The expedition ARKTIS XX/1

of the Research Vessel "Polarstern" in 2004

Edited by

Gereon Budéus

with contributions of the participants

ARK XX/1

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Bremerhaven - Longyearbyen

Fahrtleiter / Chief Scientist

Gereon Budéus

KOORDINATOR /COORDINATOR

Eberhard Fahrbach

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Der erste Fahrtabschnitt der 20. Polarstern-Expedition in die Arktis begann am 16.6.2004 in Bremerhaven. Die ersten Aktivitäten galten der Inbetriebnahme neuer oder modifizierter Geräte: Parasound Anlage sowie ADCP erfuhren in der Werftzeit umfassende Erneuerungen. Der Weg führte zunächst über die Nordsee und weiter an Norwegen vorbei zum untermeerischen Hakon Mosby Schlammvulkan, wo im Rahmen beständigeren Forschungsengagements während dieser Expedition benthische Foraminiferen untersucht wurden. Bereits der Weg dorthin wurde für eine Vielzahl luft-chemischer Untersuchungen genutzt. Hier galt das Hauptinteresse der Verbreitung von Quecksilber und persistenten organischen Schadstoffen. Die Fahrtroute von Bremerhaven aus in die arktischen Gewässer bot eine seltene Gelegenheit zu Messungen, die räumlich von den Quellengebieten bis in industrieferne Regionen reichen.

Es schloß sich an ein zonaler hydrographischer Schnitt auf 75°N, der sich von der Bäreninsel bis auf das Grönländische Schelf erstreckt. Dieser Schnitt wird seit einigen Jahren jährlich wiederholt, da man erkannt hat, daß auch die Arktischen Gewässer durch hohe Dynamik gekennzeichnet sind und die komplexen Veränderungen nur mit Hilfe langer Zeitreihen konsistenter Qualität richtig erklärt werden können. Zu den Messparametern gehörten neben den physikalischen auch verschiedene Tracer- und Nährstoffkonzentrationen. Die Suche und Erfassung eines langlebigen kleinskaligen Wirbels mit besonderer Relevanz für die tiefe Konvektion war ein weiteres Ziel, welches mit Hilfe von XBT-Abwürfen aus dem Helikopter zeitökonomisch erreicht werden konnte. Auch die Auswechslung von autonom profilierenden Verankerungen fanden auf diesem Weg von Ost nach West statt. Zwei weitere Verankerungen mit akustischen Empfängern werden die Konvektionsvorgänge mit der innovativen 'shadowgraph' Technik untersuchen.

Auch im biologischen Bereich hat sich die Erkenntnis durchgesetzt, daß einmalige Erhebungen zur Erfassung nichtstatischer Systeme unzureichend sind. Die Einrichtung des 'Hausgartens' in der Framstraße vor Spitzbergen, der nach den Arbeiten auf dem Zonalschnitt aufgesucht wurde, ist ein Versuch, durch gezielte Ausbringungen und Beprobungen über mehrere Jahre die Dynamik von tiefseespezifischen ökologischen Abläufen und ihr Wechselwirkungsnetz zu erfassen. 1999 wurde die erste Langzeitstation in einer polaren Tiefseeregion eingerichtet, und seitdem wird auch ein Schnitt über einen Tiefengradient zwischen 1000 m und 5500 m Tiefe wiederholend beprobt, was bei unserer Fahrt wegen der geringen Eisbedeckung keinerlei Probleme bereitete. Hier kam eine Vielzahl von

Geräten zum Einsatz, von Landern über Sedimentprobennahmegeräte bis zu abbildenden oder messenden optischen Verfahren.

Die bereits erwähnten luftchemischen Untersuchungen fanden selbstverständlich auf der gesamten Fahrtstrecke statt. Eine spezifisch polare Erscheinung, der besonderes Interesse galt, ist der 'Atmosphärische Quecksilberrückgang', während dessen die Konzentrationen in der Atmosphäre deutlich unter die Hintergrundwerte sinken. Hier ist ein Ziel, zu ermitteln, inwieweit die Polarregionen der Erde als endgültige Senken angesehen werden müssen.
Nach dem Ende der Arbeiten im 'Hausgarten' fand das Einlaufen von Polarstern am 16.7.2004 in Longyearbyen statt.

2. OVERVIEW AND ITINERARY

The start of the first leg of the 20th Polarstern expedition to the Arctic took place on the 16th of June 2004. First activities were related to the operational start up of new or modified equipment: Parasound and ADCP systems had undergone major modifications during the time in the shipyard. The ship's itinerary did first cross the North Sea, pass by the Norwegian coast and aim at the underwater Hakon Mosby Mud Volcano. At this site, benthic Foraminifera were investigated in the frame of a more perseverative research engangement. The steaming path from Bremerhaven to the Hakon Mosby Mud Volcano was already utilized for extensive investigations in air chemistry. The main interest concerned the spreading of mercury and Persistent Organic Pollutants (POPs). The overall ship's track from the North Sea into remote Arctic waters revealed a rare opportunity to scan the environment from the source regions to the polar areas far off from industrial plants.

A zonal transect was performed along 75°N with predominantly hydrographic measurements. The transect extended from Bear Island to the Greenland coast and is repeated annually since a number of years because it has been recognised that the Arctic Waters experience highly dynamic changes and that the complex modifications due to convection in winter can be correctly explained only with the aid of quality-consistent long term time series. On this way from east to west there were additional activities. One was the exchange of autonomously profiling moorings and a new deployment of innovative acoustic moorings using the shadowgraph technique for convection research. Another aim was the search and investigation of a submesoscale vortex which is of particular importance to deep convection. The vortex could be found very time economic by XBT throws from a helicopter.

In marine biology, too, it has been realised that nonrecurring investigations describe non static systems inadequately. The installation of the 'Hausgarten' in Fram Strait off Svalbard is an attempt to comprehend the dynamics of deep sea specific ecological processes and their interactions by systematic deployments and sampling. The first long term station in an arctic deep sea reagions was established in 1999, and since then a transect is sampled repeatedly which follows a depth gradient between 1000 m and 5500 m. Owing to low ice concentrations this posed no difficulty during ARK XX/1. A multitude of instruments was used here, as landers, sediment corers or optical devices.

The already mentioned research in air chemistry was, of course, continuously performed on the entire cruise track. A specific polar feature, which was investigated with special emphasis, is the 'Atmospheric Mercury Depletion Event', during which mercury concentrations decrease to values below the background. With respect to this phenomenon it is the aim to assess to what extent the polar regions must be regarded as final sinks.

After having finished the work in the 'Hausgarten', Polarstern's arrival at Longyearbyen was on July 16th 2004.

3. METEOROLOGY

R. Hartig, K. Buldt

RV Polarstern left Bremerhaven on June 16th steaming along the Norwegian coast heading for the first research area, the Håkon Mosby Mud Volcano. The passage was dominated by northerly winds around force 5 Bft, which resulted from the pressure gradient between a depression over Scandinavia and an anticyclone over Greenland. Off Cape Svinöy winds reached force 8 Bft for a short period, presumably to orographic forcing. First Helicopter flights bound for Tromsø, took place on June 20th at fair weather. A few towering "CB's" along the coastline didn't cause any problems.

The work in the volcano area was accompanied by very uniform weather conditions. Northeasterly winds around force 5 Bft, swell between 1 and 2 m, heavy cloud cover, scattered rain and air temperatures near 7° C describe the typical situation.

Due to bad visibility and low ceiling, on June 22nd another flight to Tromsø had to be cancelled. Visibility increased in the ships vicinity early next morning. To get an idea about the conditions at the destination we received METARs and TAFs of Tromsø and Bardufoss airport from our home office in Hamburg. With the aid of an additional radiosounding and satellite pictures a small frontal zone was observed enroute, which was expected to be flightable. Unfortunately another frontal System visible in the satellite pictures approached form northeast. Taking all the information into consideration a 6 hours timeslot with sufficient weather conditions was forecasted. Thus pilots, master, chief scientist und meteorologist agreed in an immediate attempt to reach Tromsø. After takeoff both Helicopters experienced heavy weather at the first 50 miles but better conditions at the second leg of approx. 100 miles. To minimize the risk RV Polarstern headed approximately 50 miles to Tromsø shortening the distance for the return flight. Around noon both Helicopters returned safely ending this action successfully.

Between June 24th and July 3rd research was done on an east-west transect along latitude 75° north. This period was governed by moderate wind-speed, low sea-swell und positive temperatures, giving fair conditions for scientific activities. Though air traffic was partly obstructed by low ceiling and patches of fog, all planed flights were carried out. On Friday, June 2nd Polarstern entered the ice off the Greenland coast. Final works had been done at an ice coverage of 70% to 80% first year and multiyear ice. After finishing these works, next stop of the cruise was Longyearbyen, Svalbard.
RV Polarstern stopped engines off the 12miles zone, while two people were flown by Helicopter to Longyearbyen Airport. The flight forecast was done with the aid of Longyearbyen METAR and TAF information (gained via Internet transmission). Flight conditions at takeoff were given by an overcast sky with 300ft ceiling and 4 to 6 km visibility. Conditions deteriorated due to fog formation along the coastal area, making the return flight impossible. As there was no significant change in the weather

situation predicted, RV Polarstern steamed up the “Isfjord” for 3 hours heading for an area free of fog where the Helicopter returned safely.

After this RV Polarstern set course to the “AWI-Hausgarten” research area, where scientific work was continued on July 6th. For the first 5 days weak to moderate southerly winds (Force 2-5 Bft) and wave heights between 0.5 and 2.0 m were observed. Low-pressure influence caused a cloudy to overcast sky, frequent fog and isolated rain, while the temperature ranged between 2° and 5° C. A high-pressure ridge, extending from a Siberian high over the pole to the Greenland Sea dominated the weather situation at the final days. Weak northerly winds and a sea swell below 1m were observed mainly. At temperatures between 3° and 6°C we experienced some sunny days and for some periods an excellent long-range visibility of 160km as well as some cloudy and foggy days. With the exception of the air-chemistry people, who liked to have stronger winds, there were no restrictions to scientific work, due to weather conditions.

Abbreviations:

Bft	Beaufort
CB	Cumulonimbus
METAR	Meteorological Aerodrome Report
TAF	Terminal Aerodrome Forecast

4. LONG TERM VARIABILITY OF THE HYDROGRAPHIC STRUCTURE, CONVECTION AND TRANSPORTS THE GREENLAND SEA

G. Budéus, S. Ronski, R. Plugge, L. Gerull, J. Otto, K. Partzsch, L. Kattner, B. Cembella, A. Kaletzky

Bottom water renewal in the Greenland Sea by deep convection in interplay with ice coverage and atmospheric forcing is a major element of the water mass modification in the Arctic Mediterranean. Effects influence both the central Arctic ocean and the overflow waters into the Atlantic. Since the hydrographic observations became more frequent in the late 1980s, no bottom water renewal by winter convection took place, however. Under these conditions, the deep water properties change towards higher temperatures and salinities. Furthermore, the doming structure in the Greenland Gyre, as it was observed in the mid-80s, was superseded by an essentially 2-layered water mass arrangement with a marked density step seperating the two layers presently at about 1800 m. The specific objectives of the project are to investigate the relative importances of atmospheric forcing parameters for winter convection, to clarify whether ice coverage inhibits or facilitates deep convection, to build a long term observational basis about deep water changes in the Greenland Gyre, and to contribute to the decision which deep water exchange mechanisms are at work under the absence of deep winter convection. A special focus is put on the observations of a particularly long lived submesoscale coherent vortex (SCV) within an international cooperation. Within this eddy, winter convection penetrates usually to considerably greater depths (about 2600 m) than in the surrounding waters. The eddy posesses a diameter of only 20 km, and as it shows no surface signal it is difficult to detect.

Work at sea

In the central Greenland Sea, a long term zonal CTD transect at 75° N has been performed with a regular station spacing of 10 nautical miles. This distance has not been reduced at frontal zones in order to gain time for a couple of stations dedicated to the search and investigation of the SCV. CTD and water sampler (SBE 911+ with duplicate sensors, SBE Carousell 24 bottles of 12 L each) worked faultlessly. Additional sensors were attached for Oxygen concentrations, transmission, Chlorophyll fluorescence, and Gelbstoff fluorescence.

It is not possible to describe the full details of calibration and data procedures here. A few hints may suffice to give an idea about the general procedure. We use the same sensors already for a number of years and checked for their performance with respect to unwanted cross dependencies. According to this, one of the temperature sensors shows a pressure sensitivity of roughly 1.5 mK/4000 dbar while no unspecified pressure or temperature dependence of the conductivity sensors could be found. To identify the latter is close to impossible in the field (within the polar oceans) because of the high gradients in the upper water column where suitable temperature differences occur. The locations of in-situ comparisons for temperature and salinity have been chosen carefully by checking for each data point whether a comparison is allowed or inhibited. Time alignment has been optimized for each flow path separately and will be applied together with final post cruise calibration. The difference between pre-cruise and post-cruise calibration is normally in the range of a few mK and a few 1/1000 in salinity. Bottle sample salinities were determined immediately on board. Salinites have been corrected by 0.004. Oxygen samples were taken regularly. Occasionally, also several other tracers like technetium and barium were taken.

For the first time, the search for the eddy (SCV) was performed from an helicopter in order to save ship time. A triangle grid formed by equidistant station points was constructed, where the distance between each station pair was 7 nautical miles. This is the largest allowed distance when looking for a feature of 20 km diameter and proved to be a very successfull search strategy during last year's cruise. As instruments we used deep cast XBTs which have a nominal range of 1850 m (T5, Sippican). Frequently they provided data to 2000 m. During the cast duration of about 5 minutes, the helicopter has to hover at a fixed position, which was not too difficult due to resonable weather conditions. Data aquisition software has been used which was specially modified for the actual task of our eddy search. It contains an optional one degree Celsius temperature range with a free choice of the lower temperature scale value, so that the vertical structure with the surface warm layer (or its lack) and the mid depth temperature maximum (and its depth) could easily be recognized. The search was successfull within one day and an eddy was identified on June, 26th. A following ship bound CTD survey with full depth stations showed that the eddy core was located at about

74° 54 min N, 01° E on 27-Jun-2004

This was not the eddy observed in the previous year, which was relocated later by a french cruise, but an additional one.

The in house developed EP/CC (externally powered/compressibility compensated) Jojo-mooring has been exchanged and the time series was thus successfully extended. A shallow water jojo (APV), which had been attached to the top buouyancy of one mooring was lost. This type of instrument will not be used in the future, and a different approach has to be tested in order to monitor the uppermost 100 m of the water column. On one mooring, a sound source was deployed, and two additional moorings were deployed which host hydrophones to apply the shadowgraph technique newly developed by DAMTP, Uni-Cambridge.

First results

The most outstanding single feature of the survey in the Greenland Sea was certainly the additional convective eddy, showing that two of these eddies can coexist at the same time in the central Greenland Gyre. This is remarkable, as a full region survey, performed a few weeks before our cruise, revealed no eddy in the Greenland Sea (presumably due to its coarser station spacing). These features represent the deepest convection level observed in recent years. The eddy structure we observed was broader than expected and the eddy core extended to only 2300 m, compared to 2700 m observed in the eddy the previous year. The eddy core was not vertically homogeneous but showed a vertical structure around 1500 m probably marking the convection depth of the preceeding winter.

The general situation was characterized by summer conditions with a low salinity surface layer. The subsurface layer was only marginally influenced by Atlantic Water as the salinites hardly exceed 34.9. At about 70 m depth cold temperatures (below -1° C) are encountered around 3° E, while the majority of the profiles shows temperatures warmer than -0.75° C at that depth due to summer heating. It is difficult to determine the exact depth to which winter convection has proceeded, and this has to be analyzed later. At first sight, convection seems to have affected only the upper 1000 m. The temperature maximum at intermediate depth descended by about 100 m again, which contrasts the previous winter but is in accord with the long term development. The bottom water temperature increase continued, and amounts again to about 10 mK between spring 2003 and summer 2004. This temperature increase is observed throughout the whole layer below the temperature maximum.

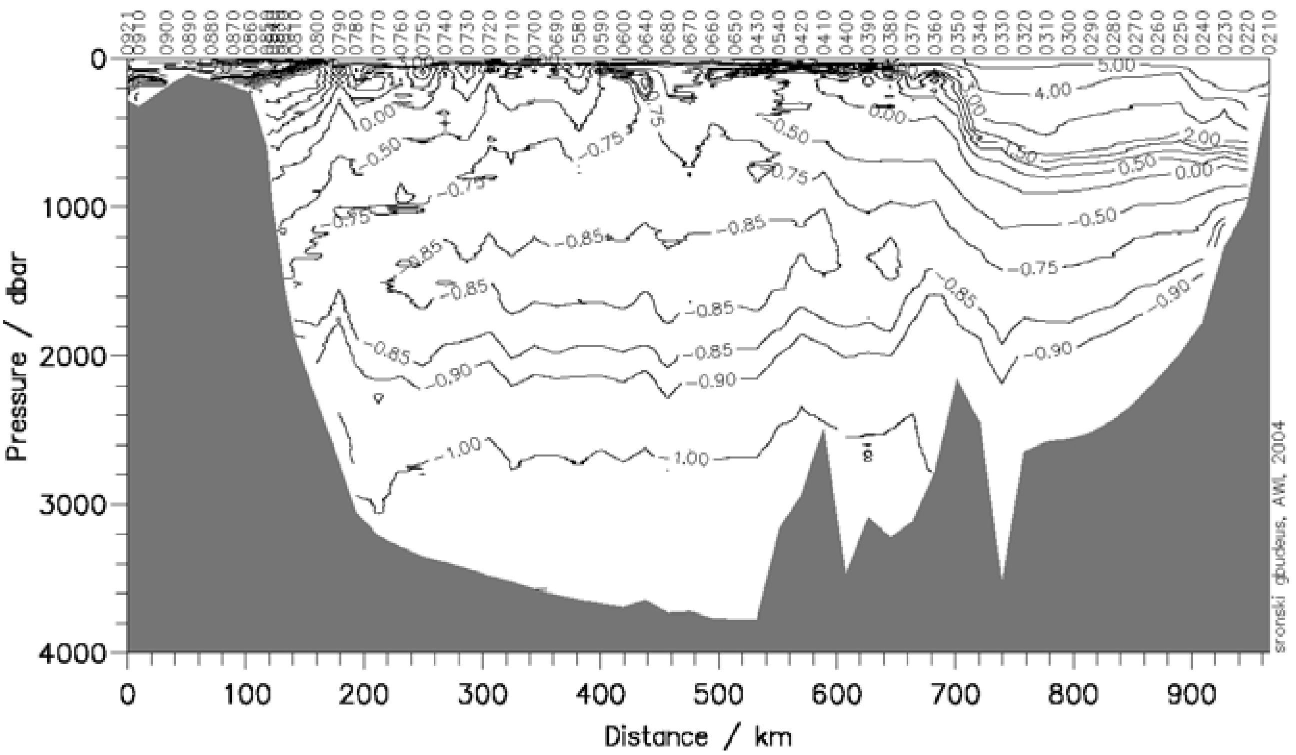


Fig. 4.1 Temperature along the zonal transect at 75° N

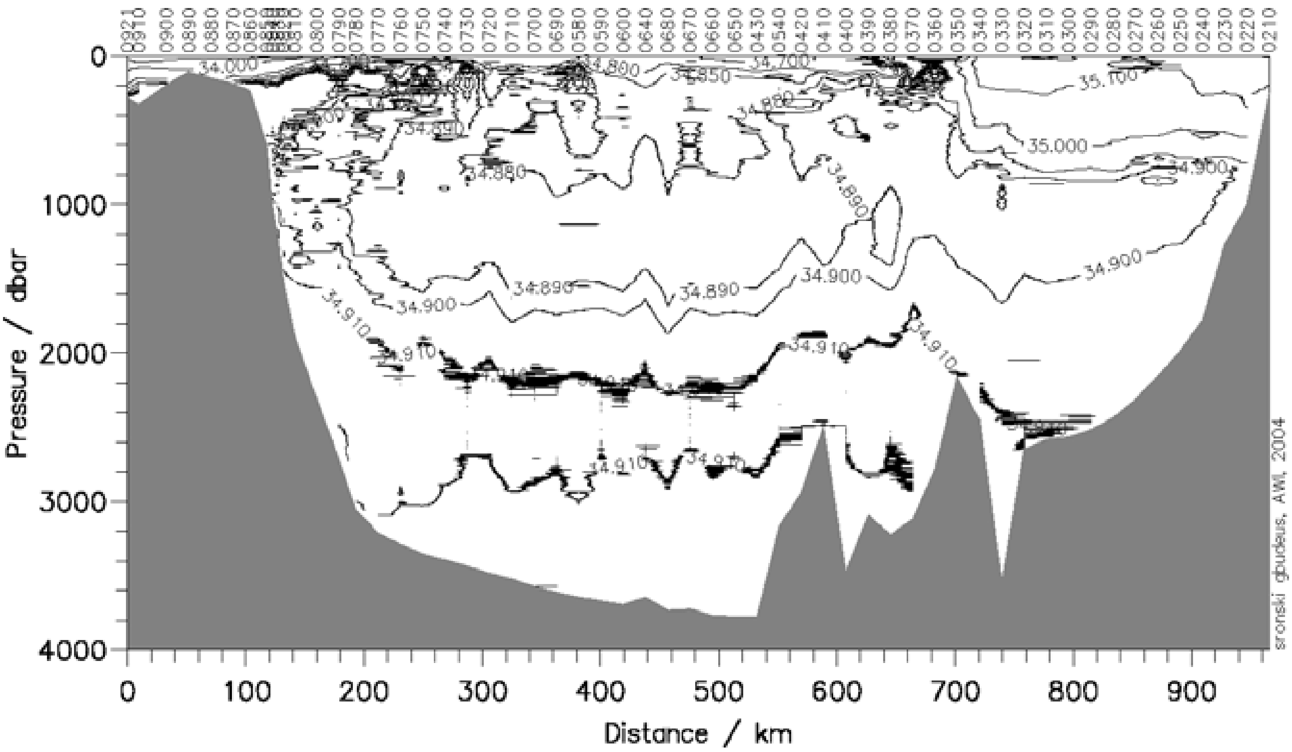


Fig. 4.2 Salinity along the zonal transect at 75° N.

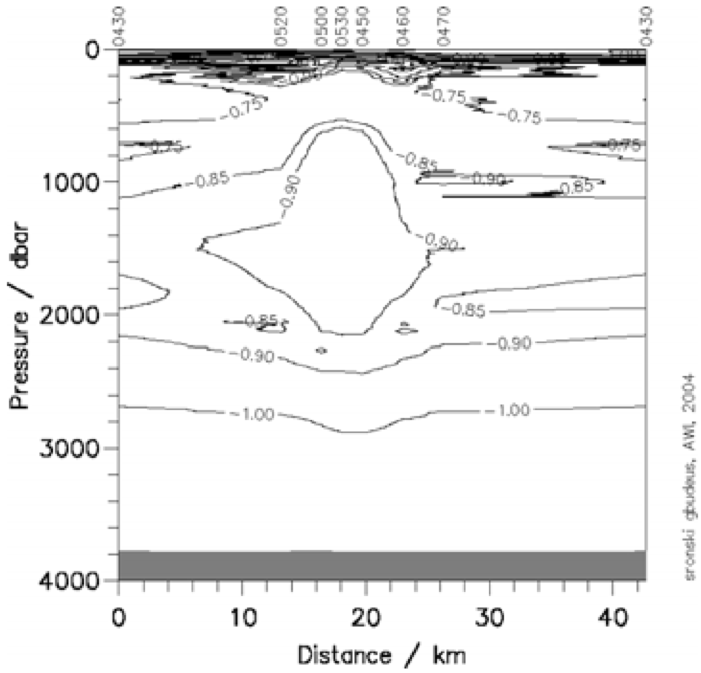


Fig. 4.3 Temperature along a transect across the coherent eddy

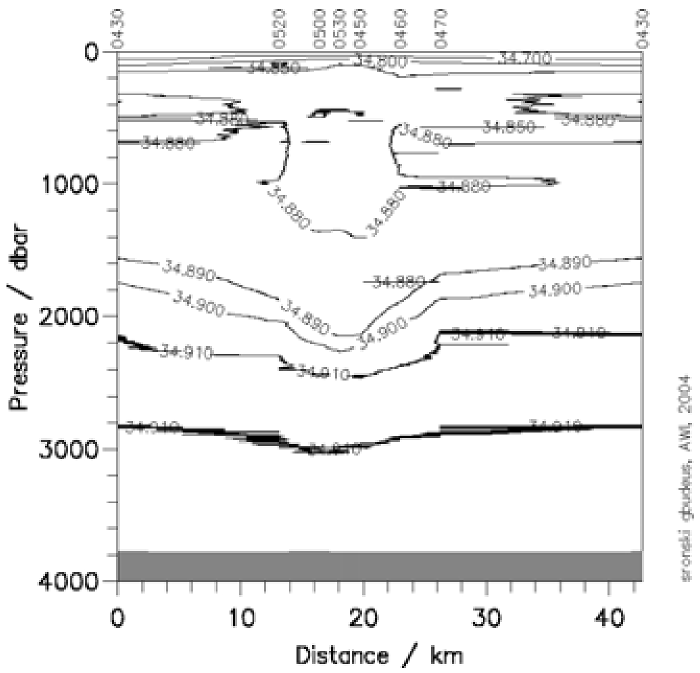


Fig. 4.4 Salinity along a transect across the coherent eddy

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

T. Soltwedel, E. Bauerfeind, M. Bergmann, J. Feickert, I. Kolar,
C. Kanzog, F. Kulescha, L. Licari, B. Sablotny, I. Schewe

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

Following a pre-site study using the French Remotely Operated Vehicle (ROV) "VICTOR 6000" in summer 1999, the AWI Deep-Sea Research Group established the first long-term station in polar deep-sea regions in the eastern Fram Strait off Spitsbergen, the “Hausgarten” (Fig. 5.1). Beside a central experimental area at 2500 m water depth, we defined 9 stations along a depth transect between 1000 - 5500 m, and additional 6 stations along a latitudinal transect crossing the central Hausgarten station, which will be revisited yearly to analyse seasonal and interannual variations in biological, geochemical and sedimentological parameters.

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

Fig. 5.1: Deep-sea long-term station "AWI-Hausgarten"

5.1 Biological oceanography and sedimentation

E. Bauerfeind, B. Sablotny

During the cruise ARK XX-1 the chance was taken to study the distribution of plankton and its changes along a transect at 75°N in the Norwegian/Greenland Seas. Samples were taken in a distance of 30 nm from the regions dominated by Atlantic waters in the east all across the Greenland Sea to the Greenland continental shelf, where waters of polar origin prevail. Water samples were taken from the CTD-Rosette-Sampler at 6 depths from the surface to 150 m water depth. Subsamples were filtered for the analysis of the organic carbon and nitrogen content, Chl. a, plankton composition, and the amount of particulate silica. In cooperation with E. Falck from the Physical Oceanography Group, samples were also taken for the analysis of inorganic dissolved nutrients. All these samples were stored until further analysis at the land-based laboratory. In the "AWI-Hausgarten" area, filtration was done for the same parameters, and additionally for the analysis of particulate 15N content of the suspended matter. Here samples were taken at the central station (HG IV) and at the northern-most (N3) and southern-most (S3) positions (see Fig. 5.1). In these areas samples were taken from the surface to the seafloor at 12 different water depths.

At the position HG IV a mooring equipped with 3 sediment traps that was installed during the cruise ARK IX-3c in 2003 was successfully recovered. However, due to a technical failure of the control units of the sediment traps almost no samples were obtained. This failure could be repaired on board and three new moorings equipped with sediment traps (7 altogether) and current meters were laid out at the positions HG IV, S3 and N3. The intention of this studies are to get better insights in the seasonal, regional and interannual fluctuations of particle formation, modification and sedimentation in relation to benthic response and possible impacts of climatic changes.

5.2 Microbiological and molecular biological investigations of bacterial deep-sea communities

C. Kanzog

Large food falls (such as fish carrion) or phytodetritus aggregates sunken to the deep seafloor constitute sudden and rich sources of food for benthic assemblages. This sporadic input of nutrients may affect the diversity and activity of bacterial deep-sea communities. Results from in situ experiments started during ARK XIX-1b will help us to understand how and to what extent the smallest benthic organisms react to such events. In spring 2003, the AWI Deep-Sea Research Group deployed two free-falling Colonization Trays, which contained different types of artificial sediments and organic matter (i.e. fish carrion, detritus, and yeast cultures). These trays were recovered and subsampled during ARK XIX-3c in summer 2003. Following the addition of fresh sediments, the trays were re-deployed for another year for sampling during ARK XX-1 summer 2004.

Since it is produced by many marine organisms, including zooplankton and several phytoplankton species, chitin is a common biopolymer in nature and possibly the most common one to occur in marine environments (Gooday, 1990). One Colonization Tray with different concentrations of chitin and different types of artificial sediments was deployed for one week at the central Hausgarten station (HG IV, 2500 m) to assess the effect of different chitin concentrations on the composition of sediment-inhabiting bacterial communities at different times after deployment. Chitinase activity was examined by using the fluorogenic substrate Methylumbelliferone-b-N-Acetyl-glucosamine. The fluorescence intensity of the samples was determined at an excitation wavelength of 356 nm and an emission wavelength of 445 nm.

To investigate turn-over rates and the composition of bacterial communities we also sampled deep-sea sediments with a multi-corer (Tab. 5.2.1). In the laboratory, these sediments will be used for long-term incubation experiments to analyse the bacterial break-down of chitin.

Tab. 5.2.1: Samples for long-term incubation experiments.

Station number	**Water depth (m)**	**Number of samples**
PS 66 / 105-1	2500	4 x 400 ml Sediment (0-3 cm)
PS 66 / 119	2500	4 x 400 ml Sediment (0-3 cm)

Station number	Water depth (m)	Number of samples
PS 66 / 127-3	2500	4 x 400 ml Sediment (0-3 cm)

In addition, we sampled each long-term station of the AWI-Hausgarten (Tab. 2) to determine bacterial numbers and biomasses, and to identify bacterial communities with molecular methods.

Tab. 5.2.2: Samples for bacterial numbers and biomasses.

Station number	**Water depth (m)**
PS 66 / 100-2	2000
PS 66 / 101-2	1500
PS 66 / 104	1200
PS 66 / 108	2500
PS 66 / 112-2	2500
PS 66 / 113-2	2500
PS / 66 114-2	3000
PS 66 / 117	2500
PS 66 / 121-2	3500
PS 66 / 122-2	4000
PS 66 / 124-2	5500
PS 66 / 125-2	2500
PS 66 / 126-2	2500
PS 66 / 127-2	2500

Bacterial biomass was determined from 1 ml sediment samples diluted with 9 ml of a sterile filtered 4% formaldehyde-seawater solution and stored refrigerated. Subsamples for molecular biological techniques (fluorescent in-situ hybridization, FISH) were prepared according to the method of Amann et al. (1997).

Literature:

Amann, R., Glöckner, F.O., Neef, A. (1997). Modern methods in subsurface microbiology - *in situ* identification of microorganisms with nucleic acid probes. FEMS Microbiol. Rev., 20: 191-200.

Gooday, G.W. (1990). The ecology of chitin degradation. Adv. Microb. Ecol., 11: 387-430.

5.3 Benthic studies at the Hausgarten long-term stations

I. Schewe, J. Feickert, I. Kolar

The standard long-term investigations in the AWI-Hausgarten area are dedicated to large-scale ecological investigations on the benthic community. The stations for these investigations are spread over a wide range in water depth and in latitudinal space (Fig. 5.1), so they cover a wide variety of different habitats. Sampling of virtually undisturbed sediments was done with a multiple corer.

During ARK XX-1, special focus was put on the investigation of variations in environmental parameters at smallest scales (from centimetres to millimetres) and their relevance for the distribution and diversity of benthic organisms. To follow this question we carried out an extremely careful sediment sampling using a giant box corer, to get both, an almost undisturbed sediment-water-interface and a large (0,25 m^2) coherent surface of the deep seafloor. The sediment surface was divided by a metal frame into sixteen (4 x 4) segments. Each segment was then sampled with a set of 12 syringes with cut of anterior ends to analyse subsamples for a variety of parameters commonly used in ecological studies (Fig. 5.3.1). This sampling strategy will allow a complex combination of parameters coming from sedimentological, biochemical and taxonomical analyses. Thus it will be possible to refer community related parameters with environmental parameters also in smallest scales.

Fig.5.3.1: Subsampling of the box-corer to assess small-scale variabilities.

During the cruise we also recovered so-called Colonisation Trays (Fig.5.3.2), which are moored frames equipped with different kinds of artificial and natural soft sediments. These sediments where enriched with different types of food and deployed for one year. The aim of this experimental setting was to investigate preferences of the smallest organisms (from bacteria to meiofauna) in colonising different kinds of habitat. Each type of sediment-food-combination was sampled for the same set of analyses also carried out for the Hausgarten long-term stations. Analyses will enable us to retrieve information about the activity, abundance and biomass as well as the diversity of colonising organisms. In addition, we will also analyse the food sources, which were either sedimented over the year on the experimental settings or which are left from the original application of food

Fig. 5.3.2: Colonisation Trays during subsampling

5.4 Ecology of eelpout from the AWI-Hausgarten and the Håkon Mosby Mud Volcano

M. Bergmann

Despite their abundance, little is known about the ecology and habitat preferences of demersal deep-sea fishes, especially of those from polar regions. Footage from the French ROV VICTOR (ARK XIX-3b and -3c) showed that fish such as zoarcid eelpout (Fig. 5.4.1 a) represent one of the dominant megafaunal organisms present in continental slope environments. Being top predators they may play important role in such ecosystems. Following previous results, we sampled the demersal fish fauna at the AWI-Hausgarten and close to the Håkon Mosby Mud Volcano (HMMV) to study their ecology and for ground-truthing of our video imagery. Both, an Agassiz trawl (Fig. 5.4.1 b) and fish traps were used to sample the fish fauna. Four trawls in total were carried out at stations of different depths and baited fish traps that were attached to a benthic lander (Fig. 5.4.1 c) were deployed twice (for 50-85 h) on the seabed at HG IV (Tab. 5.4.1). In addition to fish, the trap also caught high numbers of scavenging amphipods *(Eurythenes gryllus)* that were preserved.

Fig.5.4.1 a,b,c: Zoarcid eelpout (top), Agassiz trawl (bottom left), and benthic lander carrying two fish traps (bottom right

All fish were measured, weighed and preserved and will be subject to stomach contents and radio stable isotope analysis to determine the trophic level. The data will be compared with previously collected data on megafaunal abundance to estimate prey selectivity. Furthermore, the gonads and livers will be analysed and the otoliths read to age the fish and to determine growth and production. Different species of eelpout were caught at different stations. Megafaunal samples were also taken at each station for ground-truthing purposes and radio stable isotope analysis.

Tab. 5.4.1: Summary of sampling effort (* sampled by Agassiz trawl; ** subsample taken)

	Outside HMMV*	Hausgarten I*	Kongsfjord Canyon*	Hausgarten IV*	Hausgarten IV (Trap 1)	Hausgarten IV (Trap 2)
Water depth (m)	1300	1336	1730	2422	2486	2491
No. of fish	7	68	2	18	9	8

Mean fish condition	0.34±0.23	0.36±0.07	0.27	0.48±0.07	0.59±0.08	0.62± 0.07
No. of species	2	4+	1	2	1	1
Mega-fauna**	x	x	x	x	x	x

Acknowledgements

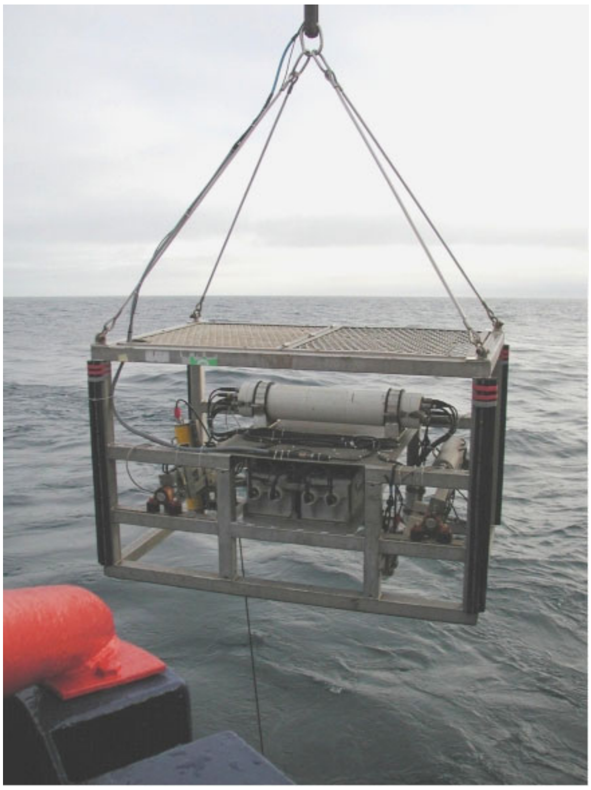
I would like to thank Boris Klein (AWI) for providing the fish traps and bait. I am also indebted to Juliane Otto, Linda Gerull, Lisa Kattner, Kati Partzsch and Ulrike Poppe for their assistance in sorting the trawl and trap catches.

5.5 Visual observations at the AWI-Hausgarten

T. Soltwedel, F. Kulescha

Large-scale distribution patterns of epifauna organisms were assessed using the so-called “OFOS” (Ocean Floor Observation System, Fig. 5.5.1) carrying a video and a still camera was towed at 1.5 m above ground at a total of 6 stations: at the central Hausgarten station (2500 m), thereby repeating a transect already assessed in 1999 and in 2002, at the northern-most and southern-most station (2300, and 2650 m, respectively), and along a transect crossing the Kongsfjord Canyon (1750 m). Additional two OFOS deployments were carried out at a bowl-shape geological structure of approx. 7,5 km in diameter at about 2000 m water depth along the Hausgarten depth transect. One OFOS transect was heading from the deepest area of the depression straight to the North towards shallower regions. The second one was heading to the East, thereby crossing a reef-like structure at the eastern flank of the depression. There is a diffrence of about 400 m between the base of the depression and the top of the reef.

Fig. 5.5.1: Ocean Floor Observation System, OFOS



OFOS deployments generally covered approx. 2 nm at the seafloor thereby producing about 24 hours of video recordings and approx. 4800 colour slides.

5.6 Benthic foraminiferal communities and stable isotopic composition

L. Licari

Benthic foraminifera are widely used as a tool to reconstruct paleoproductivity and past deep-sea ventilation patterns. For paleoceanographers, the most relevant aspect concerns the sensitivity of these organisms to changes in environmental conditions at the seafloor, indirectly recorded by particular faunal compositions specifically adapted to environmental parameters, and directly in the elemental and stable isotopic composition of their calcareous tests (Fig. 5.6.1). The accurate and reliable interpretation of the ecological information conveyed by fossil benthic foraminifera depends, in turn, on the detailed knowledge of the true behavior of modern species with regard to given environmental variables, and on how these factors affect the chemical composition of foraminiferal tests.

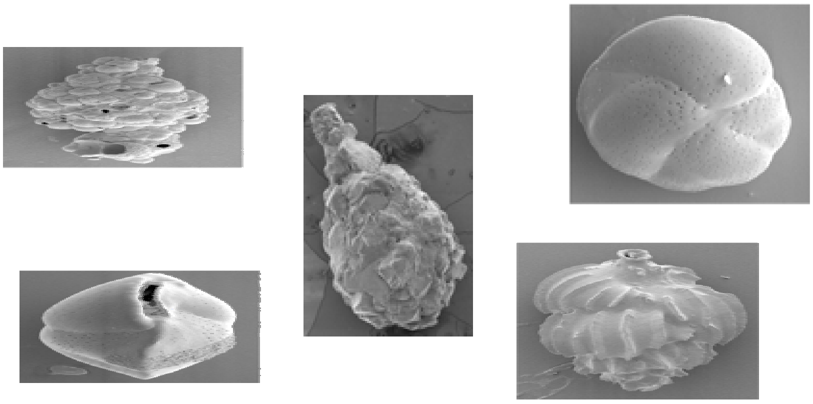


Fig .5.6.1: SEM pictures of some benthic foraminiferal species.

During leg ARK XX-1, sediment samples were recovered with a multicorer (MUC) at the Håkon Mosby Mud Volcano (HMMV) and in the “AWI-Hausgarten” area (Fig. 5.1) to investigate benthic foraminiferal assemblages and the stable carbon and oxygen isotopic composition (∂13C and ∂18O, respectively) of their tests. At each station, an additional subcore was sampled for sedimentological analyses. In addition, water samples were simultaneously collected at most stations with a rosette sampler to determine the stable carbon and oxygen isotopic composition of the water column.

- AWI “ Hausgarten”

For faunal and isotopic analyses, sediment samples were recovered at eighteen stations in the “Hausgarten” area (Fig. 5.1). At all stations, two subcores were collected and sub-sampled in 1 cm thick slices down to a subbottom depth of 15 cm. Subsamples corresponding to the same depth in the sediment were put together, fixed with a mixture of ethanol and Rose Bengal (1 g/l^{-1}) and kept cool at 4°C. In addition to these two subcores, a supplementary subcore was separately sampled at stations PS66/101, 104, and 140 following the same procedure. Further treatments and analyses (TEM, fauna, stable isotopy) of samples will be performed in Bremerhaven at the Alfred Wegener Institute for Polar and Marine Research (working group of Prof. A. Mackensen).

- Håkon Mosby Mud Volcano: the influence of methane on benthic foraminifera

A major aim of our studies is to determine how methane release affects the ∂13C signature of benthic foraminiferal carbonate and benthic foraminiferal faunas. In that purpose, sediment samples were recovered at five stations located at various habitats of HMMV. Immediately after recovering, two subcores (representing 78 cm^2 of sediment surface each) were separately sub-sampled in 1 cm slices down to a subbottom depth of 15 cm, and stored at 4°C in a mixture of ethanol and Rose Bengal (1 g/l^{-1}) until further treatment onshore. In addition, the uppermost centimeter of two subcores was separately sub-sampled in 0.5 cm slices for ultrastructural analyses on benthic foraminifera by

Transmission Electron Microscopy. Samples were immediately fixed in a solution of glutaraldehyd (3%) buffered with sodium cacodylate (0.1 M, in seawater filtered on 2 µm) and mixed with Rose Bengal. Subsequently, samples were sieved over a 63 µm mesh screen and stored at 4°C in buffer solution. Furthermore, an additional subcore was deep-frozen at four stations.

6. CHEMICAL MEASUREMENT PROGRAM

C. Temme, J. Baukau, G. Blöcker, A. Caba, C. Caliebe, W. Gerwinski, R. Gioia,
E. Hudson, A. Jahnke, Z. Xie

Reactions mechanisms of mercury and selected persistent organic pollutants (POPs) in air, water, and snow

Several international leading groups of Environmental Chemistry were joining the RV Polarstern on ARK-XX/1 2004. Their common interest was the detection of trace organic contaminants and mercury species in remote environments of the Northern Hemisphere, to investigate the environmental cycling and fate of key global pollutants. The Polarstern with her conditions has been found to be well suited to act as a ‘clean ship’ for the sampling of these trace compounds.
The chemical research program during ARK-XX/1 was focused on two major topics:

1. Determination of mercury and related volatile organic compounds (VOCs) and dissolved organic carbon (DOC) in different compartments and the calculation of the air/sea-exchange during Arctic summer
2. Determination of selected POPs in air, water, and snow

6.1. Mercury and the VOC/DOC connection

Mercury (Hg) is outstanding among the global environmental pollutants of continuing concern. The element and many of its compounds behave exceptionally in the environment due to their volatility and capability for methylation, in contrast with most of the other heavy metals. Long-range atmospheric transport of mercury, its transformation to more toxic methylmercury compounds, and their bioaccumulation in the aquatic food chain have motivated intensive research on mercury as a pollutant of global concern.
The international process study on board of Polarstern with the transect from Germany to the North Atlantic helped to examine the temporal end of Atmospheric Mercruy Depletions Events (AMDEs) during Artic summer and the spatial distribution of the relevant areas in the north Atlantic Ocean. The

fate of mercury during polar summer in the Arctic was investigated with several different methods for the detection of mercury species in air, water, snow, and ice.

Two Tekran gas-phase mercury vapour analysers (Model 2537A) were installed on Polarstern for the determination of Gaseous Elemental Mercury (GEM) and Reactive Gaseous Mercury (RGM species in the Arctic. RGM was measured with a Tekran 1130 mercury speciation unit which gave one Tekran 2537A mercury vapour analyser the ability to concurrently monitor both elemental (GEM) and reactive gaseous mercury (RGM) species in ambient air at the pg/m^3 level. The sample inlet was located on the upper deck of Polarstern in front of the GKSS container. The air was sampled at a flow rate of 1.2 L/min with a 0.45 mm PTFE filter in front of the sample inlet of the analyser.

The results of GEM measurements and ground-level ozone concentrations for the time period 16th of June to 14th of July are preliminary data. The arithmetic mean of all GEM measurements during this cruise lag is (1.6 ± 0.1) ng m^{-3} and is in good agreement with mean summer concentrations from other polar sites like Alert, Canada or Ny Ålesund, Svalbard.

Contaminations from the ships plume will be eliminated after the cruise according to the PODAS data of wind directions and wind speed relative to the ships course.

In addition the second Tekran analyser in the wet lab was used to investigate the sea/air exchange of GEM during Arctic summer. The analyser was connected to a 20 L glas bottle, called “Equilibrator”, indirectly measuring the Dissolved Gaseous Mercury (DGM) concentrations in the sea water with the help of the Henrys law constant.

We found that the Atlantic Ocean is a potential source for GEM in the atmosphere during this time of the year. The flux of GEM from the sea to the atmosphere was in the range of (0.1 to 3) ng m^{-3} h^{-1} depending on the model used for calculation. We found significantly higher fluxes when we entered the most westerly part of the 75°N transect (July 1-3) where the ocean was covered with sea ice.

The oxidative properties of the lower atmosphere (which determine mercury speciation and thus transport) are also reflected in the profile of volatile organic compounds (VOCs) it contains. Dissolved organic carbon (DOC) in surface waters is thought to be the ultimate source of these VOCs over the open sea.

Air samples were taken for VOC analysis (McGill University). Water samples were taken for photochemical and photooxidation experiments on surface water DOC, to further investigate whether these explain the VOCs found in the air samples. Alltogether, 25 whole air samples (6 L) have been taken. Most of these (14) were taken along the 75°N transect (June 24-July 3), to match the extensive water characterization of this transect. A further 7 were used to profile the transition from the North Sea (58°N, June 16) to the Norwegian Sea (72°N, June 22).

Water samples were taken to match the time/location of each air sample. To date, more than 50 samples have been taken (again, mostly along the 75°N transect) and filtered (0.2 µm). The additional samples will serve as checks on the effects of sample size, storage and materials, sampling method (Niskins vs. Glass Sphere Water Samplers (GSWS) vs. Polarstern's in situ pump in the keel), as well as adding 3 intermediate and 4 deep water samples to the data set, which allows us to expose the analytical methods to a wider range of DOC.

Aerosols are important to this study because they represent another interface between the sea surface and the atmosphere, on which DOC may give volatile compounds through photochemistry. However, the cascade impactor used to sample them required long collection times and a favorable wind direction to avoid contamination by the ship itself. Still, 9 samples were collected, each consisting of 9 size fractions. Sampling times ranged from 6 to 40 hours, but were typically 12 to 24 hours.

Towards the end of the 75°N transect, snow was sampled on ice floes in the East Greenland Current to complement the air and water sampling by the air chemistry group. Samples were taken on July 2 and 3rd at 74°58.08´N / 13°38.46´W and 75°08.52´N / 16°45.11´W, respectively. Four 250-mL samples were collected by ultra-clean methods for mercury and radionucleide analysis. These will suppplement the extensive snow sampling for these materials which will take place during ARK-XX/2. Four 1-L samples were collected for experiments on the photochemical generation of VOCs (to be done at McGill University). Finally, 40 L of snow were taken in GSWS on each occasion. These will be analysed for POPs by the BSH group.

6.2. Persistent organic pollutants (POPs)

By combining short-term atmospheric samples with the collection of representative water samples across different region of the North Atlantic / Arctic circle, answers are sought as to whether atmospheric transport or the marine phytoplankton productivity are controlling the transport and settling flux of persistent organic pollutants.

Air Sampling

Four different modified High Volume air samplers were used to collect air on board of RV Polastern during ARK-XX/1. POPs such as polychlorinated biphenyls (PCBs), polybrominated dyphenyls ethers (PBDEs), organochlorine Pesticides (HCHs, HCBs , DDTs etc.), polyflourinated compounds (PFCs), Nonylphenol (NP), and combustion-derived polychlorinated dibenzo-p-dioxins, furans (PCDD/Fs) and Total Suspended Particulate (TSP) will be investigated. Totally 45 air samples were collected from Bremerhaven to Longyearbyen during the ARK-XX/1 (see table 6.2.1 - 3). Table 6.2.1 shows samples collected using the Lancaster University High-Volume air sampler, which will be used to determine PCBs and PBDEs concentrations. Table 6.2.2 represents samples collected using the High Volume air sampler from University of Bremen and the samples collected for the determination of TSP (Total Suspended Particulate) using a TSP sampler belonging to Lancaster University. Samples from the Bremen Hi-vol will be used to investigate the concentration of dibenzo-p-dioxin and furans in the atmosphere. Table 6.2.3 shows sampling volumes and locations for the samples taken with the GKSS High-Volume air sampler in order to determine PFCs and NP in air.

Sample ID	Latitude	Longitude	Air volume (m^3)	Comments

Sample ID	Latitude	Longitude	Air volume (m^3)	Comments
ARK-XX 1	55.5-58.5 N	7.1-4.8 E	287	North Sea
ARK-XX 2	58.6-61.1 N	4.7-3.99E	193	North Sea
ARK-XX 3	61.4-63.4 N	4.0-5.06 E	196	North Sea
ARK-XX 4	63.5-65.7 N	5.08-6.98 E	200	North Sea
ARK-XX 5	65.9-68.1 N	6.98-8.94 E	191	North Sea
ARK-XX 6	68.2-69.2 N	9.03-13.2 E	190	North Sea
ARK-XX 7	69.2-71.4 N	13.2-14.8 E	188	North Sea
ARK-XX 8	72.00 N	14.72E	199	HMMV
ARK-XX 9	72.00 N	14.72E	192	HMMV
ARK-XX 10	72.00 N	14.72E	196	HMMV
ARK-XX 11	71.1-74.6 N	16.6-10.6 E	365	75º Latitude transect
ARK-XX 12	74.6-74.55 N	10.6E-4.4W	411	75º Latitude transect
ARK-XX 13	75.0-76.2 N	4.5-3.4W	458	75º Latitude transect-LYB
ARK-XX 14	76.20-78.9 N	3.7W-5.4E	490	On the way to LYB
ARK-XX 15	79.4-79.8 N	4.2E-3.20	771	Hausgarten
ARK-XX 16	79.4-79.35N	3.2-5.11E	396	Hausgarten
ARK-XX FB1	68.1N	8.9E	Field blank	North Sea
ARK-XX FB2	69.2N	13.2 E	Field blank	North sea
ARK-XX FB3	72.0 N	14.7 E	Field blank	HMMV
ARK-XX FB4	74.5 N	4.4 W	Field blank	75º Latitude transect
ARK-XX FB5	79.4N	3.2 E	Field Blank	Hausgarten

Table 6.2.1. Samples collection for the Lancaster High-Volume sampler during ARK-XX/1.

Sample ID (Bremen High-VOL)	Sample ID (TSP sampler)	Latitude	Longitude	Flow rate (ft^3/min)	Comments
ARK-XX R1	TSP ARK-XX 1	57.2-61.7 N	5.3-3.9E	13	North Sea
ARK-XX R2	No TSP sample	61.9-66.3 N	3.9-7.4 E	13	North Sea
ARK-XX R3	TSP ARK-XX 2	66.5-69.35 N	7.4-13.7 E	14	North Sea
ARK-XX R4	TSP ARK-XX 3	71.9-72.01N	14.72 E	19	HMMV
ARK-XX R5	TSP ARK-XX 4	71.10-74.6N	16.6-10.6E	20	To the 75ºtransect
ARK-XX R6	TSP ARK-XX 5	74.6-74.55N	10.6E-4.3W	20	75ºtransect
ARK-XX R7	TSP ARK-XX 6	75.0-76.1N	4.47-3.4W	19	75ºtransect to LYB
ARK-XX R8	TSP ARK-XX 7	76.2-78.91	3.1W-5.1E	19	To LYB
ARK-XX R9	TSP ARK-XX 8	79.6 N-78.9	5.18E-4.8 E	20	Hausgarten
ARK-XX RFB1	TSP ARK-XX FB1	69.38N	13.85 E	Blank	North Sea
ARK-XX RFB2	TSP ARK-XX FB2	72.0 N	14.72 E	Blank	HMMV
ARK-XX RFB3	TSP ARK-XX FB3	74.6N	4.3W	Blank	75ºtransect

Table 6.2.2. Samples collection for the Bremen High-Volume sampler and the TSP sampler during ARK-XX/1.

Sample ID	Date	Latitude	Longitude	Volume (m^3)	Comments
ARK XX-1	16/06/2004 – 21/06/2004	55.2°N – 72.0°N	6.5°E – 14.4°E	1114,6	Bremerhaven to HMMV
ARK XX-2	21/06/2004 – 23/06/2004	72.0°N – 71.2°N	14.4°E – 16.4°E	664,0	Continuous sampling at HMMV
ARK XX-3	23/06/2004 – 04/07/2004	71.3°N – 75.4°N	16.3°E – 8.2°W	913,2	75°N-transect, sampling stopped during station times
ARK XX-4	04/07/2004 – 08/07/2004	75.5°N – 78.3°N	7.6°W – 5.5°E	911,2	Sampling continued at stations if relative wind direction was 270°-90° and true wind speed was at least 5 m/s
ARK XX-5	08/07/2004 – 11/07/2004	78.4°N – 79.4°N	5.5°E – 5.1°E	917,2	Continuous sampling despite low wind speed / wind from behind
ARK XX-6	11/07/2004 – 15/07/2004	79.4°N - ?	5.1°E - ?	?	Continuous sampling despite low wind speed / wind from behind

Table 6.2.3. Samples collection for the GKSS High-Volume sampler during ARK-XX/1

GFFs (Glass Fiber Filter) precombusted at 450 °C overnight, were used to capture the particles and particle bound species, and two cylindrical 3 inch diameter polyurethane foam (PUF) adsorbants were used downstream to capture the gas-phase contaminants. Prior to use, the PUFs for the Lancaster and Bremen High-Volume sampler were cleaned with an Accelerated Solvent Extraction (ASE) system using dichloromethane (DCM) as solvent. After cleaning, the PUFs were desiccated under vacuum to remove excess solvent and stored frozen in pre-cleaned aluminum tins. The PUF adsorbant and XAD resin for NP and PFCs sampled with the GKSS high-vols were precleaned by soxhlet extraction with acetone/hexane and ethyl acetate respectively. After samples collection, GFFs and PUFs (and XAD resin) were sealed and stored frozen until they will be analysed. Because low concentration levels are expected to be found in Artic regions, all the pre-cleaning procedures was performed in a clean room at Lancaster University and GKSS.

The overall ship's track from the North Sea into the remote Artic region is a great opportunity to monitor the air concentrations of POPs from source regions to polar areas. We expect to see spatial trends in air concentrations that provide some evidence for the global fractionation theory. It is generally assumed that the atmosphere can serve as pathway for the delivery of these pollutants to water and terrestrial surfaces. Therefore, POPs can undergo long-range atmospheric transport with high volatile compounds condensing in colder (polar) regions and less volatile compounds condensing in warmer regions close to sources. This will probably not occur in one step, but in a number of steps of volatilization followed by deposition, followed by seasonal fluctuations in temperature. The effect of this will be a relative enrichment of the more volatile compounds in cold areas. Criteria for global fractionation behaviour of chemicals are various physical-chemical properties such as vapour pressure, the octanol-air partition coefficient, the octanol-water partition coefficient and the Henry's Law Constant.

PCBs are a class of compounds with a variety of different physical-chemical processes. There are 209 congeners depending from the number of chlorine atoms on the molecule and the position that these atoms occupy on the molecule. Therefore, with all these differences in physical-chemical properties, PCBs are ideal to investigate and find evidence of the global fractionation theory. These properties are very dependent on temperature and will therefore greatly influence the global transport of POPs. The temperature dropping during this cruise track, from 11 ºC to – 2 ºC is a rare opportunity to estimate the temperature dependence of POPs in the atmosphere.

Growth in interest on PBDE flame retardants has been as exponential as their apparent increase in the environment over the past 20-25 years in North America and Europe. Toxicological studies of limited PBDE congeners indicate that they are potential thyroid disruptors and developmental neurotoxicants. However, there is still very little information on PBDE contamination and its spatial trend over the regions of the world. The investigation, which will follow air sample collection on Polarstern, will attempt to comprehensively understand the spatial and temporal trend of contamination by PBDEs emerging compounds in the atmosphere.

Polyfluorinated organic acids and their derivatives are produced by industry in very large quantities and are used for many purposes. Perfluoroalkyl sulfonates are used e.g. as surfactants and surface protectors in carpets, leather, paper, packaging and upholstery. In addition, some sulfonated and carboxylated PFCs have been used in or as fire fighting foams, alkaline cleaners, shampoos, and insecticide formulations. Due to the large production quantities and the persistence in the environment, polyfluorinated compounds are meanwhile globally distributed. Perfluorooctanesulfonic acid (PFOS) has been detected in blood of ringed seals, other long chain perfluorinated chemicals have been detected in polar bears, arctic foxes, ringed seals, mink, birds and fishes collected in the Arctic.

Because of the findings of polyfluorinated compounds in Arctic biota samples, it is of special interest to investigate their long range transport. Due to their high polarity, a transport by the water phase is likely, especially since some of the PFCs have been found in North Sea water. Some precursors of PFOS and PFOA are highly volatile and can lead to an increased input of PFCs from the atmosphere to remote areas. The investigation of the wide scale distribution of polyfluorinated acids in the sea water of the North Sea and Arctic Ocean is a perfect complement to the simultaneous measurements in the atmosphere. The cruise was quite optimal for these investigations as it ranged from the likely sources (European continent) to remote areas without direct inputs.

Short-term air samples (12 hr) were collected in the North Sea, from Bremerhaven to Tromso. These samples are useful to investigate the day-night cycle (if there is any) of PCBs over the ocean and whether the marine phytoplankton is controlling the atmospheric concentrations of POPs in the marine atmosphere. We were expecting to collect more short-term atmospheric samples during the 75° latitude transect and up to the Hausgarten, but this was not possible since the ship was stopping and starting most of the time. When taking an air sample good care should be taken to minimize the risk of contamination from the ship exhaust and this was quite impossible when the ship stopped and was not kept in the wind.

All the laboratory analysis of extractions and clean up will be performed in a clean room at Lancaster University, UK, and GKSS-Research Centre in Geesthacht, Germany. Field blanks were collected in order to define blank-based limit of detection (LOD) for each sampling matrix (PUF, XAD and GFF) as the average contaminant mass of field blanks plus 3 standard deviations.

Passive air sampling

Five passive air sampler were deployed on board of the ship to look at the ship background concentrations of POPs. Passive samplers were deployed on the Peildeck near the hi-vol, in the GKSS container where matrix are treated before and after sampling, on the back of the ship, in the –30 ºC freezer on the F deck where air samples are stored and in the wet lab, where water sampling is performed.

Polyurethane Foam (PUF) samplers are used to passively sample air. The advantage of passive sampler compared with active samplers is that they are cheap because they are not power consuming and they are easy to deploy.

The surface of the PUF comes into contact with vapour phase species in the atmosphere and it will respond through three different steps:

- **Initial linear** uptake of the compound to the surface
- **A curvilinear portion** of the uptake as equilibrium is approaching
- **Equilibrium** between the air concentration and the surface.

The mass of the compound held by the surface when it is at equilibrium with the air will depend on:

1. **Temperature**
2. **Type of the surface**
3. **Physico-chemical properties of POPs**

The uptake is also influenced by:

- The **size** or **capacity** of the subsurface compartment.
- The **suface area**
- The **thickness** of the sampler.

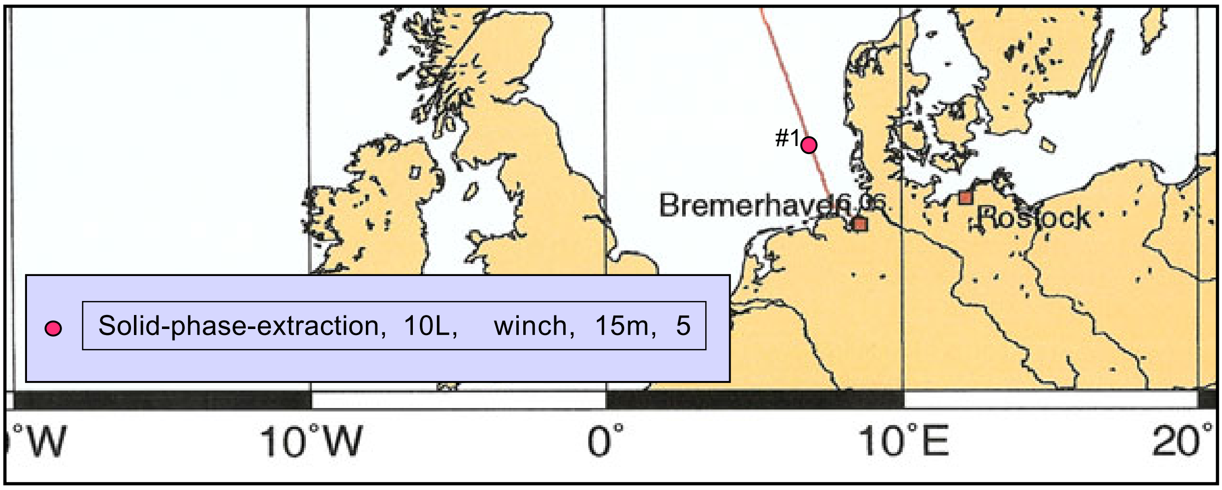
These factors above can be varied depending on the compound of interest, the deployment/sampling time and the sensitivity of the analytical instrumentation.
Time to reach equilibrium with the sampler device vary between compounds and increases with K_{oa}.
Previous studies on RV Polarstern, where passive sampler were also deployed, showed that the ship does not contribute to PCB contamination and this allowed us to conduct research on POPs on this research vessel even at very low concentration such as the Artic regions. We expected to see the same results about the ship background contamination during this cruise leg.

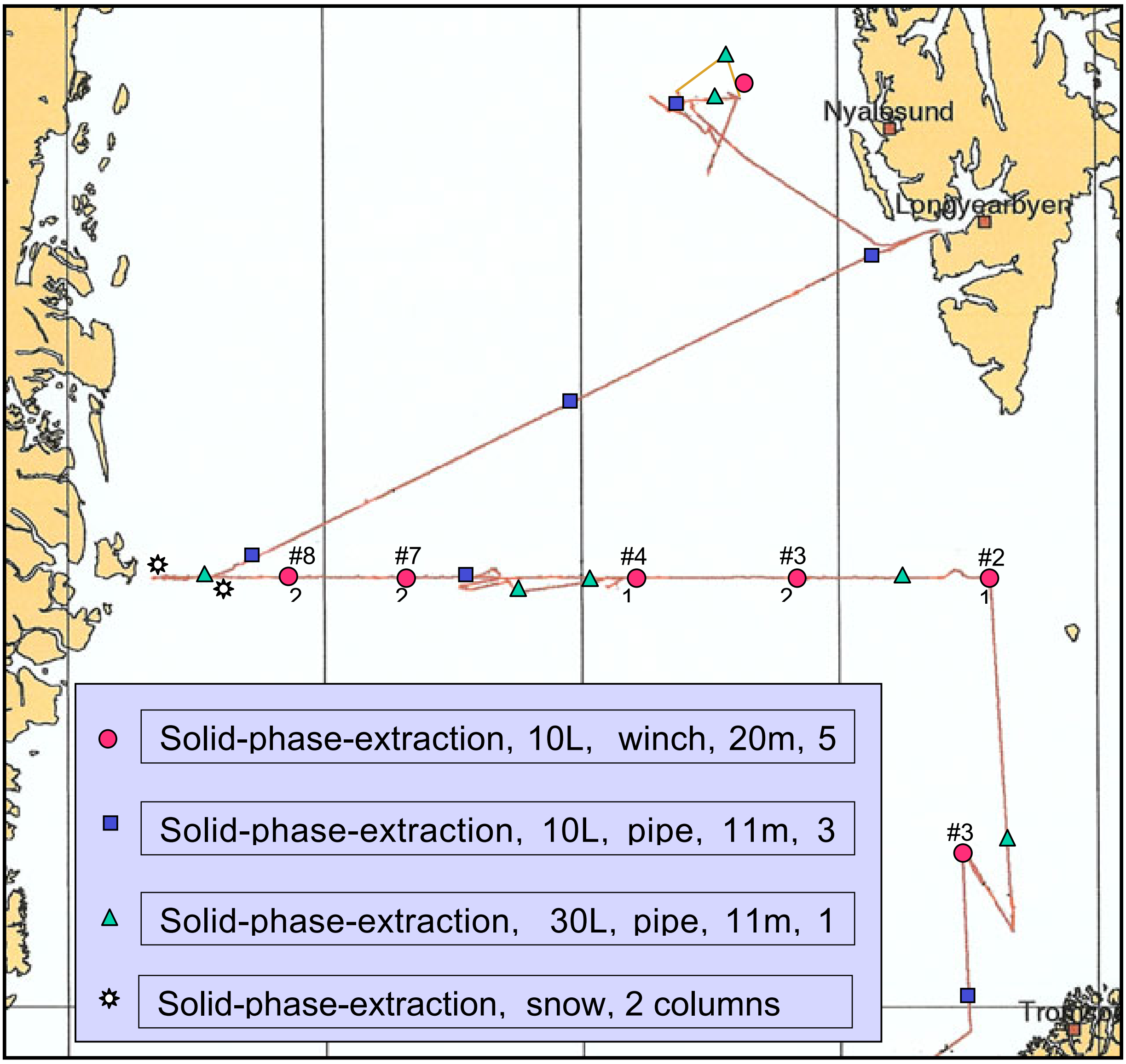
Water Sampling

Water sampling was performed simultaneously to the air sampling in order to investigate the mechanisms controlling the air-water exchange flux.
The water samples were taken from the clean seawater system (stainless steel pipe) of Polarstern (11m depth) as well as directly from the surface water (20m depth) with the glas sphere water samplers (GSWSs) from the BSH. We expect the air concentration of these compounds to be at equilibrium with the water concentration in the Artic region, given the remoteness of this area.
The majority of samples have been extracted with solid phase adsorber columns based on styrene/divinylbenzole copolymer. A mixture of deuterinated internal standards were added prior to extraction to control the extraction efficiency and to calculate the observed contaminants. Sample volumes of 10 liters and 30 liters were used for extraction to compare different factors of preconcentration. After pumping the seawater through the columns they were rinse with pure water and dried with a gentle stream of nitrogen gas. Eluation will be done after the cruise in the land based laboratory. One part of the taken replicate columns will be eluated with methanol as solvent for HPLC/MS/MS measurements, the other part will be eluted with a mixture of Hexane/Dichloromethane for GC/MS analysis.
At least 4 analytical runs per sample will be performed to detect and to quantify the whole list of expected contaminants. The main objective is the analysis of polyfluorinated compounds and some widely used pesticides, partly indicated as persistant organic pollutants.

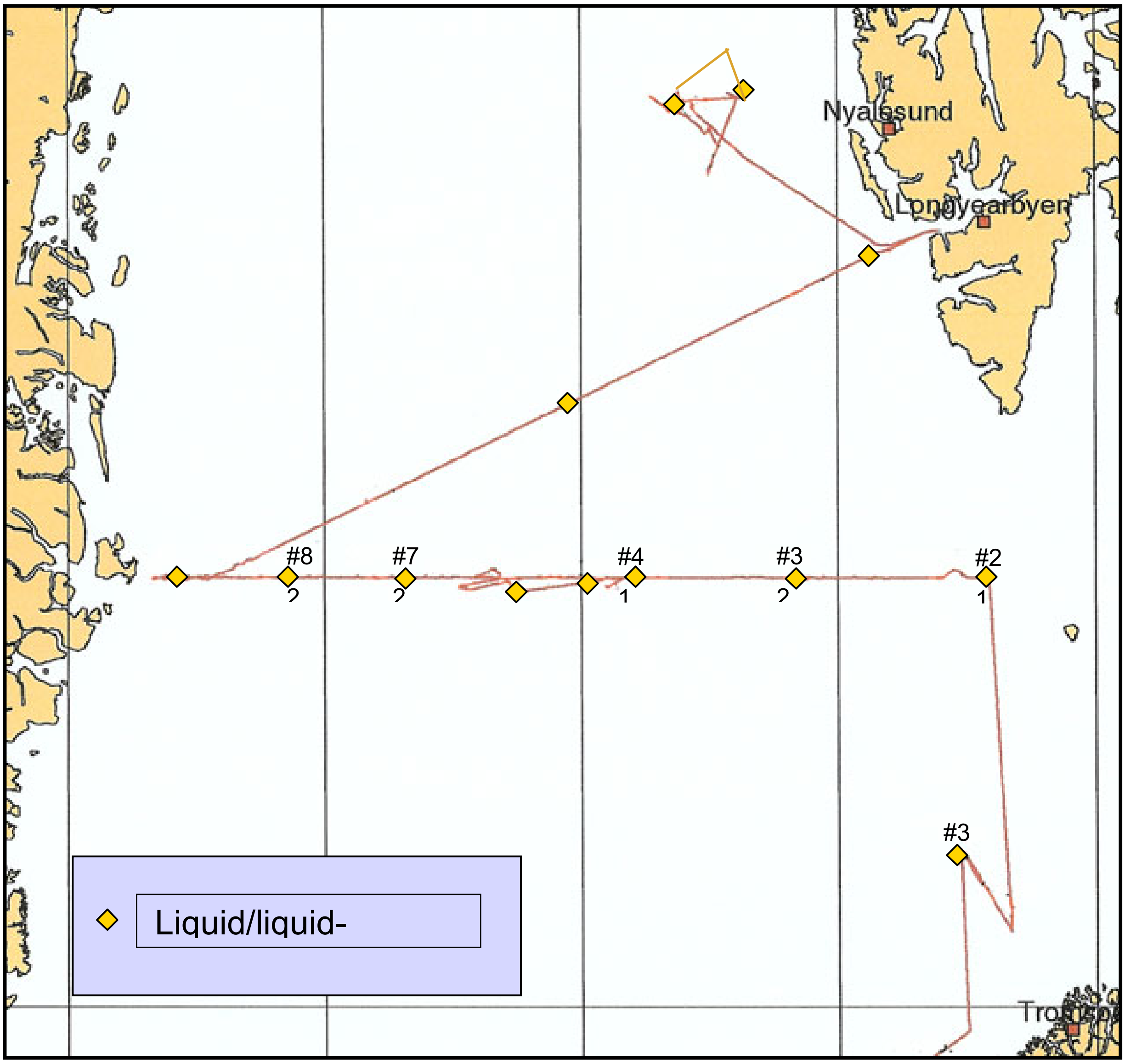
ARK-XX/1 Sampling Overview for contaminants in Seawater (BSH)

Sampling	Number of stations	Number of SPE-extractions	Number of LLE-extractions
Sampling locations winch	**8**	**40**	**8**
Sampling locations pipe	**12**	**18**	**5**
Snow samples	**2**	**4**	**0**
Quality control, blanks		6	5
Quality control, recovery		4	0
Total samples	**22**	**62**	**13**





Nyalesund
Longyearbyen
Tromsø
#8
#7
#4
#3
#2
#3
Solid-phase-extraction, 10L, winch, 20m, 5
Solid-phase-extraction, 10L, pipe, 11m, 3
Solid-phase-extraction, 30L, pipe, 11m, 1
Solid-phase-extraction, snow, 2 columns


Nyalesund
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Tromsø
Liquid/liquid-

7. SEDIMENT ACOUSTICS: ATLAS PARASOUND SYSTEM UPGRADE DS-1 TO DS-2

G. Kuhn

On the transit from Bremerhaven to Tromsø the sea acceptance test for the newly installed Parasound system upgrade DS-2 was carried out. With this upgrade the hardware of the 1989 installed Parasound DS-1 system was replaced in a first stage of extension.

The Atlas Parasound is a permanently installed system on R/V Polarstern. It determines the water depth and with variable frequencies from 2.5 to 5.5 kHz it provides high-resolution information of the sedimentary layers up to a depth of 200 meters below sea floor.

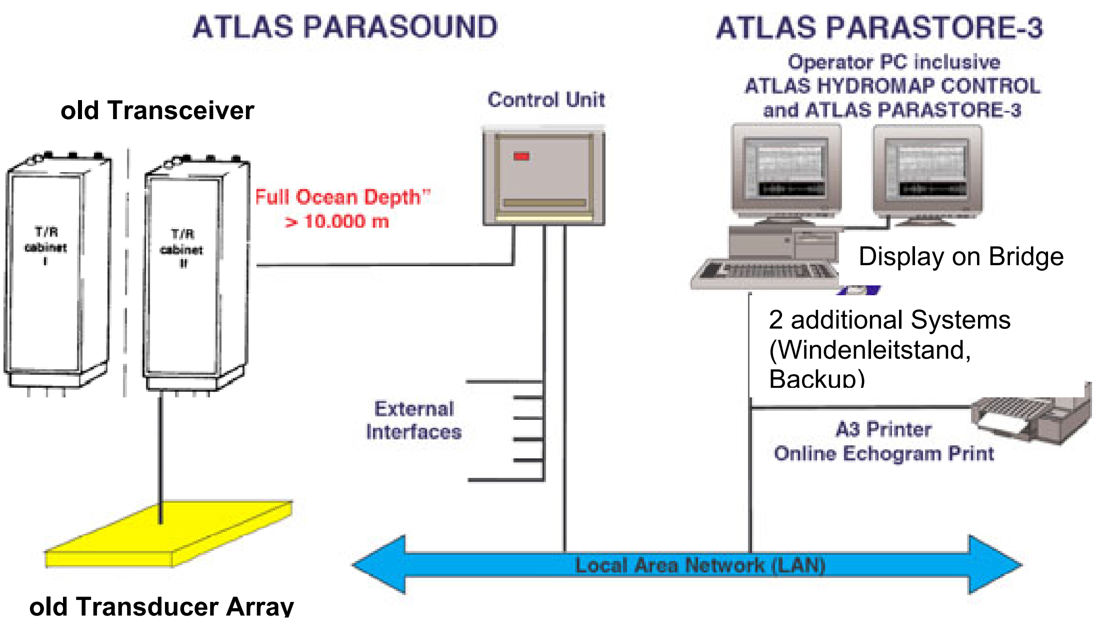

Figure 2: System architecture of new ATLAS PARASOUND DS2 system (2004) with communication over local area network.

After 4 days of trial the sea acceptance test was signed, but with some points to be fulfilled afterwards. Water depth was too low, time too short and sea state too calm to get realistic environmental conditions for testing the instrument. The crew left Polarstern on the 20th and 22th of June with Helicopter flights to Tromsø.