act as a major contribution to the Atlantic Meridional Overturning Circulation or as the source of deep Arctic Waters. All this makes the region highly sensitive to climatic changes and also leads to feedback mechanisms which vice versa affect the north European climate. Investigations of such large scale climatic aspects must evidently be based on sound perceptions of local modifications.

The hydrographic work during this cruise leg contributes to the establishment of long-term time series as are indispensable to study climatic aspects in the ocean. Both in the Greenland Sea and in Fram Strait, the Alfred-Wegener-Insitute already has a long research history which allows to quantify meridional heat fluxes, winter convection depths, heat and salt storage in the ocean, and the like, and to determine variability and trends of related physical parameters. The projects include station work, conventional moorings as well as innovative autonomously profiling moorings, and the use of autonomous underwater vehicles.

Proxy validation studies will be carried out by using the ship's sea water supply to take en route-samples of foraminifera and coccolithophores 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-XXIV/1, a novel and successful interannual comparative proxy validation study will be continued.

The Arctic Ocean is one of the fastest changing environments on earth, and there is no doubt that these changes will also affect the marine fauna. Studies of the Arctic ecosystem during this cruise leg will cover the scale from microbiology to the largest species on earth. Temperature- and CO_2-related effects on the production, fate, and aggregation of organic matter will be investigated by incubation experiments. The main intention is to further our understanding of the direction and strength of biochemical and microbiological feedback processes in the future ocean. The occurance and behaviour of marine mammals, particularly but not exclusively whales, is studied by two projects using most modern acoustic and infrared methods. The changing ice cover in the Arctic leads to modified routes of many species already to date, and the expected increase in ocean noise as is related to the use of the northern routes by freight ships in the near future necessitates monitoring of its effects, so that action is requested now.

The cruise leg will end on 10 July 2009 at Longyearbyen, Svalbard.

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

G. Budéus, B. Heinze, J. Jacob, M. Monsees, G. Rohardt, J. Saynisch, A. Schneider, J. Schnieders, O. Strothmann, A. Wisotzki, S. Zakrzewski, O. Zenk, N. Zoch (AWI)

Objectives

The region between Fram Strait and Jan Mayen has attained increased scientific attention during the recent few decades due to a number of key properties. The atmosphere ocean transfers of momentum, heat and freshwater are strong, particularly during the cold winter months. Water masses from low and high latitudes meet and interact by means of mixing at fronts, subduction, entrainment, and winter convection. Sea ice is formed in the northern and western parts and is transported southward with the cold and fresh surface waters in the East Greenland Current (EGC). Dense waters are formed which act as a major contribution to the Atlantic Meridional Overturning Circulation or as the source of deep Arctic Waters. All this makes the region highly sensitive to climatic changes and also leads to feedback mechanisms which vice versa affect the north European climate. Investigations of such large scale climatic aspects must evidently be based on sound perceptions of local modifications.

While recent research revealed that many aspects of the internal circulation in the Greenland Sea and also of convection processes turned out to work differently than thought before, certain parts of the general setting of the region are persistent and well established. At the eastern rim of the basin, the warm waters of Atlantic origin move northward as a 600 - 800 m thick layer in the West Spitsbergen Current (WSC). Recent observations show that their average velocity is slow, while local speeds are not. The western boundary of the Atlantic Water (AW) forms a sharp temperature and salinity front which is less pronounced in density. Numerous eddies form and detach from this front with associated lateral exchanges. The large scale meridional flow serves as the most important heat supply for the Arctic, although substantial portions of the waters recirculate already in Fram Strait. In this region, the AWs meet the lighter Polar Waters heading southward, and, together with deeper waters from the Arctic, they form the EGC. The sill depth in Fram Strait limits the down most extent of the exiting Deep Polar Waters to about 2,600 m. The EGC is much narrower than the West Spitsbergen Current but transports similar water volumes, and, most relevant for the fresh water and heat balance, carries with it also the melting pack ice cover.

The huge cold water dome in the central Greenland Sea has been identified by F. Nansen and Helland-Hansen already in the early decades of the 20th century (by cruises between 1901 and 1905). Since then, the doming of deep water temperatures between the warm rim currents has been regarded as synonymous to the regular occurrence of local deep and bottom water formation. In the 80s, this idea has been revised towards the cognition that bottom water formation by surface forcing is a rather rare process but must occur occasionally. With this project we delineate the hydrographic development for more than decade on a basin wide scale and identify the processes which are responsible for observed changes. The approach is based on a zonal transect at 75°N and autonomously profiling

moorings. The transect, with all stations performed to full ocean depth, is executed once per year and extends from the shelf off Bear Island to that of East Greenland, including the area covered with pack ice. Therefore it includes the water masses at the rims and allows to determine lateral gradients not only in the interior of the Greenland Basin but also towards the water mass end members. This spatial information is essential with respect to a correct perception of advectively caused modifications as e.g. the influence of the deep Arctic outflows. We also employ small station distances in order to obtain a sufficient number of stations which allows to discriminate between spatial and temporal differences. This is important as spatial and temporal variabilities amount to similar magnitudes in the research area. The annual expeditions represent a very adequate approach for the determination of the multi-year development and its underlying processes. On the other hand, the annual resolution is a minimum observation frequency, as comparisons of snapshots which are several years apart are adverse to a correct process related interpretation. LOTEVA-GS has been part of the International Polar Year (IPY) and is continued within the programme 'Polar regions and coasts in a changing earth system' (PACES).

The actual situation in the Greenland Basin is fundamentally different from that before which was characterised by a huge cold dome in the gyre's centre. The most important aspect of its present hydrographic structure is a stable vertical interface which establishes a two layer system and parts the waters in an upper and lower layer. This structure is presumably triggered by a fresh water input anomaly in 1990 which is not associated with a high Fram Strait transport and demonstrates that a temporal anomaly of the regional fresh water distribution may lead to persistent structural changes in the ocean. The vertical interface and the two layer structure prevail until today. Due to a descent of the interface, the volume of the deeper layer decreased by roughly 50 % with respect to the state in the early 90s. The descent of the interface does not show a continuous speed, but was fast at first and slower in the most recent years. There is a number of indications that the necessarily associated export in the deeper layer takes place close to the bottom and is concentrated at the western side of the basin.

During the actual two-layer phase, the deeper layer is isolated from surface influences. Thus, it continuously increases in age and is hardly ventilated. However, lateral exchanges with other water masses result in property changes. The deep Arctic outflow surrounds the Greenland gyre and has a determining influence on the waters in the deeper layer of the Greenland Basin. Vertical exchange in the deeper layer (diapycnal mixing) is also apparent in the course of the time series. It plays a minor role during its first part, can increase in importance during the succeeding part and even more if the descent of the interface will cease permanently.

The most important effect of the interface is that it serves as a barrier against a deep penetration of winter convection. The property development in the interface itself shows only minor changes, but these indicate that some restoring influence must act. The function of the interface as a barrier against ventilation is varying in relevance. When the upper layer is vertically homogeneous, it is indeed the first stability barrier met by winter convection. When the upper layer is substantially stratified, the entire layer hampers deep reaching convection. The time series shows that the upper layer can occasionally be stratified in a manner that the interface is only barely recognised as a stability maximum. This does not lead to a general reduction of convection but is apparently a reversible state.

Winter convection has diverse effects on the temperature, salinity and stability development. Temperatures might increase or decrease, salinities might increase or decrease as a result

of convection, and the water column might be homogenised or be left in the stratified condition which it attained by lateral exchange after a previous homogenizing event. Much of the previously unexpected effects of winter convection are due to the fact that an import of Atlantic waters is not generally adverse to convection but greatly modifies its results. By the inclusion of AW derivates, winter convection may lead to effects which resemble those of lateral exchange.

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 (externally powered/compressibility compensated)-Jojo, 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 interior 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, submesoscule coherent vortices have to be identified, distinguished from the background, and skipped from the background trend analysis. According to this, the transect at 75°N is performed with a station spacing of 10 nautical miles or less, what normally results in about 60 CTD stations between Greenland and Bear Island. In 2009, only about half of these stations will be performed due to time constraints. On the CTD, a double sensor set is used for temperature and conductivity, and various additional sensors will be operated. The most important of these is the electrical 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 daily complete profiles, 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 2008, too. This mooring reveals profiles between 160 m and the surface proper, and will be exchanged as well.

3. VARIABILITY OF OCEANIC FLUXES THROUGH FRAM STRAIT

B. Heinze, J. Jacob, M. Monsees, G. Rohardt, J. Saynisch, J. Schnieders, O. Strothmann, A. Wisotzki, S. Zakrzewski, O. Zenk, N. Zoch (AWI)

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 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) with a support from the national funding. Since 2006 the work had been carried out as a part of `DAMOCLES' EU Integrated Project and the new EU project 'ACOBAR' (Acoustic Technology for Observing the Interior of the Arctic Ocean) started in 2009, which embraces also oceanographic measurements in Fram Strait.

Work at sea

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. 12 of these are maintained by AWI and 6 moorings in the western part of the strait by the Norwegian Polar Institute.
During ARK-XXIV/1 cruise six moorings will be exchanged in the eastern Fram Strait. Remaining six moorings in the central part of the strait were prepared for an extended deployment time and will be exchanged in two-year turnover period. All these moorings were deployed in 2008 during the *Polarstern* cruise ARK-XXIII/2. For a 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). In 2009 three moorings to be deployed in the eastern Fram Strait will be equipped with the low-frequency modems to test underwater acoustic data transfer. Hydrographic stations with a CTD system SBE 9/11+ in the 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. Water samples will be analysed for salinity with an Autosal 8400A salinometer (Guildline). During ARK-XXIV/1 the CTD stations will be measured in between mooring work, only along the eastern part of the standard section.

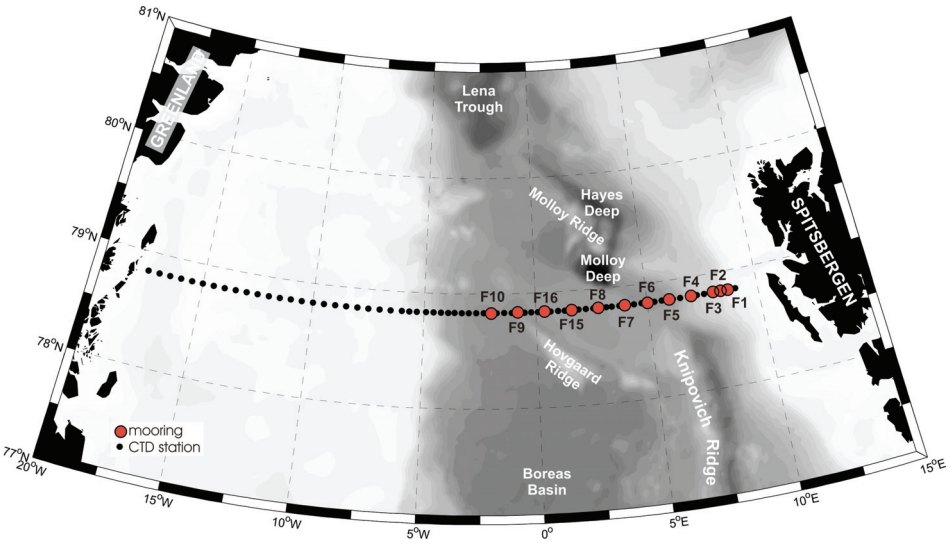

Fig. 3.1 Positions of moorings and CTD stations in Fram Strait

The Seaglider, an autonomous buoyancy driven profiling vehicle equipped with pressure, temperature, conductivity, oxygen sensors as well as with RAFOS hardware will be also deployed in Fram Strait during ARK-XXIV/1. This will be the second summer mission of the AWI glider, after the successful 1-month deployment in summer 2008. The Seaglider will be operated from the pilot station in Bremerhaven during an about 3 months' long summer mission, aimed in profiling the upper 1,000 m layer along hydrographic sections in Fram Strait. For a purpose of development of the underwater acoustic navigation system for gliders, the Seaglider deployed in summer 2009 will also register RAFOS signals from tomography moorings, deployed in three locations in Fram Strait in the frame of the ACOBAR project. This will serve for an estimation of the RAFOS signal ranges in Fram Strait.

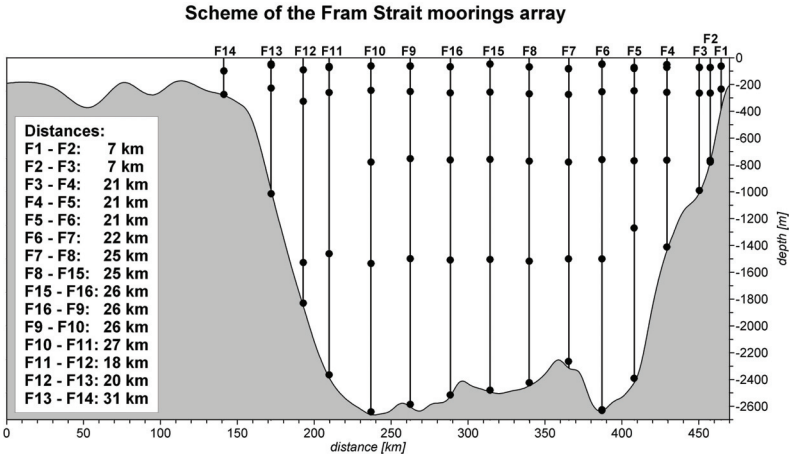

Fig. 3.2: Scheme of instrumentation at the Fram Strait moored array (moorings F1 to F6 will be exchanged during ARK-XXIV/1

4. ARCTIC MARINE EXPORT PRODUCTION IN RESPONSE TO CHANGES IN PHYSICAL PROCESSES AND ENVIRONMENTAL CONDITIONS'

A. Rosell-Mele, J. Pardiñas
(Autonomous University of Barcelona, UAB)

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, though, 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.

Little is known about current and future environment-ecosystem interactions and 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.

Within our project we link knowledge about the present variability gathered from direct water sampling and instrumental measurements with reconstructions of past changes based on paleoproxies. We have three major objectives:

- Short-term dynamics and small-scale variability: It has been shown since approximately a decade that short-term dynamics and small-scale regional variability are as pronounced as interannual changes, and that existing convection concepts are not fully valid. The opinion of the static and laterally homogeneous Arctic has also been revised since then. High-resolution vertical, regional and temporal profiles are now essential to assess the ecological response to these short-term and small scale physical processes. Water samples will be collected at high temporal and spatial resolution for this purpose during transects across the distinct Atlantic and Arctic waters and within gyres and eddies.

- Long-term and interannual changes: Additionally to the assessment of short-term or small scale changes, we aim for a long-term, interannual study to assess the current variability of the water mass composition and of the sea ice cover and their impact on the biological processes. Long-term changes are important to predict the impact of currently expected dramatic climate changes. Assessing the ecological response will also be essential to provide missing ground-truth data for improved carbon export models, as the processes in the Arctic, especially in the Greenland Sea, seem not to comply with conventional models.

- Paleoreconstructions: Historic environmental and productivity changes can only be observed from fossil markers. Our multi-proxy approach on past climate, water mass movement and ecosystem responses using geochemical biomarkers and other paleoproxies still requires multi-year calibrations with present-day conditions.

Several proxies will be studied: sea-surface temperature through Prymnesiophyte alkenones (U^{K}_{37}), Mg/Ca ratio in Foraminifera, lipids (TEX_{86}) in Archaebacteria; sea ice cover and water mass distribution using Coccolith abundance, $\delta^{18}O$ isotope ratio and highly branched isoprenoid (HBI) alkanes; carbon fluxes via radioisotopes and chlorophylls; primary production using alkenone abundance and pigments; biodiversity with microfossil species numbers (cococoliths, dinocysts, diatoms and foraminifera). Additionally, food-web structures using fatty acids and sterols are studied, due to the labile nature of the fatty acids, however, partly only for the present day ecosystem assessment. Sediment cores and first water samples have been collected in precedent cruises with the RV *Maria S. Merian* (2007) and on *Polarstern* (2008).

Work at sea

Along the transect Bremerhaven-Greenland we will filter seawater pumped through the clean seawater system from the ocean surface (6 m) in regular intervals. We will connect the water flow directly into four in-line filter systems. Salinity and temperature data will be monitored with the thermosalinograph at the same time.

In regular intervals along the transect at 75º N (Greenland – Svalbard; approx. 8 stations or every second degree longitude) we will collect water samples from the CTD rosette bottles from three depths, e.g. from chlorophyll maximum, intermediate and bottom waters. 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), 8 bottles are used per depth (24 x 12 l-rosette). This will allow us to determine the biomarkers with

separate filters and in duplicate. Collected water from the CTD rosette will be filtered by a fixed filter ramp with connected vacuum pump. During the CTD stations water samples shall be collected in parallel using the clean seawater pump (6 m). Hence, at each station we will get data from surface, chlorophyll maximum and distinct water masses.

5. PRODUCTION, FATE AND AGGREGATION OF ORGANIC MATTER IN A CHANGING ARCTIC OCEAN

M. Wurst, N. Händel (AWI, Helmholtz Young Investigators Group 'GloCar')

Objectives

Based on the awareness that global change has increasingly changed marine ecosystems, we intend to determine the effects of higher temperature and CO_2 on the production, fate and aggregation of extracellular organic matter in the Arctic Ocean. To observe temperature- and CO_2-related effects on the concentration and composition of exopolymer substances we will perform incubation experiments with arctic marine phyto- and bacterioplankton communities. Furthermore, secondary effects on the formation of organic aggregates will be investigated by using couette chambers onboard. Biogeochemical and microbiological measurements are necessary to determine future changes in the turnover of organic matter during production and decomposition processes in the Arctic Ocean. Our overarching goal is to contribute to a better understanding of the direction and strength of biogeochemical and microbiological feedback processes in the future ocean. The investigations will be conducted along the 75°N transect (ARK-XXIV/1) and in close cooperation with E. Nöthig and I. Peeken (AWI) in the AWI *Hausgarten* (ARK-XXIV/2) studying plankton ecology and sedimentation of organic matter in a changing Arctic Ocean.

Work at sea

We intend to sample arctic seawater by CTD/rosette sampler at about 5 - 8 depths along the 75°N transect (ARK-XXIV/1) and at the *Hausgarten* stations (ARK-XXIV/2) to determine the impact of microbial processes on aggregation and sedimentation in cooperation with project N-326 (M. Klages, AWI). Analyses of water samples will include biogeochemical parameters (dissolved and particulate organic carbon (DOC/ POC), dissolved and particulate organic nitrogen (DON/ PON), dissolved and total polysaccharides (DCHO/ CHO), dissolved and total amino acids (DAA/AA), transparent exopolymer particles (TEP), Coomassie stainable particles (CSP)) and microbiological parameters (phytoplankton abundance and bacterial cell numbers, bacterial biomass production (^{3}H-incorporation), activity of extracellular enzymes, bacterial uptake of glucose and amino acids).

Furthermore, perturbation experiments with arctic marine phyto- and bacterioplankton will be performed to determine the impact of increased temperature and/or CO_2 on the microbial turn-over of exopolymers. Secondary effects on the formation of organic aggregates will be investigated using couette chambers.

6. LONG-TERM PASSIVE ACOUSTIC MONITORING OF MARINE MAMMALS AND OCEAN NOISE LEVELS IN THE ATLANTIC SECTOR OF THE ARCTIC OCEAN

H. Klinck (CIMRS & NOAA Pacific Marine Environmental Laboratory)

Objectives

The Arctic Ocean is one of the fastest changing environments on earth, and there is no doubt that these changes will affect marine fauna. However, continuous monitoring of changes in this remote and hostile area is difficult and expensive. Passive acoustic long-term recorders offer the possibility to perform this task effectively and at relatively low cost. The overall goal of the CIMRS research conducted in this area is to monitor changes in the Arctic soundscape and to evaluate the effects on marine mammals. This pilot project is intended to derive baseline information needed for setting up a more comprehensive passive acoustic study in the Arctic Ocean.

Marine mammal acoustics

Estimates of the abundance and distribution of marine mammals in the Arctic Ocean are burdened with large error estimates, sometimes of the same magnitude as the estimate itself. Improvements of the current estimates are difficult. Given the vast extent of the Arctic Ocean, dedicated surveys that visually scan the ocean surface for marine mammals are difficult to organize, as ship time - particularly in ice-covered regions - is costly and personnel is limited. In general most visual sightings are available for inshore waters as these can be obtained from shore or from small vessels on day trips.

To gain knowledge on the distribution and abundance of marine mammals, offshore passive acoustic monitoring has become an important research tool. Due to the low attenuation of sounds, especially low frequency sounds, and the fact that most marine mammals vocalize regularly, passive acoustic devices allow scientists to monitor a large area efficiently. Several research institutions (mostly located in the US) have initiated passive acoustic research projects in the Arctic Ocean in recent years. These projects are focused primarily on endangered whales, including the North Atlantic and North Pacific right whales (*Eubalaena glacialis* and *Eubalaena. japonica*), bowhead whale (*Balaena mysticetus*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), and sperm whale (*Physeter macrocephalus*). However, most of these projects have been conducted in the Bering Sea, Beaufort Sea and Chukchi Sea (US waters). The project is intended to gain knowledge on these species inhabiting the Atlantic sector of the Arctic Ocean.

The North Atlantic right whale is one of the world's most endangered cetaceans. The western North Atlantic population is estimated to number 300 - 350 animals, and the eastern population is extinct or nearly so. North Atlantic right whale populations do not appear to be increasing, with anthropogenic factors – notably ship strikes and net entanglement – responsible for significant numbers of deaths. North Atlantic right whales from the western stock inhabit areas off the coast of the United States and Canada from Florida to the Scotian Shelf. Surveys of these areas are conducted relatively often, but despite intensive survey effort, approximately one-third of this population is not found in these areas during the

summer months. In addition, wintering grounds for much of the right whale population are unknown, and pelagic areas have received little dedicated survey effort. In 2007/2008 five hydrophones were deployed in a former whaling ground east of the southern tip of Greenland. The analysis of the recorded data revealed a significant number (>2000) of right whale vocalizations. Knowing that right whales occupy this area seasonally may guide conservation efforts aimed at reducing anthropogenic mortality. The proposed work further north will provide important information on the migration pattern of this and other species and provide baseline information for a future, more comprehensive passive acoustic study on this species as well as on other marine mammals in the area. The CIMRS marine mammal acoustics group has developed algorithms for the detection of calls by many species of marine mammals, including right, bowhead, humpback, blue, fin, and sperm whales. We will use these algorithms to analyze the acoustic data collected by these instruments to study the seasonal occurrence of these species.

Ocean noise

Ocean noise is an increasing problem in our oceans. Currently 90 % of global trade uses the sea for transportation. Thus is it is not surprising that shipping is a dominant sound source in the oceans. The main impact of this noise occurs in the frequency range between a few Hertz to a few hundred Hertz. Because of the low attenuation of sounds in the ocean, marine mammals developed evolutionary navigation and long-range communication systems based on sound. Most baleen whales, for example, emit sounds at frequencies < 1 kHz and could be directly affected by the increase in the noise levels caused by shipping. The potential impacts of anthropogenic noise on marine mammals are numerous, including the masking of biological signals. Due to global warming, sea ice in the northern hemisphere is shrinking dramatically. In 2007 the Northwest Passage was ice-free for the first time in recorded history. The Northeast Passage was blocked only by a narrow strip of ice most of the summer. In fact, both passages were ice-free in 2008. If current conditions continue, the passages will be ice-free for significant periods of the year in the near future. An ice-free Northeast or Northwest Passage would change the global ship based trade dramatically, as this route is radically shorter than the normal trip through the Suez Canal. From Hamburg, Germany (one of the busiest harbours in Europe) to the Japanese port city of Yokohama, for example, the trip using the northern route is ~ 7,400 nautical miles ¬just 60 % of the 11,500 nautical mile trip through the Suez. An increase in ship traffic in this area would significantly increase the noise level which potentially could influence the behaviour of marine mammals.

CIMRS is analyzing deep-ocean sound recordings from hydrophones deployed in the equatorial East Pacific (EEP), central Mid-Atlantic (CMA), northern Mid-Atlantic (NMA), Bering Sea (BS), Antarctic Peninsula (ANP), and Indian Ocean (IO). These datasets provide insight into the over-all structure for the deep-water global sound field. The hydrophones are moored in the deep sound channel, taking advantage of the efficient propagation characteristics which enable the instruments to monitor effectively large sections of the global oceans. Although not always concurrent, the deployment of the hydrophone arrays from 1996 to present allows for an up-to-date assessment of the global-scale distribution of ocean sound levels in discrete frequency bands. Comparisons of intra- and interannual time-averaged ambient-sound levels reveal strong latitudinal variations, where higher latitudes correspond with higher noise levels. Seismic and volcanic activities dominate the lower frequency bands (0-10 Hz) of all hydrophone arrays. Of interest is the periodic nature of broad-band ice noise observed in the ANP acoustic data, suggesting a climate link for these signals related to ice breakup during seasonal warming events. In addition, the multi-species

marine mammal vocalizations observed in all of our hydrophone datasets dominates sound-energy levels at specific frequencies. The proposed work in the Arctic Ocean would allow a more comprehensive study on a “global ocean noise budget”. The Arctic Ocean is of special interest as this area is heavily affected by global warming, and the shrinking of the ice cap will lead to more shipping traffic and oil exploration in this area in near future. For this reason it is very important to get baseline information on current noise levels in this area soon.

Work at sea

Two calibrated hydrophones will be deployed in the Fram Strait and the central Greenland Sea and operated continuously for at least one year. The recorded data will provide information on the seasonal presence of marine mammals as well as on noise levels in the Atlantic sector of the Arctic Ocean.

7. MAPS: MARINE MAMMAL PERIMETER SURVEILLANCE

E. Burkhardt, L. Kindermann, D. P. Zitterbart (AWI)
NN (Fa. Rheinmetall)

Objectives

The MAPS project focuses on the detection of marine mammals in the vicinity of the ship, both for acquiring abundance data and spatial temporal distribution patterns of species and to implement effective mitigation procedures which maybe required during the operation of certain hydroacoustic instruments on board. A large amount of sighting data of marine mammals are necessary to determine animal abundances and gain good estimates of the total number of animals of respective species, which are so far afflicted with great uncertainties. Multiple approaches to permanently gather data by the ship are currently under development, test and operation. Both, human observers and automated detection systems are employed for these tasks. Methods include passive and active hydroacoustics as well as dedicated and opportunistic sighting surveys and computer vision of video and infrared imaging. Sighting data will be fed into environmental suitability models which additionally use environmental proxies such as sea-ice conditions, water depth and sea surface temperature to model and predict the abundance of cetaceans in a given area. To enhance the effectiveness of marine mammal detection for mitigation purposes, automated detection signals are to be generated by algorithms integrating all methods mentioned above.

Work at sea

The scientific programme comprises the implementation of the procedures of opportunistic sighting reports for the ships crew and the installation of a new infrared camera system. The bridge personnel are logging every cetacean sighting since 2005. To alleviate this task and to interlink the sighting data with the Dship data acquisition on board, an electronic version of the log sheet (Whalelog version 1.0) has been in use since ANT-XXV/2. A new version will now be installed and tested for usability. The opportunistic approach shall be cross-validated through dedicated marine mammal observations during the cruise. During the preceding dock time the existing infrared cameras will be replaced by a new 360° scanning high resolution infrared system. This system is the first installation of a newly developed device,

originally meant for military use and represents the state-of-the-art in infrared imaging. It will be permanently mounted in the crow's nest with terminals on the bridge and in one lab. The main purpose on board is the detection of whales by the thermal signature of their blow. AWI staff and a manufacturer's engineer will finish the installation, test run and validate the system in combination with the sightings data acquired during the cruise.

8. AT SEA-DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

R. M. Lafontaine, F. Etienne, X. Vandevyvre (PolE)
not on board: C. R. Joiris

Objectives

In the frame of a long-term study on the quantitative at-sea distribution of seabirds, cetaceans and pinnipeds (seals) started on board *Polarstern* in 1988, to confirm the main hydrological mechanisms influencing this distribution: water masses and fronts – including ice edge. To connect these data with the distribution of their prey, and thus the ecological structure of the whole water column. To identify and quantify recent changes linked to global change and modifications of pack ice coverage: influence on breeding bird colonies, mainly on little auks *Alle alle* (Krabbentaucher) feeding basically at the ice edge, or on pinnipeds and polar bears (by far less evident: see further).

Work at sea

Continuous transect counts (half-an hour each, without width limitation) between stations (stationary ships sometimes attrack seabirds), from the bridge, visibility conditions allowing.

Preliminary data

During recent years – from 2005 on -, drastic changes were observed. On the one hand, the main breeding birds such as little auk (1.3 millions pairs) have heavy problems reaching the ice edge where they feed on zooplakton and back to the breeding colony. This was the case for the Jan Mayen populations in 2005: they were massively leaving the colony north to the pack ice, without return travel, because the pack ice edge was much too far (they can travel 100 to 150 km and back, but not 600): this can only reflect a massive failure in the reproduction season. The same might soon happen for the Spitsbergen colonies, and thus cause major problems for the survival of the species.

On the contrary, no direct problems are to be expected nor noticed for the polar bear and their prey – pinnipeds: they are not bound to the closed pack ice (CPI), but their distribution is limited to the OMIZ (Outer Marginal Ice Zone): they just seem to follow the retreating pack ice.

On the other hand, some cetacean populations increased enormously in the Greenland Sea, probably through import from the much more numerous Pacific populations ("stocks") following the opening of the NE and/ or NW passages: blue, humpback and Greenland "right" whales, etc.

9. BETEILIGTE INSTITUTE/ PARTICIPATING INSTITUTES

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DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg/Germany
Heli Service	Heli Service International GmbH Im Geisbaum 2 63329 Egelsbach/Germany
IPÖ	Institut für Polarökologie Wischhofstr. 1-3, Geb.12 24148 Kiel/Germany
NOAA	Oregon State University & NOAA Pacific Marine Environmental Laboratory Hatfield Marine Science Center 2030 Marine Science Drive Newport, OR 97365
Optimare	OPTIMARE Am Luneort 15a 27572 Bremerhaven/Germany
PolE	Laboratory for Polar Ecology Rue du Fodia 18 B-1367 Ramillies/Belgium
UAB	Institut de Ciència i Tecnologia Ambientals (ICTA) Universitat Autònoma de Barcelona (UAB) Edifici Cn, 4º, Campus Bellaterra 08193 Barcelona Spain

10. FAHRTTEILNEHMER / PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Budéus	Gereon	AWI	Chief Scientist,Oceanographer
Burkhardt	Elke	AWI	Technician, biology
Etienne	Fabrice	PoIE	Biologist
Fietz	Susanne	UAB	Biologist
Händel	Nicole	AWI	Technician, biology
Heinze	Birte	AWI	Student, oceanography
NN		Ing. Fa. Rheinmetall	Engineer
Jacob	Juliane	AWI	Student, oceanography
Kindermann	Lars	AWI	Physicist
Klinck	Holger	NOAA	Biologist
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NN		Heliservice	Pilot
NN		Heliservice	Mechanic
NN		Heliservice	Mechanic
NN			Technician (until Bergen)
NN			Technician (until Bergen)
NN			Technician (until Bergen)
NN			Technician (until Bergen)
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Zakrzewski	Svenja	AWI	Student, oceanography
Zenk	Oliver	Optimare	Engineer, oceanography
Zitterbart	Daniel P.	AWI	Biologist
Zoch	Nico	AWI	Student, oceanography

11. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Pahl, Uwe	Master
02.	Ettlin, Margrith	1.Offc.
03.	Krohn, Günter	Ch.Eng.
04.	Peine, Lutz	2.Offc.
05.	Fallei, Holger	2.Offc.
06.	Dugge, Heike	3.Offc.
07.	Heine, Werner	Doctor
08.	Hecht, Andreas	R.Offc.
09.	Minzlaff, Hans-Ulrich	2.Eng.
10.	Sümnicht, Stefan	2.Eng.
11.	Schaefer, Marc	2.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Winter, Andreas	Electron.
14.	Dimmler, Werner	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.	Scheel, Sebastian	A.B.
23.	Hagemann, Manfred	A.B.
24.	Schmidt, Uwe	A.B.
25.	Bäcker, Andreas	A.B.
26.	Wende, Uwe	A.B.
27	Preußner, Jörg	Storekeep.
28.	Teichert, Uwe	Mot-man
29.	Voy, Bernd	Mot-man
30.	Elsner, Klaus	Mot-man
31.	NN	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.	Wöchener, Martina	Stwdss/KS
38.	Czyborra, Bärbel	2.Steward
39.	Silinski, Carmen	2.Stwdess
40.	Gaude, Hans-Jürgen	2.Stwdess
41.	Möller, Wolfgang	2.Steward
42.	Huang, Wu-Mei	2.Steward
43.	Yu, Kwok Yuen	Laundrym.
44.	NN	Appr.
45.	NN	Appr.

ARK-XXIV/2

10 July 2009 - 3 August 2009

Longyearbyen - Reykjavik

Chief Scientist
Michael Klages

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Michael Klages
Alfred-Wegener-Institut

Der Fahrtabschnitt ARK-XXIV/2 (Longyearbyen – Reykjavik) des Forschungsschiffes *Polarstern* vom 10 Juli bis zum 3. August 2009 wird in zwei ausgewählte Untersuchungsgebiete, den *Hausgarten* und den Hakon-Mosby-Schlammvulkan führen. Während der ersten Hälfte des Fahrtabschnitts sind am *Hausgarten* Beprobungen und *in-situ* Experimente geplant, die Beiträge zu verschiedenen EU-Projekten leisten (HMMV) (HERMIONE und ESONET). Ausserdem tragen diese Arbeiten auch zu dem Anfang 2009 begonnenen Forschungsprogramm PACES (Polar Regions and Coasts in the changing Earth System) des AWI bei. In PACES werden Beiträge zu dem Topic “The changing Arctic and Antarctic” und hierbei speziell zu “Sea ice – atmosphere – ocean – ecosystem interactions in a bi-polar perspective“ erbracht. Die hierzu geplanten Arbeiten sind durch Forschungsaktivitäten während der *Polarstern*-Expedition bezüglich veränderter Meereisbedeckung und dessen Einfluss auf marine Ökosysteme und Nahrungsnetze eingebunden. Zu einem weiteren PACES Arbeitspaket “Ocean warming and acidification: organisms and their changing role in marine ecosystems” werden Untersuchungen zur funktionalen Rolle ausgewählter Schlüsselarten unter den klimatischen Bedingungen einer polaren Region und den daraus resultierenden Umgebungs- bzw. Lebensbedingungen durchgeführt. Ein Teil unserer Arbeiten wird sich darauf konzentrieren, wie ausgewählte Arten im Pelagial und am Meeresboden auf fortschreitende Erwärmung auf funktionaler Ebene (molekular bis ökosystemar) reagieren. Aufbauend auf vorliegenden Erkenntnissen sollen die geplanten Arbeiten dazu beitragen, einerseits den physiologischen und ökologischen Hintergrund artspezifischer Belastungsgrenzen aufzuzeigen, andererseits auch die Kapazität von ausgewählten Organismen hinsichtlich Eingewöhnung und Anpassung auf Veränderungen zu erarbeiten. Schließlich stellen die geplanten Arbeiten einen weiteren Beitrag zur Sicherstellung der Langzeitbeobachtung am *Hausgarten* - Tiefseeobservatorium dar, in denen wir den Einfluss von klimatisch induzierten Veränderungen auf ein arktisches Tiefseeökosystem dokumentieren, so dass *Hausgarten* als nördlichster Knoten in einem Netzwerk von zehn europäischen Observatorien innerhalb von ESONET ausgewählt wurde.

Die zweite Hälfte des Fahrtabschnitts dient der Installation eines Langzeit-Observatoriums am norwegischen Kontinentalrand zur Untersuchung von Schlammvulkanismus. Der Hakon-Mosby-Schlammvulkan liegt in 1250 m Wassertiefe in der SW Barentssee und ist ein ausgewähltes Untersuchungsgebiet der EU – Projekte ESONET, HERMIONE und MARBEF, sowie des ESF EUROCORES EuroDeep Vorhabens CHEMECO. Schlamm, Gas und Porenwässer steigen aus einer Tiefe von 3 km unter dem Meeresboden auf und bilden einen aktiven Schlammvulkan mit einem Durchmesser von 1,5 Kilometern, der seit vielen Jahren erhebliche Mengen an Methan in die Hydrosphäre entlässt. Frühere Untersuchungen des MPI, AWI und IFREMER am HMMV zeigen, dass die Geschwindigkeit des Fluidflusses die Verteilung der chemosynthetischen Gemeinschaften sowie die Stabilität des Hydratsystems und die Emission von Methan kontrolliert. Die erste Langzeitmessung der Sedimenttemperatur von September 2005 bis Juni 2006 zeigte verschiedene Eruptionsereignisse an, bei denen die Sedimenttemperaturen sich während weniger Tage um mehrere Grade änderten. Mit der Installation eines Observatoriums wird ermöglicht, geologische, physikalische, chemische und biologische Parameter kontinuierlich im Verbund zu messen, um so Schlammvulkanismus zu verstehen und Eruptionen sowie Veränderungen des

Meeresbodens vorherzusagen, und deren Auswirkungen auf Gasemissionen und benthische Gemeinschaften zu überprüfen.

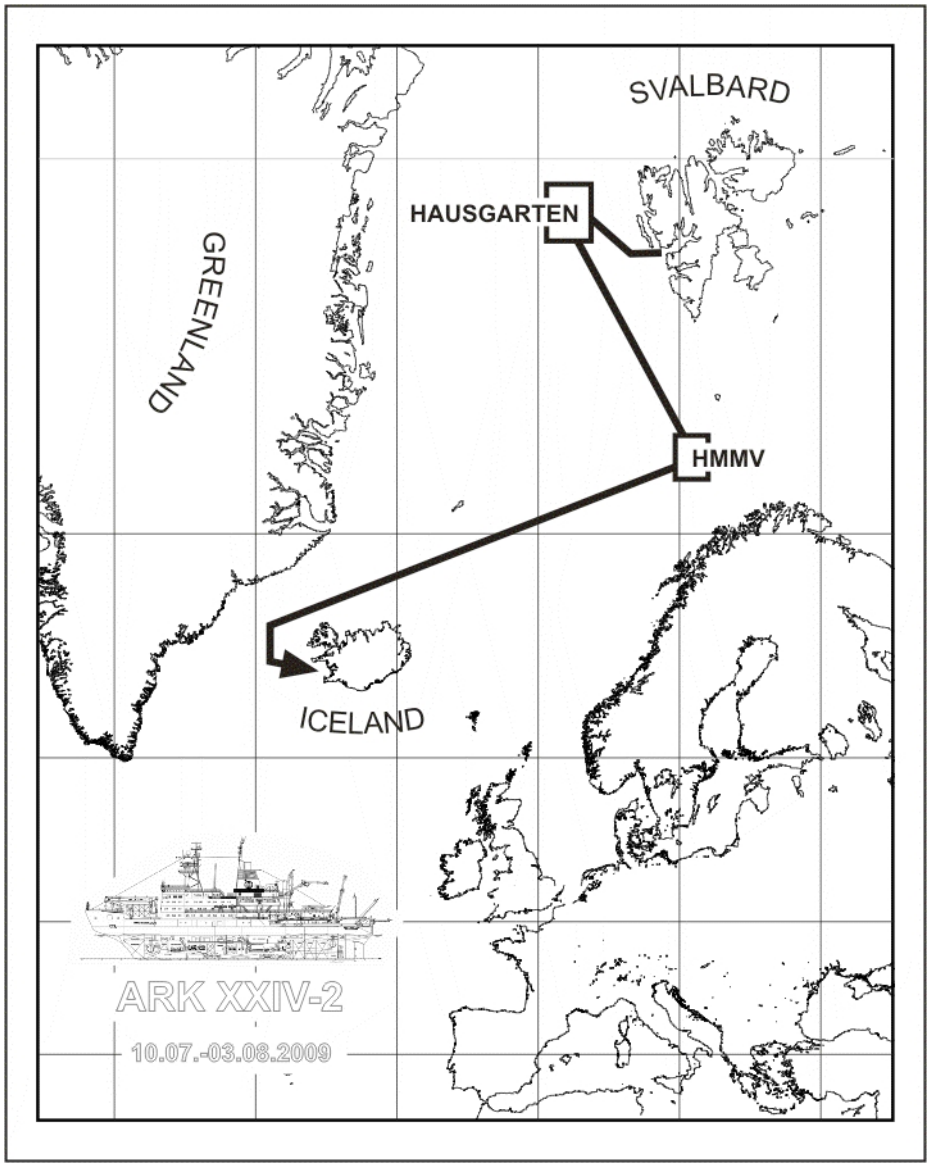

Abb. 1: Geplante Fahrtroute der Polarstern-Expediiton ARK-XXIV/2
Fig. 1: Planned route of the Polarstern expedition ARK-XXIV/2

SUMMARY AND ITINERARY

The work which is planned for the *Polarstern* expedition ARK-XXIV/2 (Longyearbyen – Reykjavik) from 10 July until 3 August in 2009 will focus on two key sites of European multidisciplinary research, the *Hausgarten* deep-sea observatory and the Hakon Mosby Mud Volcano (HMMV). The expedition will contribute to various EU projects (ESONET, HERMIONE, CHEMECO) and to the new PACES (Polar Regions and Coasts in the changing Earth System) research programme of the AWI, which started at the beginning of 2009. Our planned work is embedded in research activities through studies on changing Arctic sea ice conditions and their impact on ecosystems and food webs. These changes will be addressed through a dedicated combination of long-term observations and modelling. Our contribution to WP 6 originates from our studies on the functional specialization of selected polar marine species, from algae to mammals, on polar climate regimes and associated living conditions. These activities qualify and quantify the responses of model organisms to ongoing warming trends at key functional levels, from molecular to ecosystem. Building on recent progress, they also characterize the physiological and ecological background of species-specific sensitivities as well as the capacity of organisms and ecosystems to acclimate or adapt to change. Finally, the proposed research programme contributes to the time-series studies at the deep-sea long-term observatory *Hausgarten* where we investigate the impacts of Climate Change on an Arctic marine deep-sea ecosystem through field studies, observations and models since 1999 which qualifies this station for ESONET.

During the second half of the cruise leg the implementation of a long-term observatory on the Norwegian margin is planned. There, the Hakon Mosby Mud Volcano (HMMV) located at a water depth of 1,250 m on the SW Barents Sea slope is a priority target within the ESONET project. It is also a key site of the EU project HERMES, MERMIONE, MARBEF and the ESF EuroDeep programme CHEMECO. Liquified mud, gas, and geofluids rising from a subseafloor depth of at least 3 kilometres, form a highly active mud volcano with a diameter of 1,5 kilometer characterized by permanent gas emission. Earlier investigations of MPI, AWI and IFREMER at HMMV showed that fluid flow rates control the distribution of chemosynthetic communities, the stability of the hydrate system and gas emission. The first long-term measurement of sediment temperatures from September 2005 to June 2006 yielded evidence of several eruptive events, indicated by abrupt temperature increases of several degrees Celsius within a few days. With the implementation of a long-term observatory it is envisaged to monitor the temporal variability at HMMV to follow the sequence of events before, during and after an eruption and to analyze their effects on gas hydrate stability, seafloor morphology and the distribution and colonization patterns of benthic communities.

2. IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE ECOSYSTEMS

C. Hasemann, U. Hoge, M. Jacob, M. Klages, S. Lehmenhecker, A. Licht, N. Lochthofen, D. Olonschek, B. Sablotny, O. Sachs, T. Soltwedel, T. Wulff (AWI), S. Albrecht, M. Dillon, A. Siegmund (FIELAX), E. Bauerfeind (IFM-GEOMAR), V. Ratmeyer, C. von Deylen (MARUM)

Objectives

The marine Arctic has played an essential role in the history of our planet over the past 130 million years and considerably contributes to the present functioning of the earth and its life. The past decades have seen remarkable changes in key Arctic variables, including a decrease in sea-ice extent and sea-ice thickness, changes in temperature and salinity of Arctic waters, and associated shifts in nutrient distributions. Since Arctic organisms are highly adapted to extreme environmental conditions with strong seasonal forcing, the accelerating rate of recent climate change challenges the resilience of Arctic life. The stability of a number of Arctic populations and ecosystems is probably not strong enough to withstand the sum of these factors which might lead to a collapse of subsystems.

To detect and track the impact of large-scale environmental changes in a the transition zone between the northern North Atlantic and the central Arctic Ocean, and to experimentally determine the factors controlling deep-sea biodiversity, the Alfred Wegener Institute for Polar and Marine Research (AWI) established the deep-sea long-term observatory *Hausgarten*, which constitutes the first, and until now only open-ocean long-term station in a polar region.

Work at Sea

Hausgarten observatory in the eastern Fram Strait includes 16 permanent sampling sites along a depth transect (1,000 - 5,500 m) and along a latitudinal transect following the 2,500 m isobath crossing the central *Hausgarten* station (Fig. 2.1). Multidisciplinary research activities at *Hausgarten* cover almost all compartments of the marine ecosystem from the pelagic zone to the benthic realm, with some focus on benthic processes. Regular sampling as well as the deployment of moorings and different free-falling systems (bottom-lander), which act as local observation platforms, have taken place since the observatory was established in summer 1999. Frequent visual observations with towed photo/video systems allow the assessment of large-scale epifauna distribution patterns as well as their temporal development. To determine the factors controlling deep-sea biodiversity, a number of biological short- and long-term experiments are carried out using a Remotely Operated Vehicle (ROV).

Within the framework of an international project KONGHAU (“Impact of climate change on Arctic marine community structures and food webs”), co-financed by the EU Integrated Project HERMES (“Hotspot Ecosystem Research on the Margins of European Seas”) and the Norwegian oil company Statoil/Hydro, we will retrieve additional sediment samples on the continental shelf off Svalbard and inside the Kongsfjord (Fig. 2.1). KONGHAU combines data collected over the past 10 years from time-series work at Kongsfjord and *Hausgarten*.

Hydrographic data will be assessed using a cabled CTD-Rosette and an Autonomous Underwater Vehicle (AUV) equipped with a CTD, a water sampling system, and optical turbidity and chlorophyll sensors. Water samples will be analysed for bio-optical parameters

for the validation of satellite data. Organic matter produced in the upper water layers or introduced from land is the main food source for deep-sea organisms. To characterise and quantify organic matter fluxes to the seafloor, we use moorings carrying large sediment traps at approx. 100 m below sea-surface and about 180 m above the seafloor. Two moorings deployed in summer 2008 at approx. 2,500 m water depth at the northernmost and the central *Hausgarten* site will be recovered and newly installed for another year of sampling. A free-falling device supporting a current meter, optical oxygen sensors (optodes), and a smaller sediment trap at 2.5 m above ground will be replaced. Another bottom-lander carrying colonisation-cores with azoic, organically-enriched artificial sediments will be deployed for one year to study the attraction of “plain” sediments to meiofauna organisms, focussing on nematode communities.

To assess the recycling of carbon and to calculate the fluxes of solutes across the sediment water interface, we will perform *in-situ* oxygen measurements at the seabed. Virtually undisturbed sediment samples are taken using a video-guided multiple corer (MUC). Various biogenic compounds from these sediments are analysed to estimate activities (e.g. bacterial exoenzymatic activity) and the total biomass of the smallest sediment-inhabiting organisms. Results will help to describe ecosystem changes in the benthal of the Arctic Ocean. Sediments retrieved by the MUC will also be analysed for the quantitative and qualitative assessment of the small benthic biota.

The ROV "QUEST 4000" (MARUM, University Bremen) will be used to install and sample different experiments to study causes and effects of physical, chemical and biological gradients at the deep seafloor, and to survey large-scale distribution patterns of epi/megafauna organisms along a defined transect. By means of push-corers handled by the ROV, we will retrieve sediment samples inside and outside of surface sediments, repeatedly perturbated by plough-like disturber units integrated in one of our lander systems deployed in summer 2008. Additional push-coring will take place inside and outside a flume (8 m in length and 50 x 50 cm in cross section) installed in 2003 at the southernmost *Hausgarten* site, to study effects of increased near-bottom currents on solute exchanges at the sediment-water interface and the reaction of the associated small biota. The ROV will also be used to retrieve sediments from surface sediments covered by 4 m² cages with solid lids, preventing the sedimentation of particulate organic matter, representing the main food/energy source for benthic organisms. These cages were also deployed in summer 2008 and will be repeatedly sampled over the next years, to assess the reaction of the small biota to decreasing food availability.

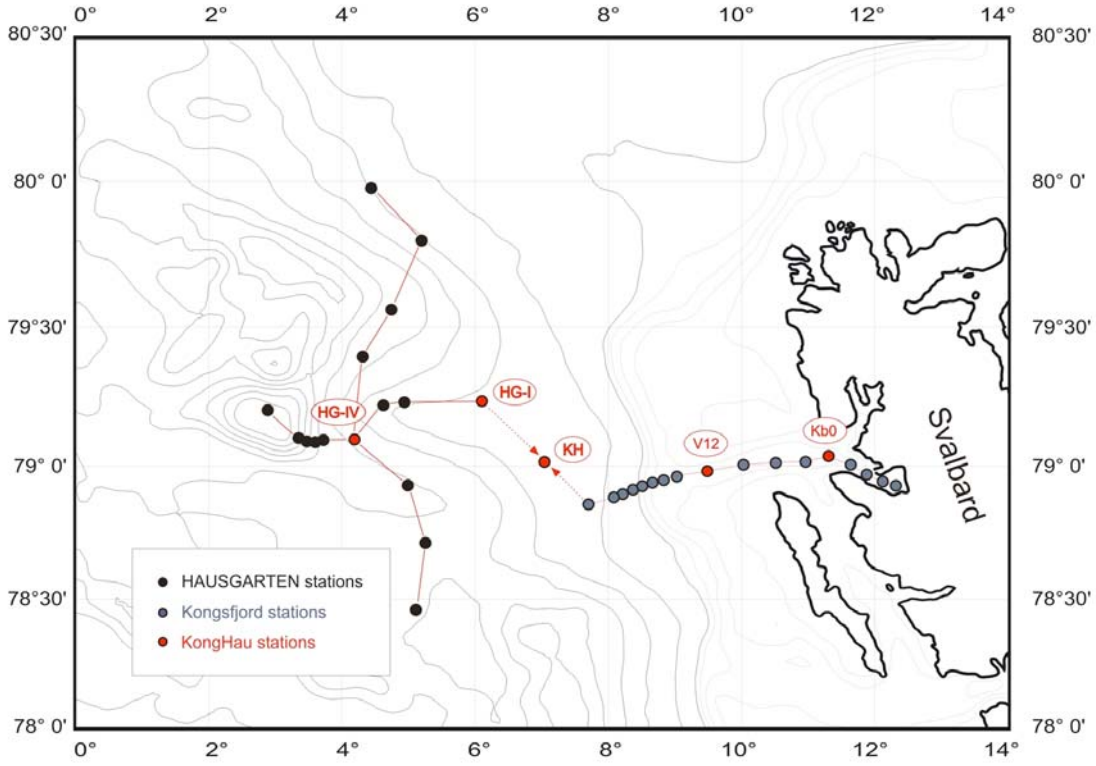

Fig. 2.1: The deep-sea long-term observatory HAUSGARTEN and sampling stations of the Kongsfjorden time-series study in eastern Fram Strait

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

D. Janussen (Senckenb.)

Objectives

Intensive research during the last decade has improved our understanding of poriferan biology, but many questions remain unresolved, particularly concerning the phylogeny, zoogeography and ecology of deep-sea sponges. New data pose new questions as well: For example, palaeontological and zoogeographic evidence indicates that the Polar seas may be a refuge of formerly widely distributed sponge taxa, such as the hexactinellid genera *Schaudinnia* (Arctic) and *Rossella* (Antarctic) (Brückner & Janussen 2005 and unpubl.), or the Demospongid family Polymastiidae (Plotkin & Janussen 2008).

During the ARK-XXIV/2-expedition, the employment of the ROV QUEST at the sea floor of AWI *Hausgarten* and Hakon Mosby Mud Volcano will deliver valuable information on distribution, aut- and and synecology of the different poriferan taxa, provided the photos are evaluated by an experienced sponge taxonomist. UW camera techniques are especially important in the deep-sea, due to the patchy distribution of the sponge species, and the limited number of benthic collection stations possible. But also on the shelf, photos in many cases deliver higher resolution than the catches, to obtain a representative picture of the sponge distrubition and ecology (as during the ANT-XXIII/8-expedition at former ice-shelf Larsen A&B, Janussen 2008). A combination of UW video with other benthic gears, as it was implemented in summer 2008 during ARK-XXIII/2-expedition at different *Hausgarten* stations, provides optimal information on the structure of the communities (Janussen in press).

Main scientific issues and questions of this proposed sponge research project are:

- Uncertaincy concerning the bathymetric boundaries between bathyal and abyssal sponge associations in the Arctic and Subarctic Ocean. E. g. to which extend eurybathic sponge taxa contain cryptic species.
- Unresolved phylogenetic status of alledgedly cosmopolitan genera (such as *Acanthascus, Bathydorus, Caulophacus, Polymastia, Suberites, Tentorium, Asbestopluma, Cladorhiza*) and of so-called “bipolar species” (e. g. *Anoxycalyx ijimai, Tentorium papillatum*).
- As commonly observed both in the Arctic *Hausgarten* and in the Antarctic deep-sea, specific Porifera associations occur in restricted areas. What are the reasons for this patchy occurrence?
- How is this phenomenon correllated with special adaptations, e. g. regarding nutrition and reproduction, to the extreme conditions of polar and deep-sea environments?
- Which are the phylogeographic origins of the present sponge fauna in Polar deep-seas?
- Which is the time factor in the poriferan colonization of oceanic environments at high latitudes, and how is it linked with tectonic and climatic events?

The history and radiation of the Porifera is closely linked with their phylogeny and zoogeography. In this project, we intend to analyze the systematic and phylogenetic relationships, with special focus on selected key taxa. **Working hypothesis**: A wide range of nutrition strategies may be an explanation for the diversity of Porifera in extreme environments, such as the deep-sea at high latitudes.

Sponges play an important ecological role by structuring the sea floor, creating substrate, habitates and acting as hosts for a whole range of other organisms. This is true particularly for the large Hexactinellida (glass sponges) in the SO and in deep-sea environments. **Working hypothesis**: Sponges may function as an ecological key factor controlling the richness and diversity of benthic communities.

Work at Sea

First evaluation of ROV photos will be integrated in the taxonomic analysis, in order to obtain the highest possible resolution of the diversity and ecological role of the porifera at each locality investigated.

If possible, also benthos colletion gears, KG (box corer) and MUC (multi corer), maybe even RD (Rauschert dredge), shall be employed. The catches need to be sieved and sorted and the samples for genetics, lipids and stable isotopes to be frozen, or fixated immediately in

RNAlater, upon collection. The participation of experienced taxonomist is of great advantage for the quick processing of all the animals, both on deck and in the lab., e. g. with the microscope.

Work in the home lab

The further evaluation of ROV and OFOS videos and photos taken, especially in the AWI *Hausgarten* during different expeditions and their comparison with UW photos from the Southern Ocean shelf and in the deep-sea (e. g. from ANDEEP/SYSTCO and ANT-XXIII/8) are planned as part of the DFG-project JA 1063/14-1.

Sponge samples will be prepared for electron microscopy and histology and for molecular biology. Sequencing will be performed in close cooperation with Prof. Dr Gert Wörheide, molecular lab., University Munich. In addition to the standard barcoding markers (COI or 16S), 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).

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4. WEST SVALBARD GAS SEEPS

T. Feseker, G. Wetzel (IFM-GEOMAR)

Objectives

Large amounts of methane are stored in the form of submarine gas hydrates, but their occurrence is limited to the pressure and temperature range of the gas hydrate stability zone (GHSZ). Dissolved or free methane gas rising from deeper sediment layers towards the seafloor may be bound in the form gas hydrates within the GHSZ. An increase in ambient temperature or a decrease in pressure leads to a shift of the GHSZ and may cause gas hydrate dissociation, resulting in the release of the bound methane. Within the water column, aerobic oxidation of methane contributes to ocean acidification. If the released methane reaches the atmosphere, it will increase the green-house effect. Rapid climate changes in

Earth history have been associated with the dissociation of gas hydrate reservoirs, but the role of gas hydrates as a buffer in the global methane cycle is still poorly understood.

Due to the relatively low temperatures prevailing at shallow water depths, submarine gas hydrates in the Arctic are close to the stability limit and therefore particularly sensitive to increasing seawater temperatures as a consequence of global climate change. Repeated oceanographic surveys have revealed that the bottom water temperature on the continental slope west of Svalbard has increased by approximately 1° C over the last 30 years. This temperature increase corresponds to a shift of the gas hydrate stability limit from approximately 366 m to 399 m water depth and is accompanied by a retreat of the GHSZ in the near-surface sediments. The discovery of numerous gas seeps at water depths between 150 and 400 m west of Svalbard during the JR211 cruise of the *RRS James Clark Ross* in August/September 2008 suggests that submarine gas hydrates may be dissociating in response to regional bottom water warming.

Work at Sea

During the ARK-XXIV/2 cruise of *Polarstern*, *in-situ* measurements of the temperature distribution and the thermal conductivity in the seabed will be conducted at selected locations close to the estimated water depth of the gas hydrate stability limit. The measurements are expected to show how far the temperature increase in the bottom water has already propagated into the sediment. If successful, they will provide new insights into past and on-going changes of the GHSZ and will help to estimate the potential release of methane from gas hydrate dissociation in the future.

5. PRODUCTION, FATE AND AGGREGATION OF ORGANIC MATTER IN A CHANGING ARCTIC OCEAN

M. Wurst, N. Händel, K. Metfies (AWI)

Objectives

Based on the awareness, that global change has increasingly changed marine ecosystems, we intend to determine the effects of higher temperature and CO_2 on the production, fate and aggregation of extracellular organic matter in the Arctic Ocean. To observe temperature- and CO_2-related effects on the concentration and composition of exopolymer substances we will perform incubation experiments with Arctic marine phyto- and bacterioplankton communities. Furthermore, secondary effects on the formation of organic aggregates will be investigated by using couette chambers onboard. Biogeochemical and microbiological measurements are necessary to determine future changes in the turnover of organic matter during production and decomposition processes in the Arctic Ocean. Our overarching goal is to contribute to a better understanding of the direction and strength of biogeochemical and microbiological feedback processes in the future ocean. The investigations will be conducted along the 75°N transect (ARK-XXIV/1) and in close cooperation with E. Nöthig and I. Peeken (AWI) in the AWI *Hausgarten* (ARK-XXIV/2), studying plankton ecology and sedimentation of organic matter in a changing Arctic ocean.

Work at Sea

We intend to sample Arctic seawater by CTD/rosette sampler at about 5 - 8 depths along the 75°N transect (ARK-XXIV/1) and at the *Hausgarten* stations (ARK-XXIV/2) to determine the impact of microbial processes on aggregation and sedimentation in cooperation with project N-326 (M. Klages, AWI). Analyses of water samples will include biogeochemical parameters (dissolved and particulate organic carbon (DOC/ POC), dissolved and particulate organic nitrogen (DON/ PON), dissolved and total polysaccharides (DCHO/ CHO), dissolved and total amino acids (DAA/AA), transparent exopolymer particles (TEP), Coomassie stainable particles (CSP)) and microbiological parameters (phytoplankton abundance and bacterial cell numbers, bacterial biomass production (^{3}H-incorporation), activity of extracellular enzymes, bacterial uptake of glucose and amino acids).

Furthermore, perturbation experiments with Arctic marine phyto- and bacterioplankton will be performed to determine the impact of increased temperature and/or CO_2 on the microbial turn-over of exopolymers. Secondary effects on the formation of organic aggregates will be investigated using couette chambers.

6. DEMONSTRATION MISSION LOOME "INSTALLATION OF A LONG TERM OBSERVATORY ON MUD VOLCANO ERUPTIONS (TARGET AREA HÅKON MOSBY MUD VOLCANO, HMMV)"

V. Asendorf, D. de Beer, P. Meyer, P. Ristova, R. Stiens, M. Viehweger, E. Weiz, F. Wenzhöfer (MPI-MM), A. Boetius (AWI), T. Feseker, G. Wetzel (IFM-GEOMAR), J. Blandin, F. Harmegnies, J. Legrand (IFREMER), L. Sanchez (MARUM), A. N. Jorge (University Paris)

Objectives

The main aim of this part of the mission ARK-XXIV/2 is the implementation of a long-term observatory on the Norwegian margin to study mud volcanism, as a Demonstration mission of the 6th FP EU project ESONET. The Håkon Mosby mud volcano (HMMV), located at a water depth of 1,250 m on the SW Barents Sea slope, is a priority target site of ESONET and EMSO. It is also a key site of the EU projects HERMES, MARBEF and the ESF EuroDeep programme CHEMECO. Liquified mud, gas, and geofluids rising from a subseafloor depth of at least 3 kilometres, form a highly active mud volcano with a diameter of 1.5 kilometer, characterized by permanent gas emission. *In-situ* temperature recordings and chemical analyses indicate high upward flow of warm geofluids in the centre, transporting large amounts of methane to the hydrosphere. In the most active central area disturbed sediments and spontaneous gas ebullition can be observed. Fluid flow velocities decrease radially towards the outer rim of HMMV, which is stabilized by gas hydrates. Earlier investigations of MPI-MM, AWI and IFREMER at HMMV showed that fluid flow rates control the distribution of chemosynthetic communities, the stability of the hydrate system and gas emission. The simplest parameter to detect variations in fluid flow as well as eruption events is *in-situ* temperature. The first long-term observation of sediment temperatures from September 2005 to June 2006 yielded evidence of several eruptive events, indicated by abrupt temperature

increases of several degrees Celsius within a few days. High-resolution bathymetric maps and video observations of the seafloor also showed changes in the morphology of HMMV. Only by detailed continuous observations, recording a wide variety of parameters, we can learn about the mechanisms of such eruptions, how to predict them from early signals, estimate the amount of gas released and the consequences for geochemistry and local communities. With the implementation of a long-term observatory, we plan a detailed investigation of the temporal variability at HMMV to follow the sequence of events before, during, and after an eruption, and to analyze their effects on gas hydrate stability, seafloor morphology and the distribution and colonization patterns of benthic communities. The goal of the project is the integration of existing technology to establish an autonomous non-cabled observatory for geo-sounds, surface temperature and –chemistry, as well as sonar detection of gas flares. Methane measurements in the seawater, and the study of colonization patterns and biodiversity will be included as well. Independent systems will be integrated around a combination of deep *in-situ* temperature recordings and geo-acoustics, which will give an early indication of eruptive events. These include sensor recordings of seafloor temperatures and chemistry, sonar systems in combination with current profilers, and biological long-term experiments and observations. This study will be carried out jointly by a consortium of marine geologists, geophysicists, chemists and biologists from Norway, France and Germany.

Work at Sea

Temperature and pore pressure lances measuring profiles at several meters below the seafloor as well as an OBS system have been deployed already in 2008 and will be recovered and redeployed individually. Hence, the work at HMMV will start with an exploratory dive around the central hotspot area where these instruments have been deployed. The use of temperature probes and geophones will allow an early identification of changes in fluid flow and mud movement. Lances with pore pressure and temperature sensors deployed at selected locations in the central area will record changes in porewater flow several meters below the seafloor. The T lance as well as OBS system will be redeployed via winch. The ROV will check on the positioning of the instruments.

Next, a non-cabled seafloor observatory will be deployed by the ROV QUEST. This observatory consists of numerous autonomous instruments some of which are linked. Acoustic wake up calls by individual instruments will be used to trigger high-resolution sampling of other instruments, which will optimize the use of power and memory resources. Using spools of sensor strings, the sensors can be positioned precisely at selected locations in the most active area of HMMV during a ROV dive after the deployment of the central frame via the ship's winch. Posidonia transponders will be used as positioning system to reach an accuracy of < 5 m. The data loggers will remain on the central frame, in a secure position several meters above the seabed.

The MPI/MARUM shuttle system is used to transport a variety of other instruments to the seafloor which are then distributed and deployed by ROV, including upward (and/or downward looking) long range ADCPs (75 kHz) for bubble observation and quantification, acoustic travel time current meters for determination of bubble-induced upwelling current and methane sensors. Each sensor package will be independently powered, and have its own electronics.

Additional visual observations (ROV bubble observations) and another main focus is the deployment of sonar systems in order to observe the dynamics of the bubble discharge at HMMV in parallel to investigations of the sea floor activities at HMMV. In combination with

current profilers and flow meters this will help to detect and quantify the release of gas bubbles.

Surface *in-situ* temperatures will be recorded along a transect and compared with earlier years. Additional sensors measuring temperature, redox potential, oxygen, pH, sulfide, and methane will be positioned directly at the seafloor to study changes in the chemical composition of the pore fluids and to investigate the spatial extent of eruptive events. Video mosaicking of the seafloor together with high resolution sampling will provide the baseline recordings on the zonation of habitats, microbial community structure as well as faunal assemblages, the effects of seepage variability on the distribution of habitats and any morphostructural changes caused by eruptive events (ESF EUROCORES CHEMECO contribution). Furthermore, colonization experiments will be recovered and redeployed.

Between the dives, acoustic survey (EK 60) will provide data for improvement of the gas emission model and sampling with gravity cores equipped with T probes will identify the position of the nearest hydrate deposits.

Expected Results

The demonstration mission LOOME contributes to the most important objectives of ESONET, namely observing the episodic release of methane from the seabed affecting climate change, and the short-term biogeochemical processes affecting the marine ecosystem. The envisioned observatory will lead to an integrated sensor package able to monitor volcanism, gas release, sediment instabilities and other geohazard events. Several modules will be relevant for tasks related to fluid flow and seepage monitoring, as well as observation of the evolution of benthic ecosystems. The sensor modules integrated in the LOOME observatory can also serve the third objective of ESONET, on the relationship between eruptions and submarine slope failures. These processes are highlighted as of fundamental importance for European society, because of their relevance to sensible climate change policies, protection of coasts and infrastructure, and for sustainable marine resource management. All data collected by LOOME will be shared and integrated via a web portal linked to the online world data center PANGAEA at MARUM. Links and interoperability with the Norwegian geological data base, and the IFREMER biological data base will be developed. Observations covering the entire size range of benthic organisms from bacteria to megafauna will complete the multidisciplinary work proposed in the LOOME DM. The assessment of the inventory of bacteria, meiofauna, macrofauna and megafauna over the observation period will provide insights into the effects of seepage variability on the biodiversity at the HMMV. To our knowledge, this is the first approach to assess expected changes in the deep-sea benthic community due to short-term morphostructural and geochemical changes (sediment perturbations, episodical seepage of toxic fluids) in surface sediments. Unfortunately, instruments taking and preserving benthic samples autonomously at pre-programmed time intervals are globally not available and, therefore, repeated sampling with various gears is compulsory to retrieve the material necessary for our investigations. As ship-time availability in the HMMV region is limited, we plan for repetitive benthic sampling campaigns before, during and after the observation phase. The LOOME observatory data will be available to biologists and ecologists to test hypotheses on factors effecting biodiversity and habitat distribution.

7. CULTURE EXPERIMENTS ON THE $\delta^{13}C$ VALUES RECORDED IN TESTS OF BENTHIC FORAMINIFERA FROM METHANE SOURCES AT THE HÅKON MOSBY MUD VOLCANO (HMMV)

J. Wollenburg, R. Petereit (AWI)

Objectives

Whether the $\delta^{13}C$ signal from benthic foraminifers is a valid tool for identifying potential sources of submarine methane release to the atmosphere is heavily discussed and will be verified by our project. Our strategy includes (1) to sample and examine the isotopic signature of live benthic foraminifers and environmental water mass properties from the Hakon Mosby mud volcano and (2) to retrieve life benthic foraminifers under *in-situ* conditions using a newly developed autoclave system allowing methane-related cultivation experiments under original pressure conditions.

Work at Sea

Three autoclaves were built and will be operated during this years cruise. The ROV “QUEST" will take the autoclaves (one or two per dive) to the seafloor, fill it with a push core, close it, and take it back onboard with the seafloor bottom pressure (125 - 128 bar). In the subsequent months the unique action of these autoclaves will enable us to carry out experiments on deep-sea benthic foraminifera and their associated fauna and flora under *in-situ* pressure. Additional push cores (alternatively multiple core liners) will be transferred in pressure-free mesocosms, and treated in the same way than the autoclaves. The results obtained approximately 6 months after the expedition, will be compared to similar successful experiments from 2007 and 2008.

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No.	Name	Rank
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4.	Peine Lutz	2. Offc.
5.	Fallei, Holger	2. Offc.
6.	Dugge, Heike	3.Offc.
7.	Heine, Werner	Doctor
8.	Hecht, Andreas	R.Offc.
9.	Minzlaff, Hans-Ulrich	2.Eng.
10.	Sümnicht, Stefan	2.Eng.
11.	Schaefer, Marc	3.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Winter, Andreas	Electron.
14.	Dimmler, Werner	Electron.
15.	Muhle, Helmut	Electron.
16.	Himmel,Frank	Electron
17.	Loidl, Reiner	Boatsw.
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25.	Bäcker, Andreas	A.B.
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37.	Wöckener, Martina	Stwdss/KS
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ARK-XXIV/3

5 August 2009 - 25 September 2009

Reykjavik - Bremerhaven

Chief Scientist
Wilfried Jokat

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Wilfried Jokat
Alfred-Wegener-Institut

Die Expedition ARK-XXIV/3 mit dem Forschungsschiff *Polarstern* wird am 5 August 2009 in Reykjavik (Island) beginnen und am 25. September 2009 in Bremerhaven enden. Die wissenschaftlichen Aktivitäten auf dem Schiff konzentrieren sich auf geowissenschaftliche Fragestellungen. Es sollen neue Erkenntnisse über die geologische Geschichte des Ostgrönlandschelfs gewonnen werden. Die geplanten Experimente beinhalten sowohl tiefenseismische Experimente, um die tiefere Krustenstruktur zu erfassen, als auch reflektionsseismische Messungen zur Bestimmung der Sedimentstrukturen. Diese Profile werden so weit nördlich vermessen wie es die Eisbedingungen in der Saison 2009 erlauben. Diese Aktivitäten werden durch ein kleines geologisches Beprobungsprogramm ergänzt.

Der zweite Schwerpunkt dieser Expedition besteht in der logistischen Unterstützung von geologischen und geodätischen Programmen, die entsprechende Messungen/Beprobungen auf Grönland selbst durchführen möchten. Die geologische Arbeitsgruppe hat die Beprobung von Süsswasserseen an der Küste zum Ziel. Aus den Sedimentproben sollen neue Informationen über die Ausdehnung des grönländischen Eisschildes während der letzten Eiszeit gewonnen werden. Die geodätischen Arbeiten werden die aktuellen Vertikalbewegungen von Grönland messen. Es werden Hebungsraten erwartet, wie sie auch von anderen früher vereisten Festlandgebieten, wie z.B. Skandinavien bekannt sind.

Dieses geowissenschaftliche Programm wird durch Projekte ergänzt, die sich für Wasserproben und atmosphärische Zirkulation interessieren. Die Kombination aus Ceilometer, Vollhimmelskamera sowie Pyrano- und Pyrgeometer ermittelt den Zustand der bewölkten Atmosphäre und ihren Einfluss auf die Nettostrahlungsbilanz an der Meeresoberfläche im Rahmen des „Meridional Ocean Radiation Experiment“ MORE . Gemessene Temperatur- und Feuchteprofile dienen auch zur Validation der Produkte des Radiometer IASI an Bord des neuen europäischen Wettersatelliten MetOp.

Wissenschaftler aus Belgien werden im Rahmen eines Langfristprojektes Vögel und Wale zählen, um deren Verbreitung zu dokumentieren.

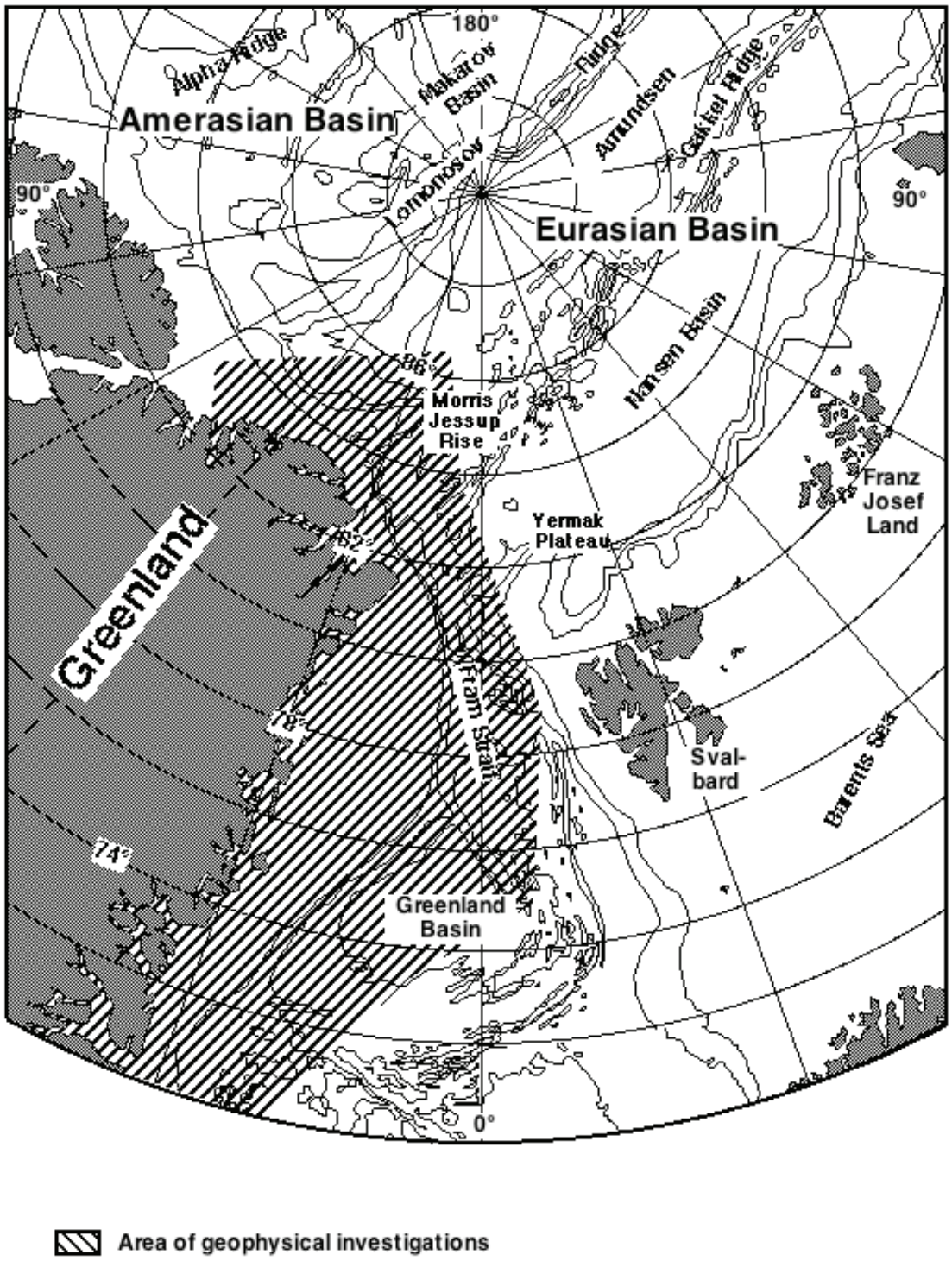

Abb. 1: Geplantes Arbeitsgebiet der Polarstern-Expedition ARK-XXIV/3
Fig. 1: Planned area of operations of the Polarstern expedition ARK-XXIV/3

SUMMARY AND ITINERARY

The *Polarstern* expedition ARK-XXIV/3 will start on 5 August 2009 in Reykjavik (Iceland), and will terminate on 25 September 2009 in Bremerhaven. The scientific programmes aim to retrieve new information on the geoscientific evolution of the East Greenland margin. The activities include deep seismic sounding profiles to unravel the deeper structure of the East Greenland margin supplemented by seismic reflection data, which map in detail the sediment structures beneath the sea floor. These lines will be acquired as far north as the ice permits and is supplemented by a small geological programme.

The second focus of this cruise is the support of geological and geodetic programmes, which aim to retrieve new information from onshore East Greenland. In this region, the geological field party will try to probe lakes along the coast to gather new information on the latest glacial history and/or extent of the Greenland ice shield, the geodetic programme will measure how fast the Greenlandic island is presently moving vertically. We expect vertical movements, which are normal for formerly glaciated continents like Scandinavia.

This programme which is clearly focussed on geoscientific objectives is supplemented by a water sampling, atmospheric observations, and bird as well as mammal watching project.

In the framework of the “Meridional Ocean Radiation Experiment” MORE the state of the atmosphere and its effect on the net radiation budget at the sea surface will be obtained by a combination of a ceilometer, full sky imager as well as pyrano- and pyrgeometer. Retrieved temperature- and humidity profiles serve to validate products of the IASI radiometer on board the new European weather satellite MetOp.

Since the ice conditions varied in the past years significantly it has to be considered that an alternate region (Northern Svalbard) might be investigated, if the Greenland shelf is too heavily covered by sea ice.

2. CRUSTAL ARCHITECTURE AND EVOLUTION OF THE CONJUGATE VOLCANIC MARGINS AND BASINS OFF THE BARENTS SEA AND EAST GREENLAND

C. Brons-Illing, C. Busche, D. Damaske, C. Feld, W. Geissler, J. Gossler, A. Hegewald, L. Jensen, W. Jokat, J. Kollofrath, C. Läderach, P. Lehmann, V. Leinweber, H. Martens, D. Penshorn, A. Prokoph, F. Winter (AWI)

Objectives

Globally, the volcanic margin off Norway between Jan Mayen and Greenland-Senja fracture zones is one of the best explored and studied both by academia and industry. The large existing geophysical and geological database comprises a regional grid of deep wide-angle seismic data (OBS and ESP), deep and standard multi-channel seismic (MCS) reflection profiles, potential field data, and scientific and commercial drill holes. The data reveal important vertical and lateral variations in crustal structure and composition resulting from a complex history of rifting prior to and during the last Late Cretaceous-Early Tertiary rift episode leading to break-up and volcanic margin formation. One of the critical parameters to better understand the rifting processes in general is a similar geophysical database also along the conjugate margin. Only this information will allow an unbiased view on the entire effect of the process, and its symmetry. Thus, this project aims to enlarge the geophysical database along the East Greenland margin to allow a sound comparison of both margin structures. The first part of these investigations was funded in 2003 by the Euromargins programme. This projects aims to continue the research of this first phase.

Off Greenland deep seismic data only exist from the fjords and on the outer margin south of 76^{o}N, whereas regional MCS and potential field data exist on most of the margin. Only one scientific well has been drilled on this margin segment. Four regional deep seismic profiles gathered in 2003 from the Jan Mayen Fracture Zone to the Greenland Fracture Zone revealed for the first time the deeper structure of this continental margin. Raytracing models indicate that the margin close to the Jan Mayen Fracture Zone is heavily intruded and underplated by volcanic material presumably erupted during and after the initial break-up. First estimates indicate that the amount of volcanic material might be of similar dimension like it was found along the Mid-Norwegian margin. Moreover, the East Greenland margin hosts a large, negative magnetic anomaly, which has no counterpart off Norway. The size and extend of this anomaly north of Shannon Island is quite speculative. The seismic and magnetic data indicate that the style of volcanism changes towards the north. The seismic reflection data clearly show that a volcanic outer high exists around 76°N. From the existing data, however, its crustal structure and geological significance during the break-up process is not known. No deep seismic data provide information on any structural link between the negative magnetic anomaly close to the Greenlandic coast and the magmatic outer high north of 76°N. It is completely unknown how the crust beneath the present day shelf was affected by the rift process between 75° and 79°N. The main objectives of the proposal are to provide an improved regional crustal database covering both conjugate margins which will allow us to address the volcanic margin evolution in time and space, i.e. the "total rift "concept. This includes in general:

- Crustal and uppermost mantle architecture (crustal thickness variations, rift polarities, distribution of extrusives, intrusives, magmatic underplating).

- Tectonic and magmatic interplays and styles prior to, during and subsequent to break-up.
- Regional extension and magmatism.
- Along-strike segmentation, magmatic and tectonic (a)symmetry, structural inheritance.
- Interplay of sedimentation, magmatism and vertical motion.

And more specific for the East Greenland margin:

- How is the crustal structure between Shannon Island and the Greenland Fracture Zone? Is the volcanism vanishing like the magnetic data indicate or are the magnetic data biased by the sedimentary cover?
- North of the Greenland Fracture Zone there are strong indications that the Boreas Basin opened at ultra-slow spreading rates. Do we observe also reduced volcanism north and south of the Greenland Fracture Zone during the rift-drift transition? Has the Boreas Basin a seismic signature of non-volcanic rifted margin due to a reduced melt supply during the rift-drift period? How do the volumes of volcanic material estimated by seismic velocities relate to the findings more in the south?
- What is the crustal structure south of the Jan Mayen Fracture Zone? Can we observe here also a large seismic high velocity body?
- What is the sedimentary structure of the East Greenland shelf between 75 and 79°N, and how was the shelf affected by the rifting event? Are there indications for strong erosional events related to this episode?

Work at Sea

Extensive seismic investigations will be performed. Steep as well as wide-angle data will be acquired to provide constraints to these problems:

- 3 deep seismic profiles across the East Greenland margin using OBH/OBS instruments. Up to 30 instruments with a spacing of 10 - 20 km will be used. The exact location of the profiles will strongly depend on the actual distribution of the sea ice cover.
- The existing multi-channel seismic network off the margin will be supplemented and extended onto the margin to better constrain the sedimentary and upper crustal structure of this area. The network will be prolongated, as much north as the ice conditions will allow. Especially the area north of the Greenland Fracture Zone is of interest, since this part of the shelf should be tectonically affected by the Cenozoic strike-slip movements between Greenland and Svalbard. The deep seismic lines will be part of this network.
- Heat flow measurements will be conducted along the deep seismic lines, while retrieving the OBS.

The data will be standard processed, ray-traced and analysed. Special efforts will be made to image deeper crustal levels with a 3,000 m streamer to better constrain the geometry of lower crustal high velocity bodies along the margin. Seismic crustal models will be used to provide a first order estimate in a standard way on the amount of underplated/intruded magmatic material.

Expected results

- New information on the distribution a deep crustal high velocity body.
- To extent the database on the sedimentary structure of the East Greenland shelf and the adjacent basins.
- New heat flow data, which provide first information on the general heat flow of ultra slow spreading systems.

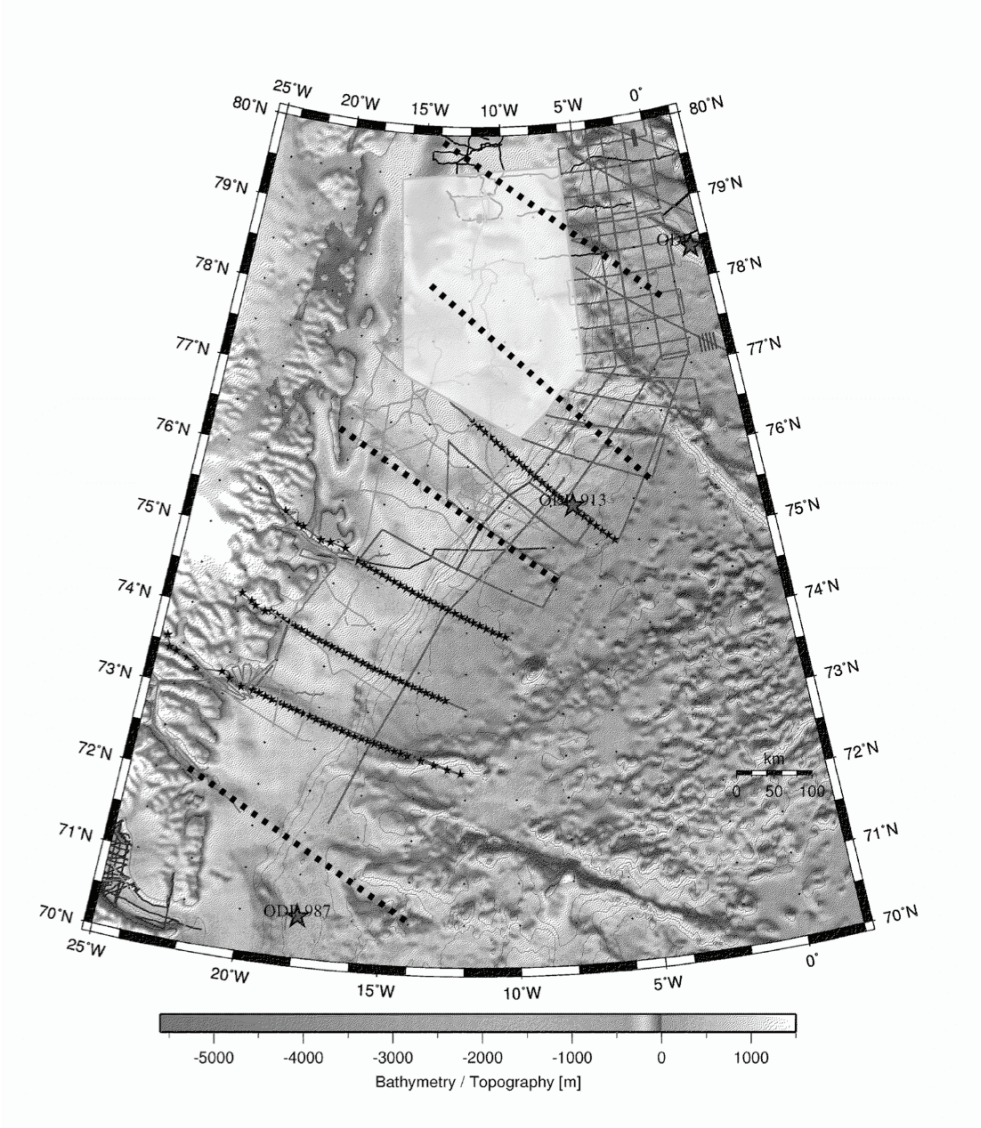

Fig. 2.1: The different grey lines indicate the location of MCS profiles on the East Greenland shelf. The triangles indicate OBH locations from an experiment in 2003, and mark the location of existing deep seismic profiles across the continental margin. The light grey box indicates the area, where new MCS data will be acquired, if ice permits. The dotted lines indicate the location of the proposed deep seismic profiles. Along these lines also MCS seismic will be acquired with a 3,000 m streamer.

3. SHALLOW ACOUSTIC AND GEOLOGICAL INVESTIGATIONS ALONG THE CONTINENTAL MARGIN OFF NE GREENLAND

M. Sommer, D. Winkelmann (IFM-GEOMAR)
not on board: U. Beckert

Objectives

Glaciated continental margins of the polar regions are characterised by highest sedimentation rates, changing sedimentary regimes and repeated isostatic movements. The concert of these frequent and rapidly changing pattern shape these continental shelves and slopes, creating a very heterogeneous morphology. Broad and relatively shallow shelf areas are separated by glacial troughs. Submarine channel systems up to canyon-size but also enormous submarine slides have developed on these slopes and near the shelf break.

Acoustic data (bathymetry and sediment-penetrating) which have been measured directly are rare and the coverage is rather low. Thus, the survey of the NE Greenland shelf by high-resolution swath bathymetry and parametric echo-sounding systems aboard *Polarstern* will provide new insight into morphology, shallow structure and sedimentary history of this shelf. Sediment gravity cores are to be recovered from interesting sites to study the paleo-environmental changes and climate history in more detail.

Work at Sea

Based on the swath bathymetry in combination with the Parasound data geological sampling will be conducted along the northern most part of the Molloy Basin. If possible a mud volcano discovered at the East Greenland margin will be investigated in greater detail.

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

B. Männel, K. Novotny, R. Rosenau (TU Dresden)
not on board: M. Scheinert (TU Dresden)

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. Due to its location at high- and sub-polar latitudes it reacts in a very sensitive way to changes in the environmental and climate conditions. Therefore, the Greenland ice sheet has been subject to intensive geophysical and glaciological investigations for almost one century.

Changes of the ice sheet are visible indirectly 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 and 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.

North-East Greenland 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 – according to model predictions – reaches maximum values for 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 changes for the horizontal as well as for the vertical components with accuracy in the sub-centimetre 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 are to be set-up at ice-free bedrock locations.

The geodetic work to be carried out during this *Polarstern* cruise is a continuation of a project started in 2008 during the cruises ARK-XXIII/1 and 2. At that time, 16 locations at bedrock were surveyed, where GPS stations were successfully set up and observed for the first time (Fig. 4.1). The geodetic network configuration realized in this way includes a west-east component (stations at the ice edge and at the coast), and covers a north-south extension from about 74°N to 81.5°N. Depending on the logistic conditions, we will occupy up to all 16 stations again in order to carry out a first re-observation by geodetic GPS positioning.

From the analysis of the 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 on the glacial history and on the recent ice 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 can be regarded as a continuing contribution to the internationally coordinated project POLENET (Polar Earth Observatory Network) of the International Polar Year 2007/08 (IPY). Linked to this international coordination we closely cooperate with Danish and other international partners (cf. Project partners).

Planned activities

All locations will be reached by helicopter. Additionally to the 16 existing stations, new stations shall be set up, preferably in the region from 71°N to 74°N. They will be chosen in such a way to find an optimum position in respect to exposure, geological conditions and free visibility over the horizon. The GPS equipment will be set up and remain at each location for permanent observation of 5 to 10 days at least. Further geodetic stations will be observed in close cooperation and coordination with the Danish partners. These stations include short-term GPS observations as well as tide gauge deployments at the coast of Greenland, preferably close to GPS stations.

Additionally, we will support the field work of the group of University of Cologne in carrying out GPS-based height observations of the level of those lakes, which will be probed by sediment cores, as well as of geomorphological features indicating relative sea-level curves of the Holocene.

Tab. 4.1: List of GPS stations installed and observed in 2008 and to be re-observed during ARK-XXIV/3

ID	Longitude	Latitude	Geographical Region
ROME	**-19.0617**	**81.0718**	**Kronprins Christian Land CN**
CENT	**-21.7236**	**80.1913**	**Centrumsø (Kronprins Christian Land CS)**
HOLM	**-16.4315**	**80.2730**	**Holm Land SE**
CRIW	**-24.3136**	**80.0925**	**Kronprins Christian Land SW**
BLAF	**-22.6494**	**79.5329**	**Kronprins Christian Land S**
HOVG	**-18.2306**	**79.7002**	**Hovgaard Ø**
LAMW	**-22.3061**	**79.2265**	**Lambert Land W**
BILD	**-23.5033**	**78.1164**	**Bildsøe Nunatakker**
FRAN	**-18.6273**	**78.5784**	**Franske Øer**
LOUI	**-23.0414**	**76.7033**	**Dronning Louise Land CE**
RECH	**-21.8829**	**76.2402**	**Rechnitzer Land E**
SKOL	**-18.6703**	**76.1495**	**Store Koldewey S**
OSTE	**-22.1104**	**75.2836**	**C. H. Ostenfeld Land**
SHAN	**-17.6520**	**74.9336**	**Shannon S**
BART	**-24.1605**	**74.1745**	**Ole Roemer Land**
HOPE	**-20.3737**	**73.8699**	**Hold with Hope NE**

NE North-East
CN Centre-North
CS Centre-South
etc.

Project partners

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Danish National Space Center, Kopenhagen
Dr. Finn Bo Madsen, Dr. René Forsberg

University of Cologne
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Dr. Bernd Wagner

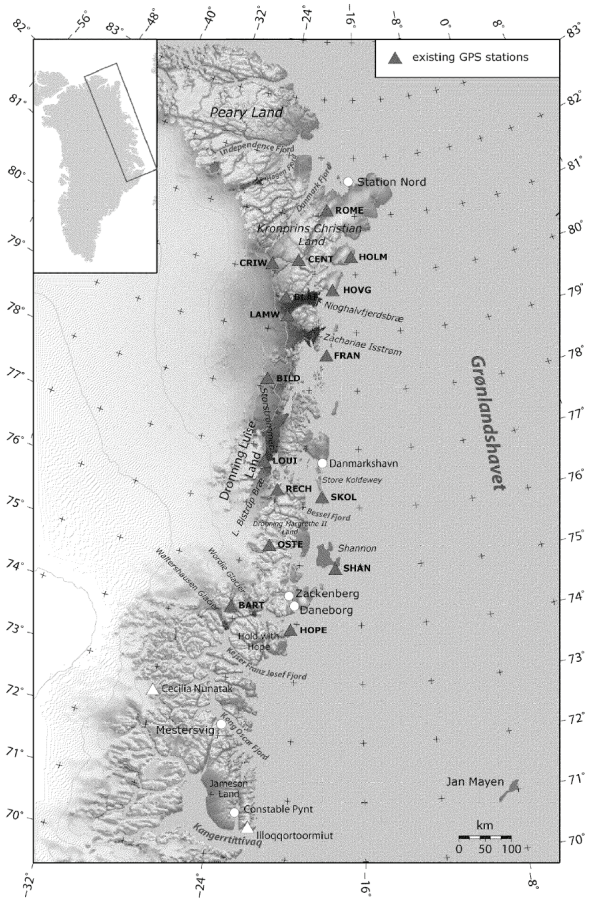

Fig. 4.1: Working area with the GPS stations which were set up 2008 and shall be re-observed during this cruise (white triangles). Optional new stations shall be set up in the ice-free region from 71°N to 74°N.

5. RECONSTRUCTION OF THE LATE WEICHSELIAN AND HOLOCENE ENVIRONMENTAL HISTORY OF NORTH-EAST GREENLAND BASED ON PALEOLIMNOLOGICAL AND GEOMORPHOLOGICAL ARCHIVES

S. Berg, M. Kukkonen, D. Treu, B. Wagner (University Cologne), O. Bennike (GEUS), D. White (Macquarie University)

Objectives

The existing knowledge of past glacial and climate variability in East and North-East Greenland is mainly based on the investigation of ice cores, geomorphological features, and marine and lacustrine sediment sequences. An ice-core record from the Renland ice cap (Fig. 5.1) provides substantial information on climate changes back to the Pleistocene in central East Greenland (Johnsen et al. 1992, Vinther et al., 2008). A similar ice-core record

covering such a long period, however, does not exist from North-East Greenland. For this region geomorphological studies and the investigation of marine and lacustrine sediment cores provide information on the minimum ages of deglaciation at the Pleistocene/Holocene transition (e.g., Bennike and Björck 2002, Cremer et al., 2008) and on postglacial climatic and environmental changes in the coastal ice-free regions (e.g., Hjort 1979, 1997, Funder and Abrahamsen 1988, Wagner et al., 2000). A detailed picture of these paleoclimatic and paleoenvironmental changes is, however, still missing compared with the region south of Store Koldewey (76°N, Fig. 5.1), where several studies improved the knowledge significantly during the past years (e.g., Wagner et al. 2000, 2008, Wagner and Melles 2001, 2002, Klug et al., in press a, b).

Some geomorphological investigations in interior North and North-East Greenland indicate that during the early Holocene thermal maximum glaciers withdrew up to 20 km behind their present positions (Hjort 1997, and references herein). However, these geomorphological results can hardly be confirmed by lacustrine sediment records. The existing lacustrine sediment records from north of Store Koldewey concentrate on palynological analyses, which were partly complemented with sedimentological, biogeochemical and fossil analyses (Funder and Abrahamsen, 1988, Fredskild, 1995, Bay and Fredskild, 1997, Bennike and Weidick, 2001). In addition to the fact that only few continuous records from this region exist, most of these sediment sequences are chronologically poorly constrained, which complicates robust paleoenvironmental reconstructions.

One important source of information to reconstruct the glacial history of a region are relative sea-level curves (Peltier, 1998, 2004). However, only very few curves exist from central East Greenland (Funder 1989, Wagner and Melles, 2002) and only one from North-East Greenland (Hjort, 1979).

The investigation of sediment records from lakes from different regions in North-East Greenland, in close combination with geomorphological investigations in the vicinity of these lakes, will provide information on the timing and speed of deglaciation after the Last Glacial Maximum, on the climatic history after deglaciation, and on relative sea-level changes related to isostatic uplift and global sea-level changes. For the determination of minimum ages of deglaciation and for the establishment of robust chronologies on the sediment sequences recovered, 14C Accelerator Mass Spectrometry (AMS) dating will be employed. For the reconstruction of the paleoclimatic and paleoenvironmental history, 1 - 2 cores from each region visited shall be studied in detail with a resolution of < 50 years in order to detect also short-term variabilities. For the establishment of relative sea-level curves for the individual regions, the sedimentary records from 3 - 6 lakes located at different altitudes above sea level will be studied. Radiocarbon dating, micro- and macrofossil analyses as well as biogeochemical and granulometric analyses can be restricted to those horizons, which indicate an isolation contact between marine and lacustrine settings. Special attention will be given to horizons that potentially can be attributed to the impact of the Storegga tsunami, which hit the coast of East Greenland about 8150 cal yr BP. So far, deposits of the Storegga tsunami have been found in only one lake in central East Greenland (Wagner et al., 2007), but the tsunami should have hit the coast of Greenland also further north. More findings of Storegga tsunami deposits would be necessary to confirm the occurrence of these deposits in Greenland and to reconstruct run-up heights as done before in Norway, the Faroe Islands, and United Kingdom (e.g. Bondevik et al., 1997).

As a future perspective, the minimum ages of deglaciation will be compiled together with other available data on historic glacial margins in order to gain profound information on

regional similarities and differences in the glacial history. For a regional refinement of the glacial history in North-East Greenland, and for a better understanding of the interactions between ice load changes, climatic changes, isostatic uplift and global sea-level changes, the reconstructed environmental data and the relative sea-level curves will be compared with modelled data and with recent GPS observations carried out by the group of TU Dresden.

Planned activities

It is planned to focus the paleolimnological and geomorphological studies to at least two regions in North-East Greenland. The anticipated primary region for the fieldwork stretches from north of Store Koldewey (76°N) to Independence Fjord (82°N). Obviously, the realization of fieldwork in this region depends strongly on the ice conditions in summer 2009 and on the coordination of the individual research programmes during the cruise. Therefore, alternative locations further south (down to the Scoresby Sound region at approx. 71°N) will be considered for the fieldwork, if too harsh ice conditions prevent the ship from reaching the encompassed target regions in North-East Greenland. The geological group will realize the field camps with support of the *Polarstern* helicopters, which will transport the scientific equipment and the expedition members between the individual regions. Preferably, the individual field camps will be based close to locations, where GPS stations have already been installed in 2008, c.f. Scheinert, this book. At each region investigated, the geological group will split into two teams. One team (4 persons) will be responsible for lake sediment coring. The other team (2 persons) will carry out geomorphological investigations in the vicinity of the lakes investigated and will support the lake sediment coring once their own work is finished. The coring of lake sediments includes bathymetric and hydrological measurements on the lakes investigated. Lake transects at different altitudes above sea level are needed for the establishment of relative sea-level curves for the individual regions. For the coring of large and deep lakes an UWITEC platform equipped with UWITEC gravity and piston corer will be used. Smaller and shallower lakes will be cored from a small floating platform using a Russian peat corer. The employment of both coring equipments ensures a fast and efficient progress at each region investigated. The geomorphological investigations will concentrate on two main objectives. The investigation of fossil shorelines will substantially support the reconstruction of relative sea-level curves. The sampling for exposure dating will be used to obtain information on the timing of deglaciation.

Since an accurate determination of recent lake-level heights and sills, respectively, is a prerequisite for the reconstruction of relative sea-level changes in the past, precise height measurements have to be carried out. For this purpose, up to two members of the TU Dresden group will participate in the geological fieldwork in order to realize these measurements, which will comprise GPS and levelling.

It is envisaged to spend about 7 to 10 days per region. Since the postglacial sediment sequences in East and North-East Greenland in general are not longer than 2 - 3 m, this period will be of sufficient extent to recover complete sediment sequences from 3 - 6 lakes.

Project partners

Dresden University of Technology (Germany); Dr. Mirko Scheinert
GEUS, Copenhagen (Denmark); Dr. Ole Bennike
Macquarie University Sydney (Australia); Dr. Duanne White

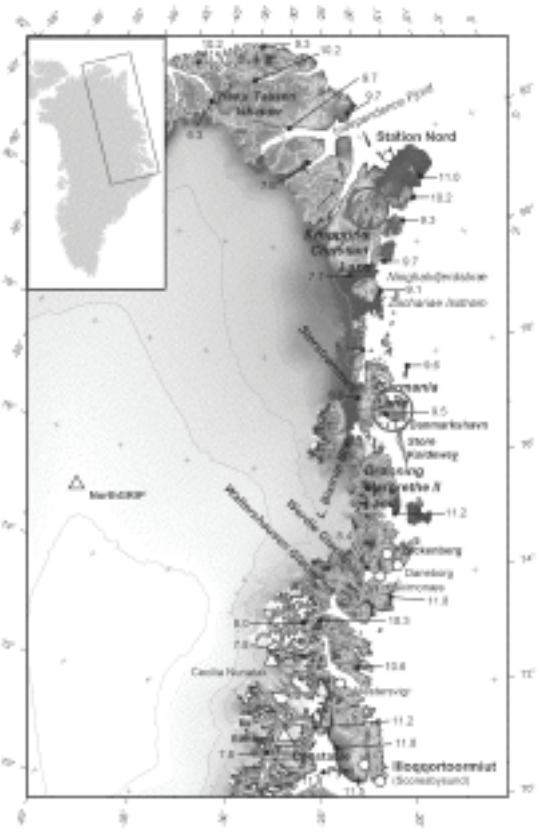

Fig. 5.1: Overview of the working area. The preferred working area stretches from Store Koldewey to Independence Fjord. Two target areas are encircled. Field camps shall be based close to existing GPS stations (triangles). White dots indicate the distribution of oldest radiocarbon dates (calibrated thousand years before present) pertaining to the last deglaciation of the ice-free parts of Greenland (from Bennike and Björck, 2002).

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6. INVESTIGATION OF PERFLUORINATED ORGANIC COMPOUNDS AND THE BROMINATED FLAME-RETARDANTS IN THE NORTH ATLANTIC AND THE ARCTIC

Z. Xie, J. Busch (GKSS)

Objectives

Per- and polyfluorinated organic compounds such as perfluorocarboxylic and sulfonic acids, perfluoro alkyl sulfonamide and N-substituted sulfonamides (PFASs), and fluorotelomer alcohols (FTOHs) are substances that have been extensively used and applied in industrial and consumer products in the past 50 years due to their surface-active properties and thermal as well as chemical stability. Among these substances are perfluorooctanoate (PFOA) and perfluorooctanesulfonate (PFOS). PFOA and PFOS are toxic, persistent, bioaccumulative and ubiquitously distributed, even in remote locations such as the Arctic or the Antarctica.

Brominated flame retardants (BFRs), particularly polybrominated diphenyls (PBDEs), tetrabromobisphenol A (TBBPA) and hexabromocyclododecane (HBCD) have been used in a number of commercial application to prevent fire with world production more than 200,000 metric tons each year. Levels of BFRs seem to be increasing in environment and humans in the past 30 years. Trace levels have been determined in the air and polar bears in the Arctic.

In previously studies, PFASs and FTOHs have been determined in the atmosphere in the Northeast Atlantic and the European Arctic. Atmospheric PBDEs have been studied in Canadian Arctic. Very few data for other BFRs in the Arctic are available. Concentrations of PFASs, FTOHs and BFRs in ocean water and snow pack have not been investigated yet.

For the 2009 cruise ARK-XXIV-3, the proposed project is focused on the determination of PFCs, BFRs and organic fluorinated pesticides in surface waters and air from the Western to Eastern Greenland Sea. The aim of the project is to characterize the distribution of novel PFCs in the atmosphere and sea water of the Arctic Ocean and evaluate the air–sea gas exchange process intervening in the transport of PFCs and BFRs into coastal regions. Data will be used to estimate the transport path of PFCs and BFRs from high concentrated region to relatively low contaminated region, and discover the flow of persistent organic pollutants via air-water or air-snow interaction in the Arctic summer.

Work at the sea

Air samples are collected using a high-volume air sampler operating at a constant flow rate of 500 L min^{-1}. The high volume air sampler consists of a high volume pump, a digital flow meter, a metal filter holder and a PUF/PAD-2 column. GF/F 8 filter is used to collect atmospheric particles. The ship-borne air samples are collected on the upper deck of the research vessel. Field blanks are prepared by spiking surrogate standards in the PUF/PAD-2 column and shortly exposure to the sampling site.

Different sampling procedures for determination of PFCs in water phase will be applied and compared. High volume water samples are collected using Kiel In-Situ Pump (KISP) equipped with PAD-2 column which is optimal for unpolar substances. 2-l water samplers

followed with solid-phase extraction are compared with PAD-4 column samples for determination of perfluorinated acids. A glass fiber filter (GF/F 52) is used to collect suspended particular matters (SPM). Snow sample will be collected with a 50-l barrel and followed with solid-phase extraction.

Expected results

By combining short-term atmospheric samples and the collections of reprehensive water samples across different regions of the western and eastern Greenland Sea, findings are sought as to determine atmospheric deposition and setting flux of these organic pollutants.

7. COMPOSITION OF THE ATMOSPHERE AND RADIATION BUDGET AT THE ATMOSPHERE/SEA-ICE/OCEAN INTERSECTION (METOP & MORE)

N. Renkosik, A. Tessendorf (IFM-GEOMAR)
not on board: A. Macke (IFM-GEOMAR)

Objectives

The net radiation budget at the surface is the driving force for most physical processes in the climate system. It is mainly determined by the complex spatial distribution of humidity, temperature and condensates in the atmosphere. The project aims at observing both the radiation budget and the state of the cloudy atmosphere as accurately as possible to provide realistic atmosphere-radiation relationships for use in climate models and in remote sensing. A special focus is given on the interplay between clouds and sea ice with respect to the downwelling shortwave and longwave radiation. Atmospheric profiles from radio soundings will be used to validate the satellite based profiles from the IASI instrument onboard the new European polar orbiting satellite MetOp.

Work at sea

All required instruments (pyranometer, pyrgeometer, sky imager) are stored onboard *Polarstern* and only need to be installed upon departure from Reykjavik.

Radiosoundings will be performed close to the overpass times of the MetOp satellite. Synoptical observations will be done every hour. During direct sun situations the aerosol optical thickness will be measured with a hand-held sun photometer. Sea ice coverage and brightness will be monitored by visual inspection and camera images.

Expected results

Atmospheric cloud coverage, cloud types, sea ice coverage, ice type and corresponding net radiation budget.

8. AT SEA-DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

C. Joiris, A. Joris, F. Van Hove (PolE)

Objectives

In the frame of a long-term study on the quantitative at-sea distribution of seabirds, cetaceans and pinnipeds (seals) started on board *Polarstern* in 1988, to confirm the main hydrological mechanisms influencing this distribution: water masses and fronts – including ice edge. To connect these data with the distribution of their prey, and thus the ecological structure of the whole water column. To identify and quantify recent changes linked to global change and modifications of pack ice coverage: influence on breeding bird colonies, mainly on little auks *Alle alle* (Krabbentaucher) feeding basically at the ice edge, or on pinnipeds and polar bears (by far less evident: see further).

Work at sea

Continuous transect counts (half-an hour each, without width limitation) between stations (stationary ships sometimes attrack seabirds), from the bridge, visibility conditions allowing.

Preliminary data

During recent years – from 2005 on -, drastic changes were observed. On the one hand, the main breeding birds such as little auk (1.3 millions pairs) have heavy problems reaching the ice edge where they feed on zooplankton and back to the breeding colony. This was the case for the Jan Mayen populations in 2005: they were massively leaving the colony north to the pack ice, without return travel, because the pack ice edge was much too far (they can travel 100 to 150 km and back, but not 600): this can only reflect a massive failure in the reproduction season. The same might soon happen for the Spitsbergen colonies, and thus cause major problems for the survival of the species.

On the contrary, no direct problems are to be expected nor noticed for the polar bear and their prey – pinnipeds: they are not bound to the closed pack ice (CPI), but their distribution is limited to the OMIZ (Outer Marginal Ice Zone): they just seem to follow the retreating pack ice.

On the other hand, some cetacean populations increased enormously in the Greenland Sea, probably through import from the much more numerous Pacific populations (“stocks”) following the opening of the NE and/ or NW passages: blue, humpback and Greenland “right” whales, etc.

9. FAHRTTEILNEHMER / PARTICIPANTS

Name	Vorname/ First Name	Institut/ Institute	Beruf/ Profession
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11. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1.	Schwarze, Stefan	Master
2.	Ettlin, Margrith	1.Offc.
3.	Krohn, Günter	Ch. Eng.
4.	Peine Lutz	2. Offc.
5.	Fallei, Holger	2. Offc.
6.	Dugge, Heike	3.Offc.
7.	Heine, Werner	Doctor
8.	Hecht, Andreas	R.Offc.
9.	Minzlaff, Hans-Ulrich	2.Eng.
10.	Sümnicht, Stefan	2.Eng.
11.	Schaefer, Marc	3.Eng.
12.	Scholz, Manfred	Elec.Tech.
13.	Winter, Andreas	Electron.
14.	Dimmler, Werner	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.	Scheel, Sebastian	A.B.
23.	Hagemann, Manfred	A.B.
24.	Schmidt, Uwe	A.B.
25.	Bäcker, Andreas	A.B.
26.	Wende, Uwe	A.B.
27.	Preußner, Jörg	Storek.
28.	Voy, Bernd	Mot-man
29.	Teichert, Uwe	Mot-man
30.	Elsner, Klaus	Mot-man
31.	NN	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.	NN	Appr.
45.	NN	Appr.

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ARK-XXVI/1	**20.06.2009 - 10.07.2009**	**Bremerhaven - Longyearbyen**
ARK-XXVI/2	**10.07.2009 - 03.08.2009**	**Longyearbyen - Reykjavik**
ARK-XXVI/3	**05.08.2009 - 25.09.2009**	**Reykjavik - Bremerhaven**