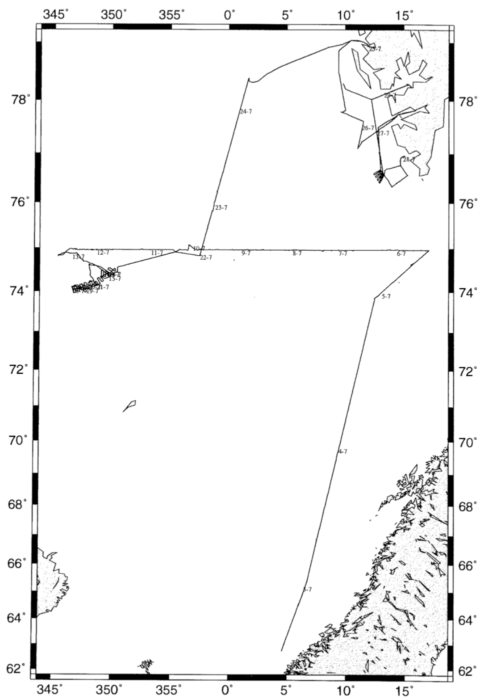
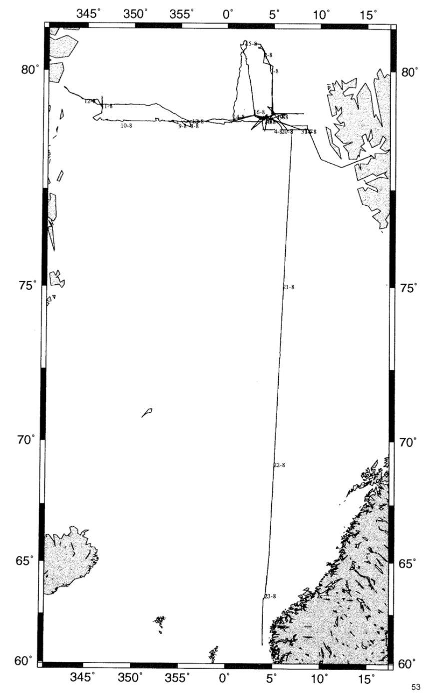
CRUISE REPORT: ARK-XVI_1, ARK-XVI_2

(Updated MAR 2018)





Highlights

Cruise Summary Information

Section Designation	leg 1 ARK-XVI/1 (75N)
	leg 2 ARK-XVI/2
Expedition designation (ExpoCodes)	leg 1 06AQ20000630
	leg 2 06AQ20000730
Chief Scientists	leg 1 Gunther Krause/AWI,
	leg 2 Ursula Schauer/AWI
Dates	leg 1 2000.06.30 - 2000.07.31
	leg 2 2000.07.30 - 2000.08.26
Ship	*Polarstern*
Ports of call	leg 1 Bremerhaven-Longyearbyen
	leg 2 Longyearbyen-Bremerhaven
	79° 8' 16.8" N
Geographic Boundaries	14° 37' 12" W 17° 6' 0" E
	5° 33' 50.4" N
Stations	leg 1 56 CTD stations,
	leg 2 67 CTD stations
Floats and drifters deployed	0
Moorings deployed or recovered	leg 1 2 recovered 2 deployed
	leg 2 12 recovered 16 deployed

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The Expeditions ARKTIS XVI/1 and ARKTIS XVI/2 of the Research Vessel "Polarstern" in 2000

Edited by Gunther Krause and Ursula Schauer
with contributions of the participants

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ARK XVI/1

30.06. -31.07.2000
Bremerhaven - Longyearbyen

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KOORDINATOR/CO-ORDINATOR
Wolfgang Arntz

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1. SUMMARY AND NARRATIVE OF THE CRUISE

RV "POLARSTERN" started for her 16th Arctic expedition into the Greenland Sea and the Fram Strait from her homeport late at night on June 30, 2000. Scientific programmes began in the vicinity of Bear Island July 6 with a hydrographic section along 75°N as far as the Greenland Shelf (July 13.). The most western position at 014°37,2'W was determined by a dense ice cover. Too much time would have been needed to proceed further.

56 CTD-Rosette stations were occupied to study variations of the stratification of water masses on this section, as it has been done almost yearly since 1988. The long-term objective is a better understanding of the processes involved in bottom water renewal, the details of which are not yet known to us to a satisfactory extent.

From the water samples the concentrations of several nutrients were determined. They will be used not only as additional tracers for the water masses but also for a study of the seasonal and inter- annual variability of their nutrient inventory. Water samples were also collected for stocktaking of the plankton communities, supplemented by hauls with a multinet.

Two moorings close to the hydrographic section in the central Greenland Sea were recovered and replaced. Each consists of a taut mooring line on which an automatic profiler for temperature and salinity moves up and down between 90m and 3600m every second day for one year. The systems worked very well: One of the profilers yielded 156 profiles during 362 days, the other 63 profiles during 135 days. It is the first time that such data sets have been obtained in the Greenland Sea.

In the area of the Greenland continental slope field work between 74°N and 75° was carried out for the multidisciplinary project ARKTIEF. The overall aim of this project is to comprehend the down-slope fluxes of water, sediments and organisms from the shelf into the deep-sea. On board a Geology and a Biology group were involved in close co-operation. Their common interests were focused on the submarine channel systems which were found to exist in the area by mapping with the GLORIA long-range side-scan sonar a few years before. On this cruise, more detailed charting using HYDROSWEEP and PARASOUND was performed in an attempt to survey a prominent channel (working name "Arktief-Channel") from its possible origin on the shelf and its course into the deep-sea.

Previous studies revealed that in·such submarine channel systems and on the slope the lateral gravitational mass transport of shelf sediments may overprint the pelagic sedimentation. The analysed data of the bottom samples collected on this cruise will be added to available paleo- oceanographic data sets in order to investigate the role of the channel sediments in reconstructing the climate with a high temporal resolution in the late Quarternary.

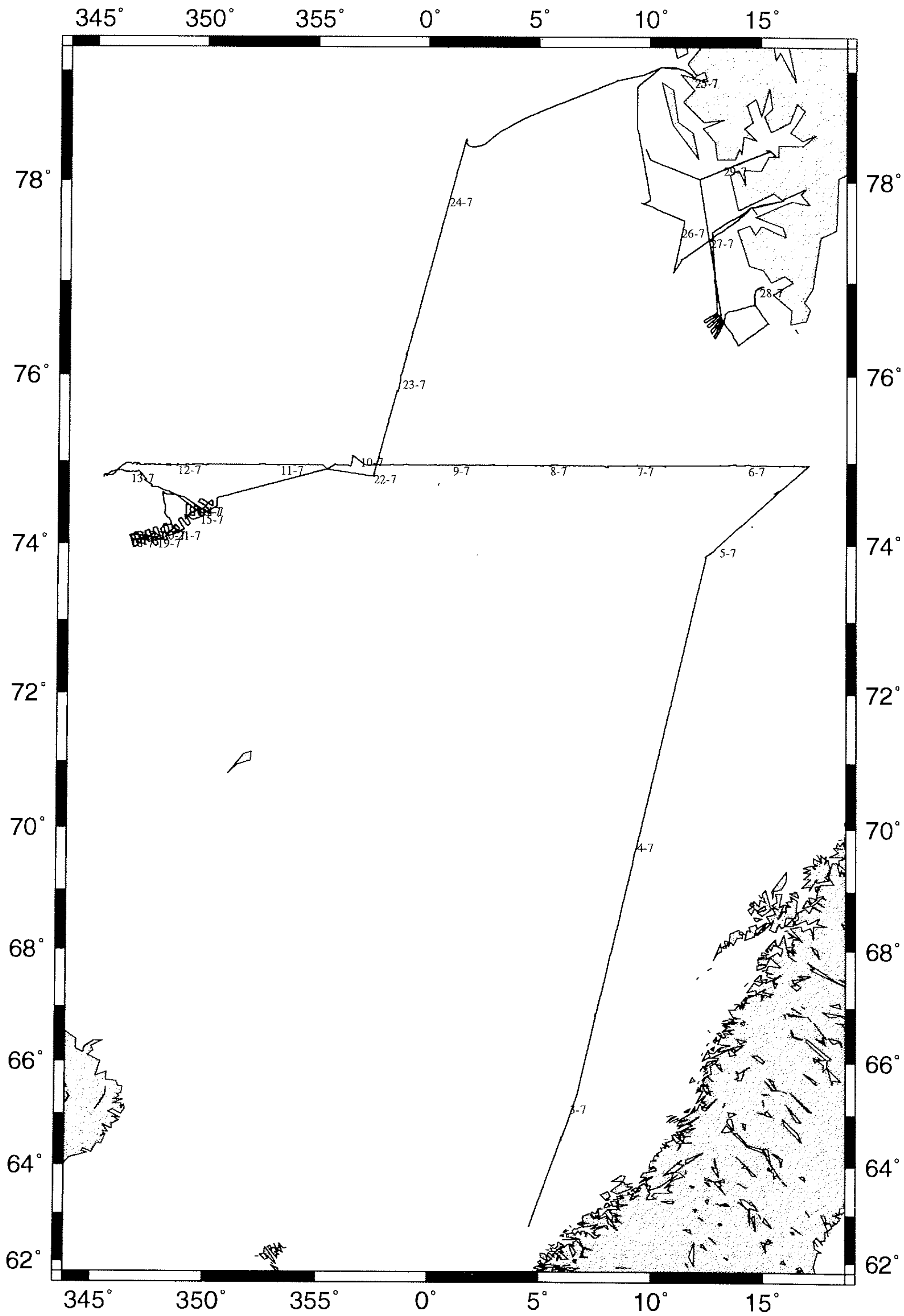
The surveyed channel was of a U-shape and incised into the sea floor in the order of 50m on an average width of 2000m. This testifies to energetic currents as the cause for its formation. The joint investigations with a survey of the benthos in and in the vicinity of the channel will help to find out whether the channel is still active for drainage flows from the shelf or if it is a fossil structure.

The benthos projects aimed also at an assessment of the distribution patterns and activities of benthic organisms and their relevance for the ecosystem "Arctic Deep-sea". In addition to the bottom samples collected extensive photographic surveys of the sea floor perpendicular and in the direction of the channel were performed with the OFOS-system. 5800 colour slides will have to be analysed.

Throughout the cruise water samples were collected and analysed for their methane content. The scientific objectives are to study the cycle of methane in Northern high latitudes and to particularly quantify the contributions of submarine archive gas venting sites. Special emphasis was put on several sections off the West coast of Svalbard and on measurements in Kongsfjord and Van MijenfJord. While working in the KongsfJord the scientific village of Ny-Alesund was visited.

Finally, continuous measurements of the concentrations of atmospheric trace gases and persistent organic pollutants were performed. These measurements will supplement a program for the determination of global matter fluxes for which data already exist from Antarctica up to 50°N.

All investigations have considerably benefited from favourable weather conditions. On July 31, the first leg of the cruise ARKXVI ended in Longyearbyen.



2. ATMOSPHERIC INVESTIGATIONS

2.1 METEOROLOGICAL CONDITIONS

(C. Knaack)

POLARSTERN left Bremerhaven on June 30 at 23:00 h with a north-west wind of force 5 on the rear of a weakening low over southern Sweden. On the way to the first test station at 73,8°N 12,5°N on July 5 northerly winds of mostly of Bft 5 prevailed which had been caused by a north Scandinavian low. Next midnight the zonal hydrographic section along 75°N began.

The amount of clouds corresponded to the climatic average in the region south-west of Svalbard: an overcast sky was observed during more than 90% of the time, mostly stratocumulus and stratus layers with a ceiling between 1000 and 3000 feet. The pressure patterns during the following days were arranged in a meridional mode. High ridges and low troughs alternated. The weather was quiet. The first ice contact occurred during the night of July 12: 4-7/10 drift ice, thickness about 2,5 m.

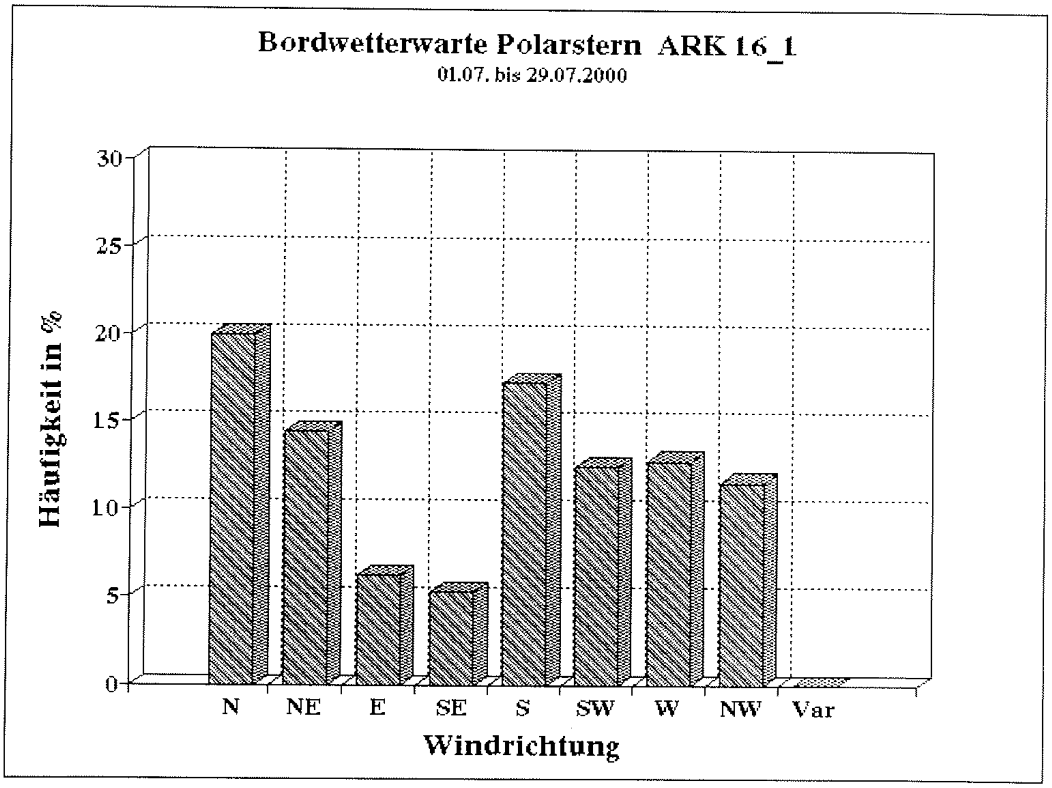
On July 13 the 75°-section was completed at 14°W. The investigations were continued in an area around 74°N 11°W until July 21.

During this time it had been very foggy. The visibility was often less than 200 m, but the vertical extension at times was small, so that the sun above the fog was visible, for example on July 17.

With a cyclonic upper air flow around Greenland, surface depressions were guided into the East Greenland Sea. Occasionally, the southerly wind increased to Bft 6-7. On July 21 a narrow high ridge produced some sunny periods which, after all, made spectrometer measurements possible. The next day a cold front brought some showers. High pressure coming from south established its centre (1030 hPa) at the Greenwich meridian at 70°N on July 23, when POLARSTERN took a north easterly course for Svalbard. This high caused continuous sunshine without any clouds for two days.

On July 24, POLARSTERN passed an ice field with an extension of about 5 nautical miles at 78°N 2°E. The wind came from south-west with Bft 4 - 5. During the afternoon of July 25, POLARSTERN stayed in the Kongsfjord close to Ny Alesund. Meanwhile on the rear of a weak cold front the wind veered to Northwest. Obviously due to an orographic effect the wind strengthened from 5 m/sec outside to 10 m/sec inside the fjord. Two days later, investigations were carried out in the van Mijenfjord.

After the research work was completed in an area near the south west coast of Svalbard, POLARSTERN arrived at the lsfjord on July 29. Next morning at Longyearbyen the cruise ARK XVI/1 ended. The weather in these last days was determined by an almost stationary cyclone situated between Svalbard, Franz-Josef-Land and Nowaja Semlja with north-westerly winds varying between Bft 3 and 7. Embedded troughs caused some rain and snow showers. On the whole, this cruise was favoured by the weather, we experienced more sun and less wind than usual.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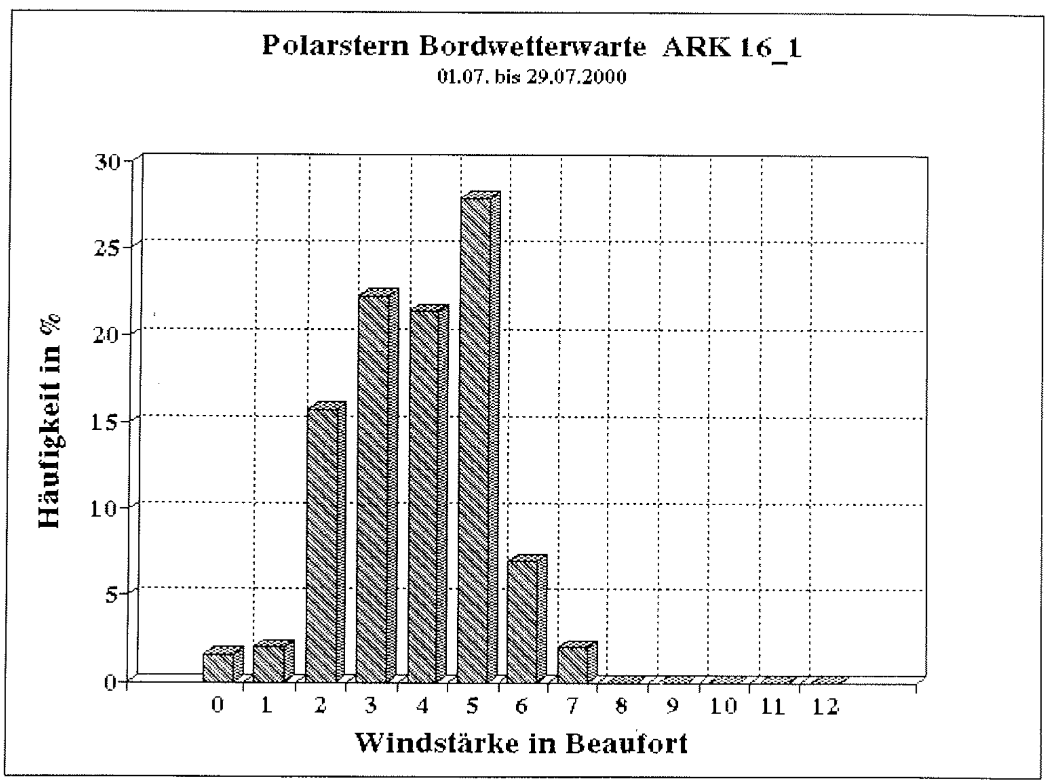
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Windstärke in Beaufort

2.2 MEASUREMENTS OF ATMOSPHERIC TRACE GASES USING FT-IR SPECTROSCOPY (AWI)

(H. Deckelmann, C. Weinzierl)

Measurement technique

In recent years FT-IR spectroscopy has proven to be a valuable tool for atmospheric chemistry and physics. Using the sun as source of light, the column abundances of several troposheric and stratospheric gases can be measured. The method is very sensitive due to the long absorption paths at high solar zenith angles. Among the species with mainly tropospheric relevance e.g. CO, C_2H_2, C_2H_6, CH_2O, OCS and various CFCs can be measured. Important measurable stratospheric species include O_3, HCl, HNO_3, NO, NO_2 and $ClONO_2$. For some species (e.g. HCl, HF, NO_2) a vertical profile can be determined by analyses of the pressure broadening of the spectral lines, however, the vertical resolution is limited.

Background and aim of the campaign

The focus of the measurements during ARK XVI/1 are investigations of the transport and chemistry of tropospheric trace gases and open questions in the stratospheric ozone chemistry. Information on the distribution of trace gas· concentrations in the free troposphere are still sparse. Ground based in-situ measurements cover only the surface layer and satellite instruments are typically limited to the altitudes above 10 km. One of the objectives during the cruise is for example the investigation of the transport of anthropogenic compounds, e.g. CO, CH_2O, C_2H_2 or C_2H_6, from the source regions (industrial regions in Europe and North America) into the polar areas.

First measurements by our FT-IR spectrometer during ANT XIV-1 between 50°N and 40°S .and a profile analysis yield a large variability of several tropospheric compounds in the free troposphere. FT-IR-observations at the Koldewey station yield strong seasonal variabilities for CO, C_2H_2, C_2H_6 and CH_2O with maximum values in winter. The measurements during this campaign will allow to study the transport processes and chemical conversion of a few tropospheric anthropogenic compounds in the Northern Hemisphere north of 50°N.

The stratospheric polar ozone loss mainly occurs in relatively isolated stratospheric low pressure systems that form during late summer/fall in the polar regions. Neither the dynamical processes during the formation of the vortices nor the initial chemical composition of the air masses in the vortices during their evolution, are sufficiently documented by ground-based measurements. To a great extend the ozone chemistry during the polar winter depends on the partitioning of the stratospheric anorganic chlorine reservoir. During the polar winter this partitioning changes dramatically due to heterogeneous reactions on the surfaces of Polar Stratopheric Cloud (PSC) particles that can form at extremely low temperatures. A large fraction of the anorganic chlorine is converted from more passive compounds into active species that rapidly destroy ozone after the return of the sun in spring.

Recent results from our FT-IR instrument at the Koldewey station suggest that changes in the chlorine partitioning occur earlier than expected. Also, the negative trend in the polar ozone seems to occur earlier than one would expect from our current understanding of the stratospheric chemistry.

Despite bad weather conditions at the beginning of the cruise, a large number of absorption spectra could be recorded at important positions with high resolution.

The measurements during this cruise together with the ones of ANT XVIl-1 and -2 can be considered as a part of a major campaign, in which spectra were recorded between 70°S and 80°N. Since the measurements in the Antarctic and the Arctic could be carried out in the summer months the photochemical processes are comparable due to the similarity of the sun's radiation. This is a relevant precondition for the studies of the depletion processes of CO or C_2H_6.

2.3 SAMPLING OF PERSISTENT ORGANIC POLLUTANTS (POPS)

(S. Lakaschus)

During the whole cruise air and water samples were taken, which will be analysed for organic pollutants like PCBs, HCHs and HCH.

By simultaneous sampling in air and water it will be possible to calculate air-water gas exchange rates. Furthermore, these samples and the samples taken on the previous cruises ANT XVII/1 and ANT XVII/2 will contribute to a better understanding of the global distribution of POPs.

On the upper deck 21 air samples were taken by the use of three high volume samplers. Some of these samples will be analysed by the Norwegian Institute for Air Research and the "lnstitut für Ostseeforschung Warnemunde for a comparison of the analytical methods.

The water samples were taken from the clean seawater system of the POLARSTERN as well as directly from the surface water with an in-situ pump. At 10 stations samples were taken from the Rosette.

The results of the cruise will be available in 2 to 3 months after the chemical analysis of the samples by gas-chromatography and mass-spectrometry.

2.4 METHANE BUDGET OF WATER MASSES

(E. Damm, A Terbruggen)

Objectives

The goal of our investigations was to estimate the methane budget of different water masses of the Greenland Sea at the transect at 75°N.

A further goal was to record the impact of fossil methane in the water column and to prove the modification of the present marine methane cycle at active submarine gas venting sites at the Spitsbergen shelf and fjords. Investigations of the stable carbon and hydrogen isotopic ratio of the fossil methane will be carried out both to explain its genesis and origin and to understand mechanisms and pathways of incorporation of fossil methane into the recent carbon cycle.

Work at sea

Methane concentrations were measured at 30 stations along the 75°N transect, at 3 stations at the S- N transect and at 21 stations on the Westspitsbergen shelf, in the Kongsfjord and Van Mijenfjord (Fig. 2.4.1) Water samples were collected in Niskin bottles mounted on a rosette sampler from water depths of 3800m up to the surface (4m). The dissolved gases were immediately extracted from the water and were analysed for methane by a gas chromatograph equipped with a flame ionization detector (FID) on board of the ship. Gas samples were stored for investigations of the isotopic signature of methane to be carried out in the home laboratory. Furthermore, water samples were taken and filtered for the analysis of chlorophyll-a and for DMSP analysis. All samples were fixed and stored refrigerated for analysis in the home laboratory.

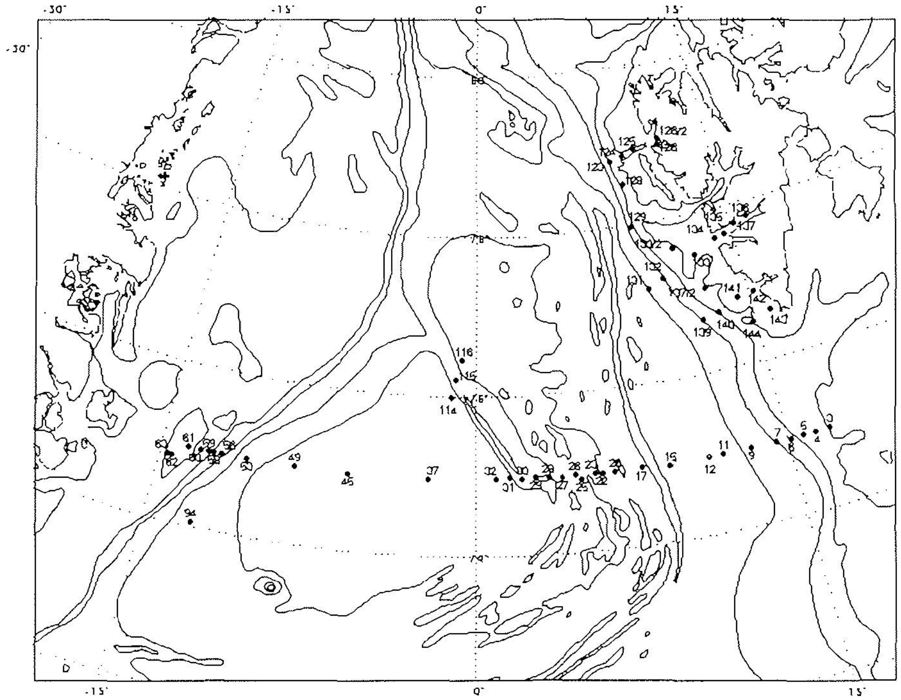


Fig. 2.4.1: station map of methane measurements

Preliminary results

In general, the methane concentration in the surface water is in equillibrium with the atmosphere or slightly supersaturated in the Greenland Sea along the 75° transect. The concentration decreased rapidly with depth in the water column below 1000 m at the western part of the transect (Fig. 2.4.2, station 37 to 49). With respect to atmospheric methane background values of about 25% of saturation were reached in 2000 m water depth already. This low background corresponds to a characteristical threshold level and means that methane consumption virtually ceases because of the isolation of deep water masses from the surface ocean. In comparison, the Atlantic water in the West Spitzbergen Current shows a smaller decrease of concentration in the water column, and background values of about 50% of saturation with respect to atmospheric methane prevail down to the bottom (Fig. 2.4.2, station 12 to 17). This can be caused by convective ventilation of atmospheric methane or by the supply of methane by bottom sources. More about the origin of the methane in the Atlantic water will be known if the isotopic signature will have been determined.

The surface water at the Greenland shelf was supersaturated with respect to atmospheric methane caused by insitu methane production in the euphotic zone (Fig 2.4.2, station 60 to 63).

Near bottom maxima of methane were detected on the Barents Sea shelf (Fig. 2.4.2 station 3, 4). The methane anomaly is depleted before it reaches the surface water in an intermediate 100 m thick layer. The source of the methane enrichment is really unknown however, the investigation of the isotopic signature will contribute to explain the provenance (Fig 2.4.2).

All stations occupied on the shelf of Westspitsbergen and in the Kongsfjord and Van Mijenford are affected by injections from bottom sources. Therefore, bottom or intermediate water concentrations are up to two orders of magnitude higher than the normal background concentration level. Methane enrichments in the fjords are shown in

Fig 2.4.3. Although the concentration is decreasing upwards, the surface water is supersaturated with respect to the atmospheric methane level at the majority of the stations indicating that this shelf region and the fjords act as sources for atmospheric methane. Also, here the sources of methane anomalies are not yet known. However, these enrichments could be associated with undetected gas vents located at the shelf. They could originate from recycling of sea water through the sea-bed or by submarine groundwater discharge

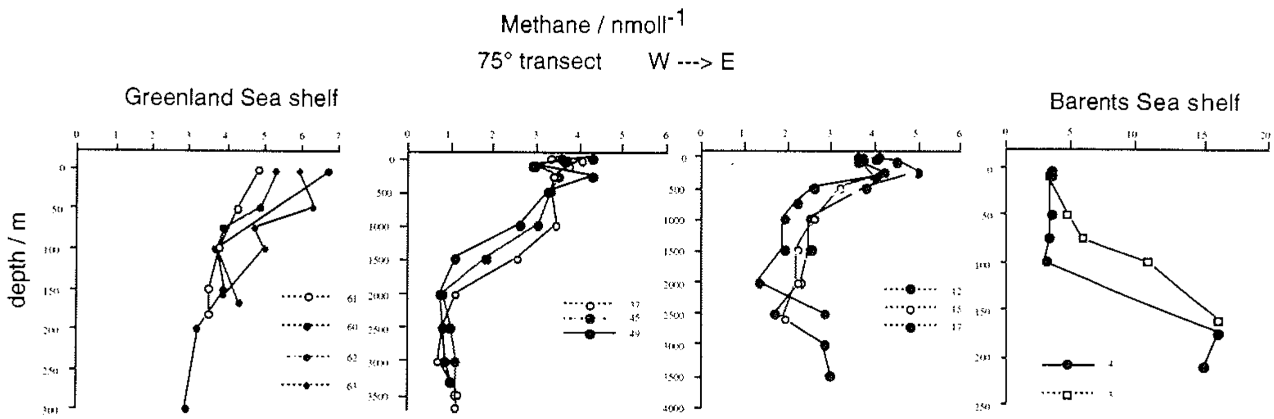


Fig. 2.4.2: Selected profiles of methane concentrations at the 75° transect

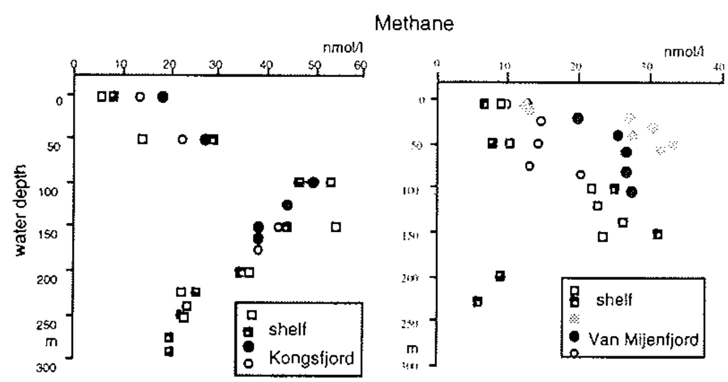


Fig. 2.4.3: Methane enrichments in the Kongsford and Van Mijenfjord

3. INVESTIGATION IN THE WATER COLUMN

3.1 PHYSICAL OCEANOGRAPHY OF THE GREENLAND SEA

(G. Budeus, R. Plugge, S Ronski, J Tambke, S Adam, B.H. Buck, R. Hoheisel-Huxmann)

1. General

The work of the Instrument Development/Physical Oceanography group concentrated on the main item of long-term changes in the Greenland Sea. The sampling continued field work of previous years. It is focussed on the understanding of changes in water mass properties with and without winter convection. A longer time series is necessitated to identify the conditions under which deep convection occurs and to resolve processes acting under its absence. During the last few years a clear increase in bottom water temperature was observed, amounting to roughly 10 mK/a. The temperature increase affected not only the bottom waters but rather the entire water column below 2000 m. At the same time, no deep convection could be identified during this time interval.

During ARK XVI/1 the time series were continued by an east-west transect across the Greenland Sea at 75°N and a short south-north transect towards Fram Strait. In the central Greenland Gyre, two moored deep sea profilers were recovered and two were deployed.

2. Equipment and methods

For the station work a 'SBE 911 plus' CTD with duplicate T and C sensors was used. The duplication allows for immediate checks of sensor drifts on board. Water was sampled by means of a SBE32 rosette, equipped with 24 bottles each of 12 I content. The equipment worked faultlessly. For temperature comparisons an SBE35 thermometer was applied. Each time a bottle is fired the thermometer is triggered by the SBE32 rosette and internally stores measured temperatures Comparisons between SBE35 and CTD measurements have been restricted to depth levels below 2000 m to ensure a thermally quiet environment. Checks of vertical temperature gradients showed, however, that even in the closed basins of the Arctic Mediterranean a constriction to these depths does not guarantee temperature fluctuations small enough to allow for in situ calibrations on the level of 1 mK. Therefore, at each sampling point it has been individually verified that temperature calibration was allowed. The CTD measurements at valid calibration points show deviations in the order of 1 mK from the SBE35 values.

Water for salinity checks has been sampled at chosen locations and the samples have been analysed in the ship's lab. Application of the resulting corrections will be done during the post processing on land. An RDI ADCP (150 kHz) has been running continuously. Water has been sampled and stored for SF-6 analysis, allowing an identification of the spreading pathways of Greenland Sea Bottom and Intermediate Waters. Analysis will be performed by the University of East Anglia, UK.

3. Moorings

The moorings deployed and recovered in the central Greenland Gyre are a special development of AWI and are designed to provide profiles over the entire water column every second day for one year. The moored deep-sea profiler vehicle consists of a buoyancy module and a modified self-contained CTD. The vertical movement along a taut mooring line is initiated by a control unit on top of the mooring. This delivers a weight to the profiler vehicle for each cast, so that the vehicle movement is powered by gravity. The weight is removed at the bottom, and the slightly buoyant vehicle returns to the surface. Because of the large vertical extent of the movement (3600 m) the compressibility of the vehicle is adjusted to match that of cold seawater (Euro Goos: Externally powered / cmpressibility compensated (EP/CC - Jojo).

The two moorings deployed in 1999 have been replaced (74°55'N, 04°20'W, and the one at 75°05'N, 03°20'W has been moved to 74°50'N, 2°30'W in order to fit into the new EU-project ‚Convection'. The recovered moorings were intact and successfully sampled their time series of one profile over the entire water column (3700 m) every second day. One mooring provided a time series of deep sea profiles over the entire year, the other one over 168 days. Both series started in July 1999.

The downward and upward speeds of the vehicle with 0.75 and 0.25 m/s were excellently adjusted. Only during times of strong horizontal currents which extended over the entire water column, the instrument's buoyancy (equivalent to 100 g) did not overcome the friction between rope and vehicle. After such periods the sampling continued according to the planned time schedule. An example of the temperature development is shown in Fig. 3.1.1. The data will reveal unique information about the exact time of winter ventilation and give a better assessment of the relation between forcing and water column modification in winter.

4. CTD station work

The transect on 75°N extends from the Norwegian shelf to East Greenland. For decisive conclusions the final calibration has to be awaited, but owing to the high quality of the primary data some ad hoc statements can be made.

The upper waters have been ventilated to about 1400 m depth. as is indicated by temperature and salinity changes in comparison with the 1999 data (as well as by the moorings). The intermediate temperature maximum at now roughly 1600 m depth stands out prominently therefore (see Fig. 3.1.2).

From 1999 to 2000, modifications of the deepest parts of the water column are clearly significant. The isotherm 1.15°C (potential temperature) has now disappeared, and lowest temperatures of approximately -1.146°C are observed at the bottom. The isotherms in the lower water column were thus observed at increasingly greater depths. The cause of this temperature increase has to be carefully identified after the final calibrations will have been applied. A preliminary evaluation of the time series of the volume below selected isopycnals (Fig. 3.1.3) indicates that lateral isopycnal mixing cannot explain the full range of property changes in the lower intermediate and deep waters, and that the hypothesis of vertical advection in the central gyre contributes to the temperature increase and density reduction in the deep waters. The evaluation of the SF-6 samples will assist in this investigation.

Fig. captions

3.11
Part of the time series of temperature profiles (3-January 2000 (profile 78) to 7 March 2000 (profile 110)) illustrating the begin of the winter ventilation in the central Greenland Sea. The scale is valid for the first profile, the succeeding profiles are shifted with a constant shift between the casts.

3.1.2
Temperature distribution at the zonal transect on 75°N.

3.13
The decreasing volume below selected isotherms corresponds with the trend to higher temperatures in the bottom water of the Greenland Sea.

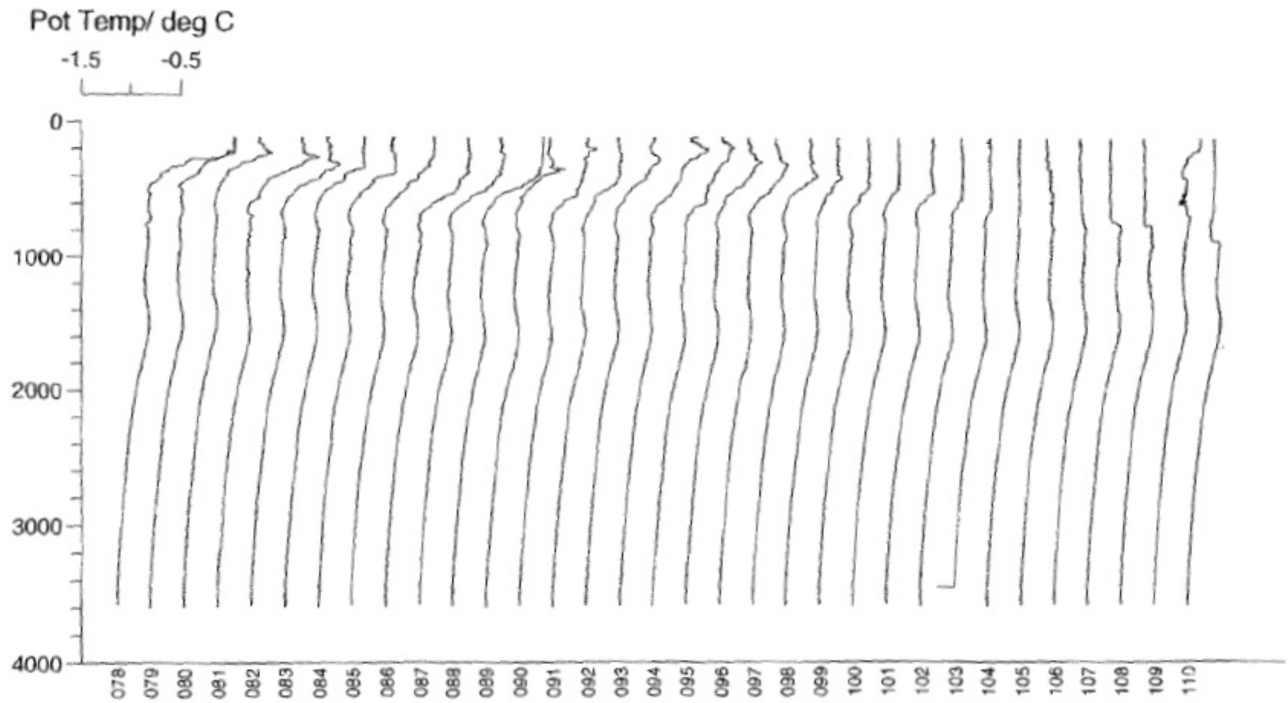


Fig. 3.1.1

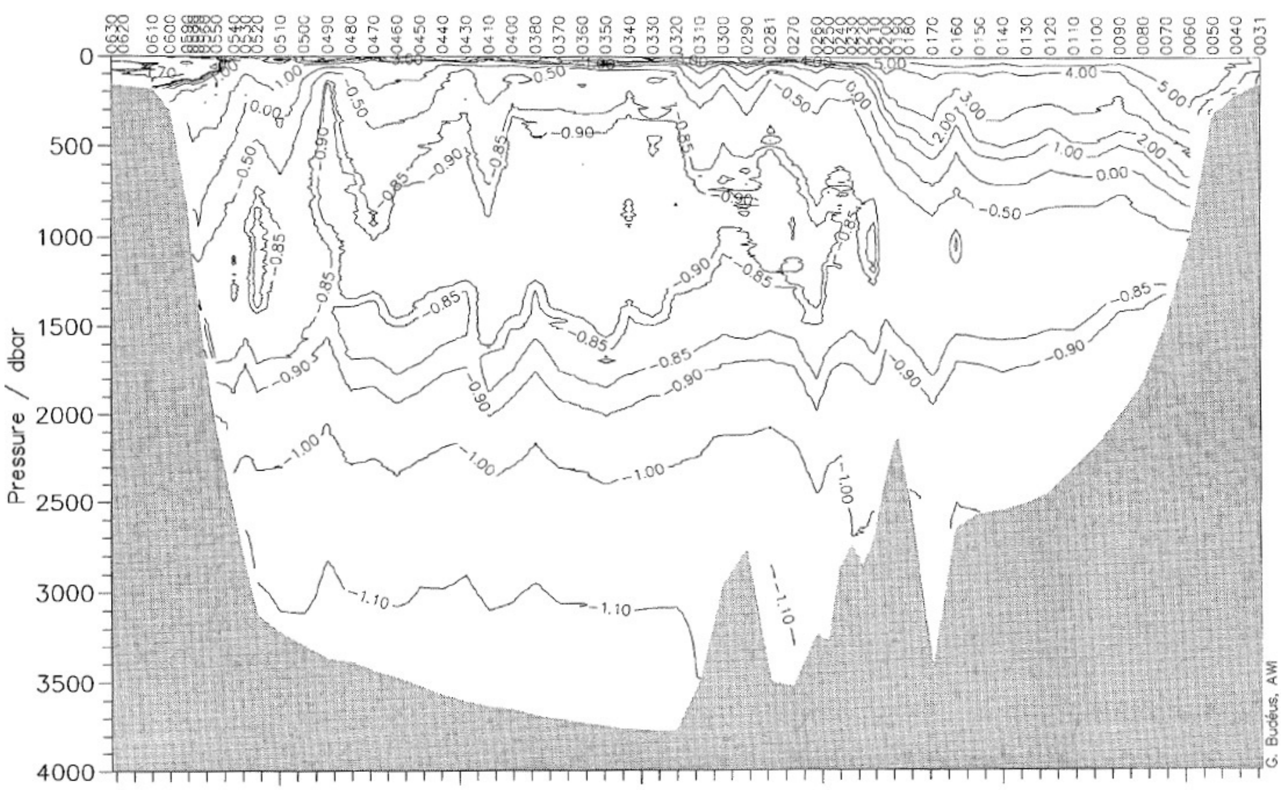


Fig 3.1.2

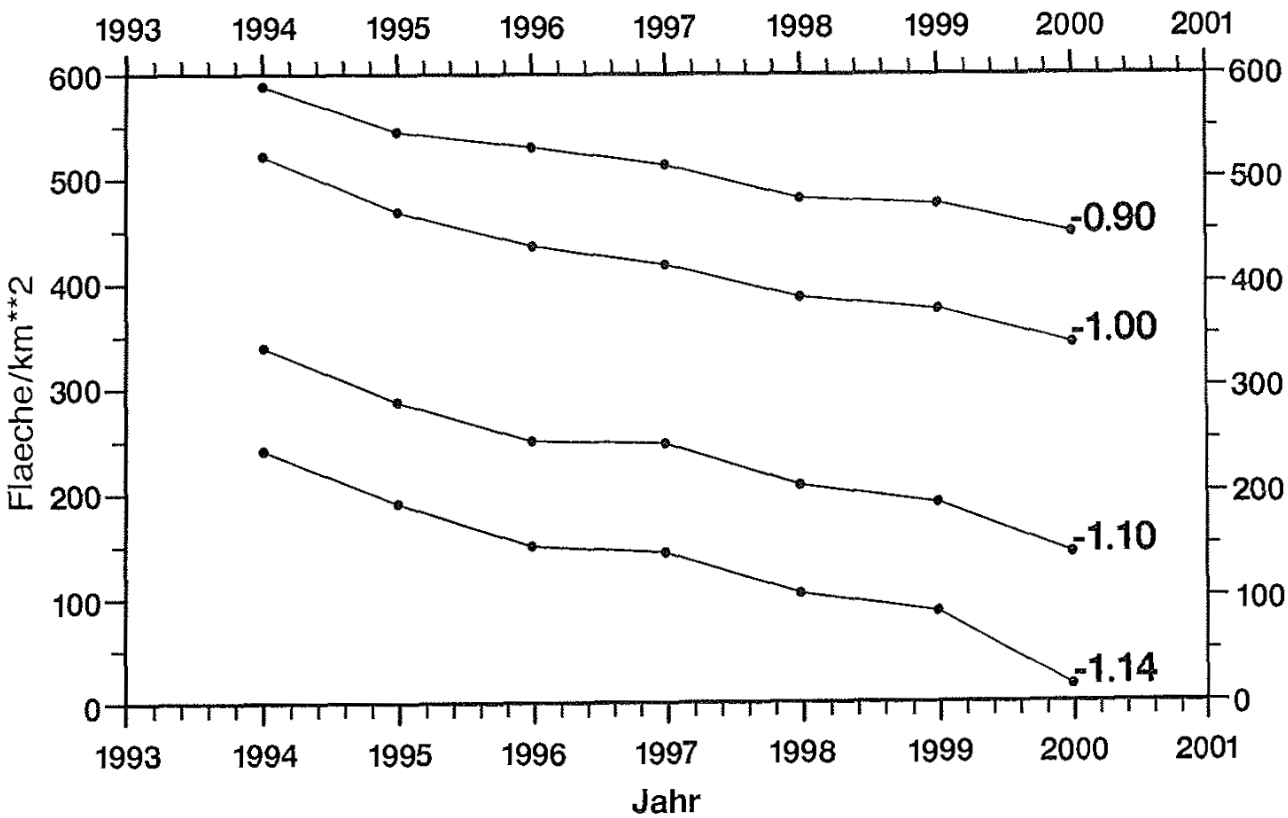


Fig 3.1.3

3.2 DISTRIBUTION OF NUTRIENTS

(C. Hartmann, P. Ducardus, M. Sturcken)

Nutrient concentrations provide a valuable tool to trace water masses and to detect transport and mixing mechanisms. The objective of this investigation was to determine the vertical and horizontal distribution of nutrients across the Greenland Sea along 75°N and to compare these data with oceanographic parameters.

In comparison with the measurements on the same transect of former years, the seasonal and interannual variability will be determined.

With respect to the water mass analysis especially silicate but also phosphate are good tracers for outflow of upper halocline Arctic surface water along the Greenland slope This water is especially rich in silicate compared to Atlantic water.

At 60 stations (Fig. 3.2.1) across the Greenland Sea at 75°N and at 22 stations during the south-north transect, crossing the Greenland and Boreas Basins. water samples were collected for the analysis of nutrients (silicate, phosphate, nitrate and nitrite), which were measured within a few hours after collection. The nutrients were determined with a Technicon Autoanalyzer system according to standard methods.

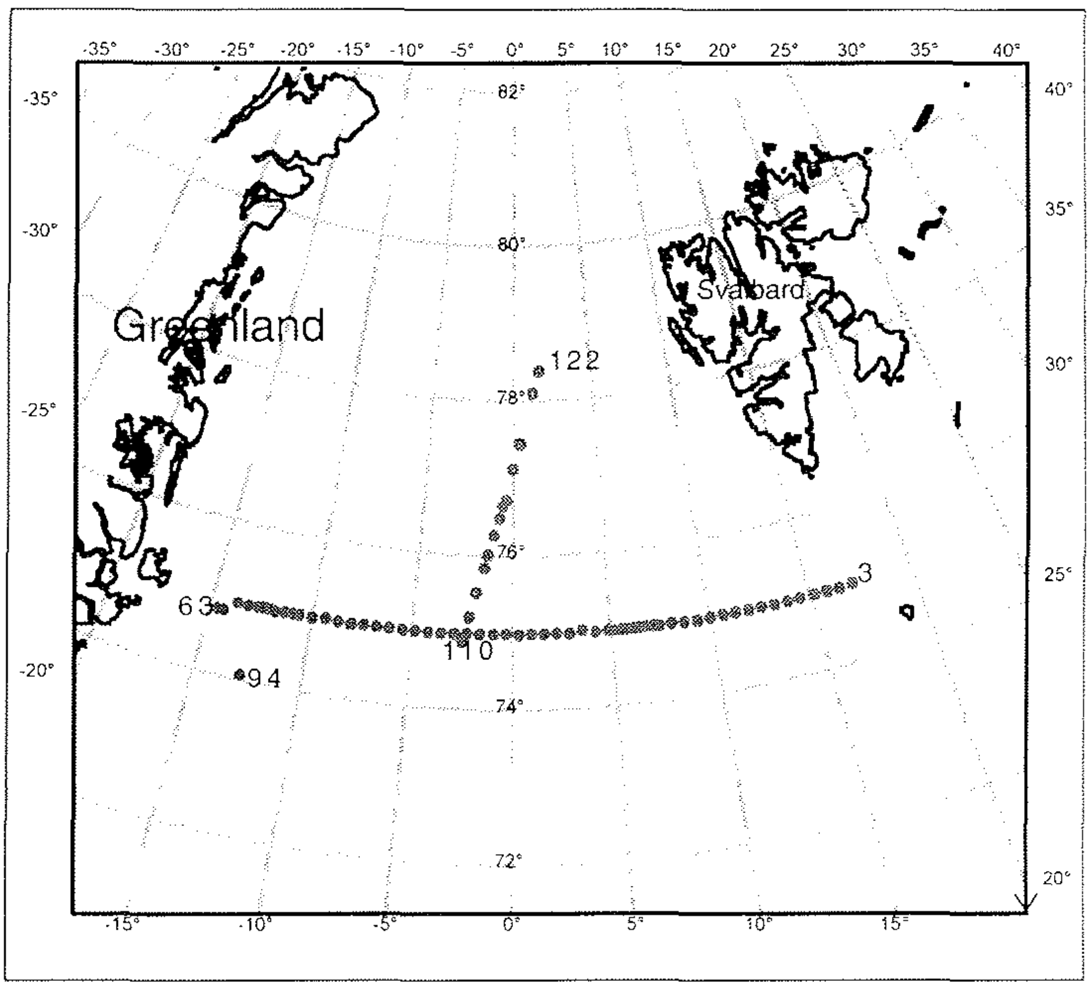
Preliminary Results

In the entire water column, nutrient concentrations generally increased with depth.

Nitrate increased to about 15 µM, phosphate to 1.1 µM and silicate to 12 µM in the centre of Greenland Sea. The surface concentrations in the western and eastern parts of the Greenland Sea transect were higher than concentrations measured on cruise ARK XIV/2 in September 1998.

From station 24 (74.9°N, 5.5'E) to station 50 (74.9°N, 10°W) nitrate was mostly depleted in the surface with concentrations below 1 µM. Silicate and phosphate were also lower than in the eastern and western parts of this transect. In the Atlantic water nitrate concentrations were highest compared with Greenland Sea and Polar Water.

West of station 55 (11.8°W) a slight decrease of silicate concentrations was found at water depths above 100 m. A clear signal of outflowing upper halocline Arctic surface water could not be observed since the westernmost station was not close enough to Greenland.



Location of sampling for nutrients

Fig. 3.2.1

3.3 PHYTO- AND ZOOPLANKTON ECOLOGY

(V. Larionov)

The distribution of microphyto- and microzooplankton in the water column was measured along the two oceanographic transects, and the distribution of mesozooplankton along the one on 75°N.

The main tasks are the following:

- an investigation of the species composition and quantitative characteristics (cell concentration and biomass) of microphytoplankton;
- qualitative and quantitative analyses of the community of formaline-fixable microphytoplankton fixable in formaline;
- a study of the spatial distribution of mesozooplanktonic organisms in the different layers of the water column.

At 25 oceanographic stations (see Table 3.3.1) water samples were taken by the rosette sampling system. On each station samples were obtained at 5-14 discrete depths in the water column selected on the basis of the thermohaline structure (216 samples total). Samples (the volume 1,5-2 I) were concentrated with the standard method of inverted filtration through Nucleopore-filters with a pore diameter 2 µm and fixed with buffered 37% formaline (final concentration 1-2%). At 7 stations simultaneously zooplankton samples were taken by the Multinet in the following layers of the water column: 500-200 m, 200-50 m, 50-0 m (21 samples total; see Table 3.3.1). They were fixed in the same way.

Microscopical studies of the taxonomical composition and quantitative analysis of both series of samples will be carried out in the home laboratory to investigate the distribution of plankton in the Greenland Sea basin.

Table 3.3.1: List of stations with plankton investigations

St.No.	Horizons of phytoplankton sampling, m	Multinet
4	Surface, 20, 50, 100, bottom	
6	Surface, 25, 50, 100, 500, bottom	
8	Surface, 25, 50, 100, 250, 500, 1000, bottom	
10	Surface, 25, 50, 100, 250, 500, 1000, bottom	+
12	Surface, 25, 50, 100, 350, 500, 1000, bottom	
14	Surface, 25, 50, 100, 250, 500, 1000, bottom	
16	Surface, 25, 50, 100, 250, 1000, bottom	
18	Surface,25, 50,100,350,500, 1000, bottom	+
24	Surface, 25, 50, 100, 250, 500, 1000, bottom	+
27	Surface, 25, 50,100,250,500, 1390, bottom	
33	Surface, 25, 50, 100, 250, 500, 1000, bottom	+
40	Surface, 10, 25, 50, 75, 100,150,250,500, 1000, bottom	+
46	Surface, 25, 50, 100, 350, 750, 1000, 1600, bottom	
49	Surface, 25, 50, 75,150,250,350,750, 1000, 1224, 1500, bottom	+
55	Surface, 10, 25, 50, 75, 100, 150, 250, 350, 500, 750, 1000, 1500, bottom	
57	Surface, 25, 50, 75, 100, 200, 500, 750, 1000, bottom	+
59	Surface, 50, 100, 250, 500, bottom	
62	Surface, 10, 25, 50, 73, 100, 150, bottom	
110	Surface, 10, 25, 50, 75, 150, 350, 500, 1500, 2000, bottom	
115	Surface,25,50, 100,250, 1000, bottom	
117	Surface, 25, 50, 100, 200, 500, 750, 1500, bottom	
119	Surface, 25, 50, 100, 250, 500, 1000, bottom	
120	Surface, 25, 50,100,200,500, 750, 1500, bottom	
121	Surface, 25, 50, 100, 200, 250, 500, 750, bottom	
122	Surface, 10, 25, 50, 75, 100, 150, 350, 500, 750, bottom	

4. GEOLOGY AND BIOLOGY OF A DEEP-SEA CHANNEL SYSTEM IN THE GREENLAND SEA

4.1 INTRODUCTION

An extensive mapping of the bottom topography by the GLORIA long-range side-scan sonar carried out in the frame of the Special Research Programme SFB 313 in the early nineties showed that the Greenland Basin is structured by a large system of channels which extend from the continental slope into the deep-sea (Mienert et al. 1993, Hollender 1996). These channels may form important pathways for the transport of sediments and dense water masses from the East Greenland shelf into the basin. Therefore, the current investigations undertaken within the framework of the multi-disciplinary research programme "ARKTIEF" focus on the shelf drainage via these channels. These shelf drainage flows may stimulate energetic currents in otherwise quiet regions having a considerable impact on the sedimentation and living conditions in the deep-sea. The properties of the benthos and the sediments may provide insights into the time scales and intensity of downslope flows.

In 1999, a segment of the Greenland Basin channel system, which has been first discovered during a routine HYDROSWEEP survey in 1994 (Hubberten 1995), was explored by the French deep diving ROV "VICTOR 6000" (Krause 1999). The deep-sea biology was studied along three short transects, and bottom samples were taken at selected stations. Furthermore, a mooring was deployed in the vicinity of the VICTOR tracks in the channel (Schauer 2000). Based on the results of this pilot study, the main aims during expedition ARK XVI/1 were to visit this area again in order to map the course of the channel systems and as far as possible towards its origin on the continental slope by HYDROSWEEP and PARASOUND surveys. Furthermore, research areas should be selected along the course of the channel to study the small and medium-scale biological variability in terms of benthic distribution patterns and turnover processes, including seafloor imaging by OFOS. The geological programme aimed at characterising the larger scale subsurface structure of the channel and the adjacent areas, mapping the various sedimentary facies, and sampling surface and near surface sediments for a detailed study on various sedimentological, organic geochemical and micropaleontological tracers which may reflect the various sedimentation processes, in particular gravitative mass transports. Additionally, the history of sediment transport in the channel should be elucidated by analysing sediment cores. The results of both the biological and geological programmes will give new information for the discussion whether the channel system is "active" or "fossil" today.

4.2 BATHYMETRICAL SURVEY

(S. Daschner, J. Matthiessen)

The swath sounding system HYDROSWEEP was employed for a detailed bathymetric survey at the East Greenland continental margin (Fig. 4.2.1). Several segments of channels have been identified during GLORIA mapping in the study area (Hollender 1996), but the structure of the system could not unequivocally be identified. An area of more than 2200 km 2 was continuously mapped showing that several of these segments belong to a single channel. The channel was traced back more than 120 km from the Greenland Basin in about 3300 m water depth at 74° 30'N, 9° 30'W to the continental rise at 74° N, 13° 15' W in about 2600 m water depth. Clear evidence for a channel extending beyond the lower slope could not be found, but it may continue as a shallow depression upslope. A survey across the continental slope could not be conducted because of a dense ice coverage. A preliminary interpretation of the HYDROSWEEP data neither revealed unequivocal evidence of tributary channels nor branching of the channel along its course into the deep-sea. Any larger depositional regions in the distal parts of the channel have not been observed.

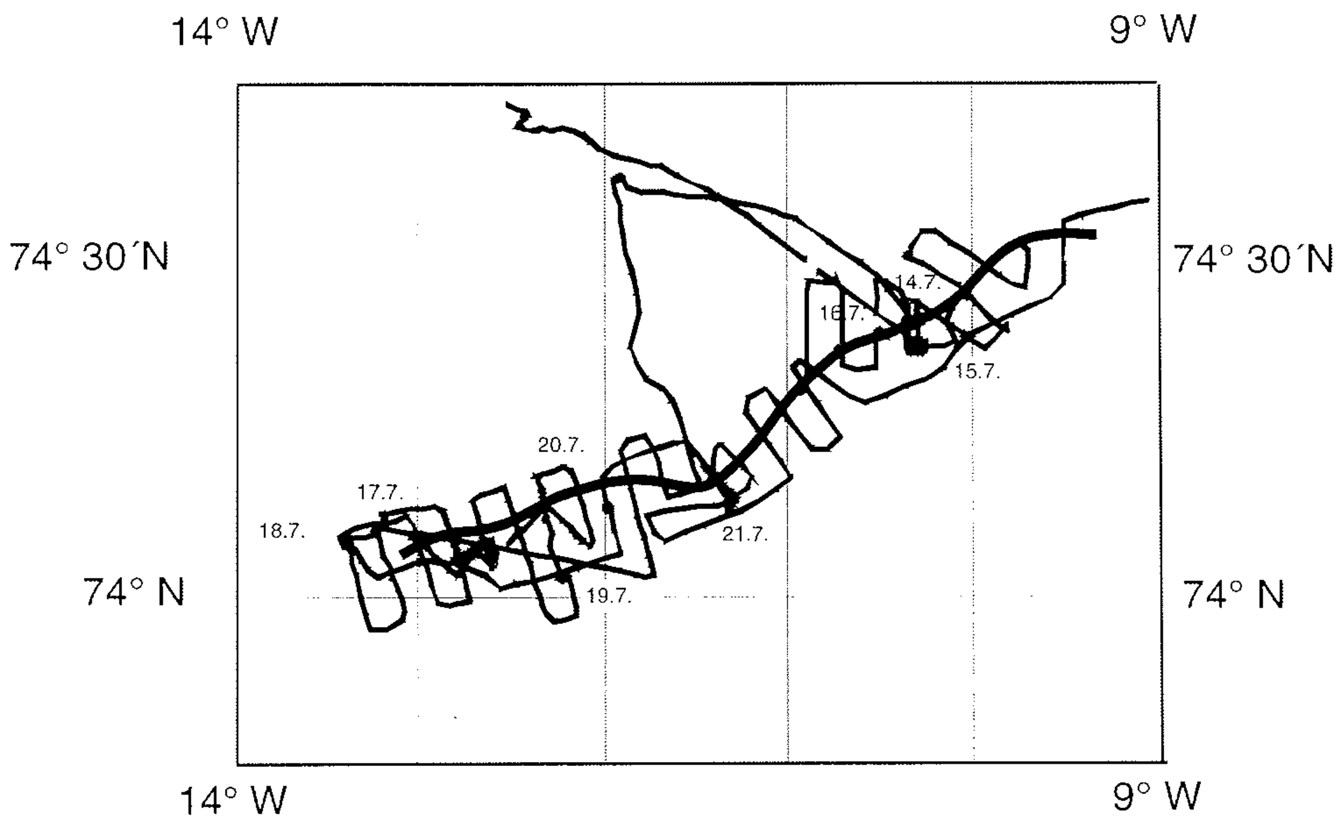


Fig. 4.2.1: Hydrosweep survey of the channel area. The course of the channel is indicated by the heavy line

4.3 SEDIMENT ECHOSOUDING

(J. Matthiessen, D. Birgel, B. Chiaventone, S. Daschner. K. Fenker, C. Kierdorf, N. Koukina, U. Langrock, J. Vernaleken, D. Zeeb)

The ship-mounted PARASOUND echosounding system of RV "POLARSTERN" was in operation during the work in the Greenland Sea in order to characterise the acoustic behaviour of the uppermost sediment layers. The PARASOUND transects were usually conducted perpendicular to the axis of the channel in order to identify lateral variability of sedimentary facies. Few transects could be worked up along the course of the channel to reveal possible erosion and/or deposition downslope from the continental margin. Furthermore, PARASOUND profiling was used to select coring locations and transects for the OFOS surveys. The data were digitized by two different systems: 1) the PARASOUND system for simultaneous printing on a chart recorder (Atlas Deso 25), and 2) by the PARADIGM system (Spiess 1992). For details of the method and standard settings used during the expedition see e.g. Niessen & Whittington (1994).

In the investigation area, the acoustic penetration was usually down to a sediment depth of 25 to 40 m, except for the channel where penetration was usually less than 5 m. The U-shaped channel is incised into the sea floor up to 100 m, but mainly less than 50 m, and is relatively narrow with an average width of ca. 2000 m. The channel has an asymmetric shape because the levee deposits on the southern flank are usually thicker than on the northern one (Fig. 4.3.1) thinning out distally. The levee deposits usually show a number of distinct parallel acoustic reflectors whereas only one prominent reflector is seen in the channel sections. Some levees stand out clearly by more than

20 m from the adjacent sea bottom. On the lower continental slope at the westernmost end of the mapped area, the channel is becoming much wider (ca. 10 km), probably ending at a slide headwall. Shallow depressions upslope (<10 m) of the possible headwall may indicate that the channel originates on the upper continental slope. Although the acoustic penetration is low on the continental slope, debris flow deposits can be clearly identified.

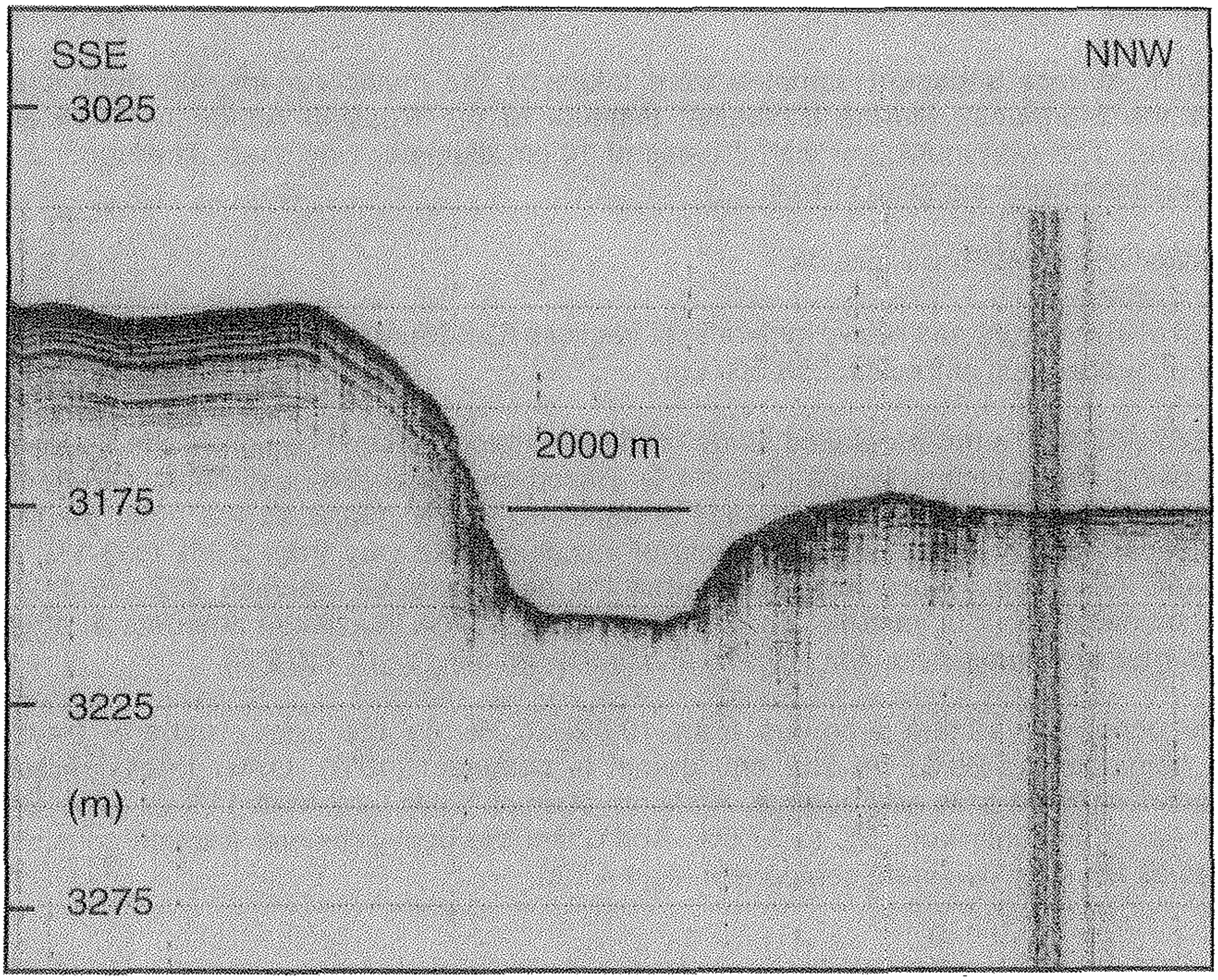


Fig. 4.3.1: A cross-section of the channel recorded by PARASOUND at 74°24'N, 10°24'W

4.4 MARINE GEOLOGY

4.4.1 SAMPLING PROGRAM

(J. Matthiessen, D. Birgel, S. Daschner, C. Kierdorf, N. Koukina, U. Langreck, J. Vernaleken)

Surface and near-surface sediments were collected in the study area on transects across and along the channel to sample the various sedimentary environments. A more detailed sampling was done along the OFOS transects in collaboration with the benthos group. Additionally, samples were taken along a transect from the shelf break to the deep-sea. In order to get undisturbed surface and near- surface sediments, the giant box corer (GKG) with a size of 50x50x60 cm and the multi corer (MUC) with a tube diameter of 10 cm were used. The sampling was routinely done by the MUC because of the better recovery of sediment surfaces. Gravity corers were used to obtain long sediment cores from the channels and the adjacent levees.

The initial macroscopic analysis of the surface sediments suggests that the composition of sediments from the channel and the adjacent levees is similar. In general, the deep-sea sediments differ considerably from the upper continental slope sediments which contain considerable amounts of sand and gravel. The lack of erosional surfaces and the comparable sediment composition along the course of the channel suggest recent and sub-recent deposition. Further detailed land-based sedimentological, geochemical and micropaleontological studies as well as analyses of the HYDROSWEEP and PARASOUND records are required to evaluate the variability of sediments in the study area with respect to transport processes.

4.4.2 MINERALOGICAL COMPOSITION OF SEDIMENTS IN THE GREENLAND SEA

(N. Koukina)

During ARK-XVI/1, surface sediment samples were taken by the multicorer for sedimentological investigation at the Murmansk Marine Biological Institute of the Russian Academy of Science (Murmansk, Russia). The AWI multicorer with 8 tubes of 10 cm diameter was used. The upper 5 cm (every 1 cm) of sediment were sampled (Tab. 4.4.1).

The future investigations in MMBI will include:

- granulometric analysis;
- mineralogical analysis (light and heavy minerals) of fractions 63-125µm and 125-250 µm;
- morphology of quartz grain of fraction 250-500 µm.

For the core PS57/107-2SL a more detailed study of the mineralogical composition of the sediments was performed using smear-slide analysis (Tab. 4.4.1). Based on smear-slide estimates, terrigenous minerals are predominant. The sediments consist of 48,4% to 55,1% quartz as the most dominant component. Feldspars reach up to 9,4%. Amounts of volcanic glass vary from 2,1% to 3,3%, and maximum amounts of volcanic glass were counted in the depth interval between 312 cm 412 cm (fig. 1a). Organic remains occur in variable amounts from 4,2% -15,6%. Maximum amounts of organic remains were counted in the upper horizon (15,5%) and in 512 cm core depth (10,2%).

Heavy minerals occur in variable amounts from 10,5%-26,0%. In the heavy mineral fraction, pyroxenes are dominant (23-60%). At 212 cm, garnet is dominant (40%). Other heavy minerals present are amphibols, black ores and opaque. Amounts of amphiboles vary from 11% to 18%. Black ores occur in variable amounts from 5% to 37,5%. At 412 cm the heavy mineral fraction consists of 37,5% black ores as the most dominant component (fig. 4.4.1.b).

a)

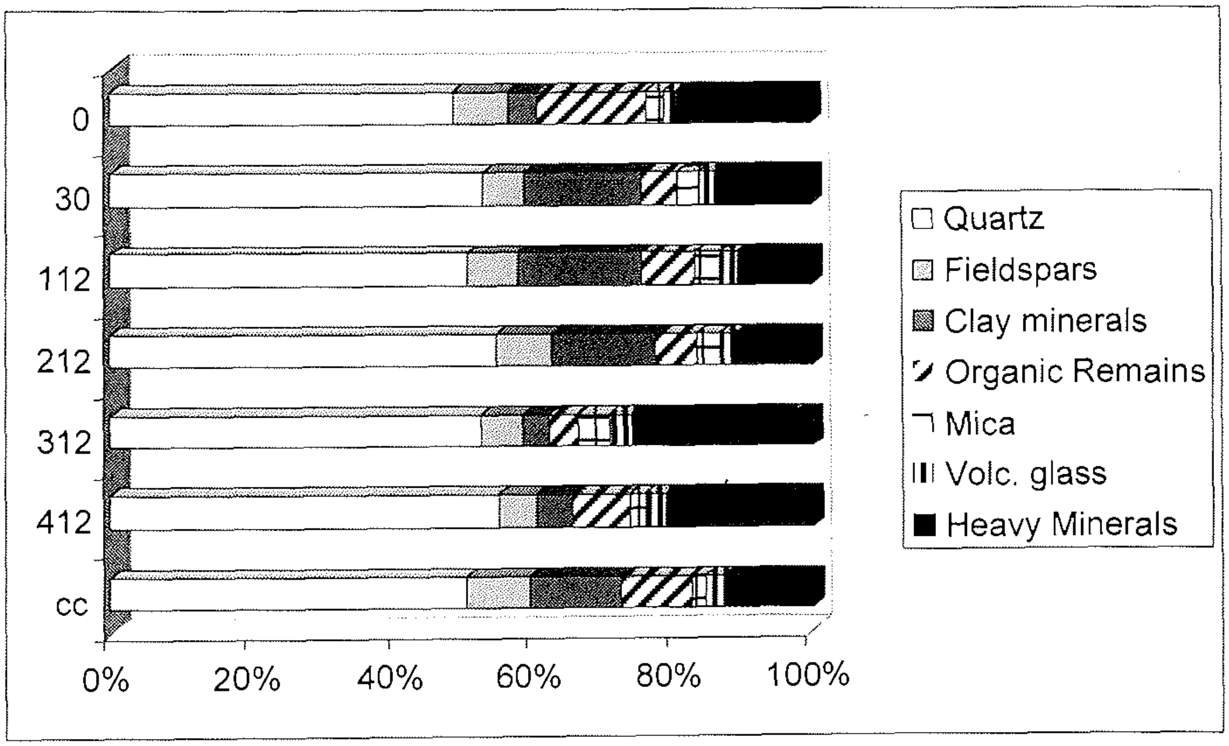


Fig. 4.4.1: Bulk (a) and heavy

b)

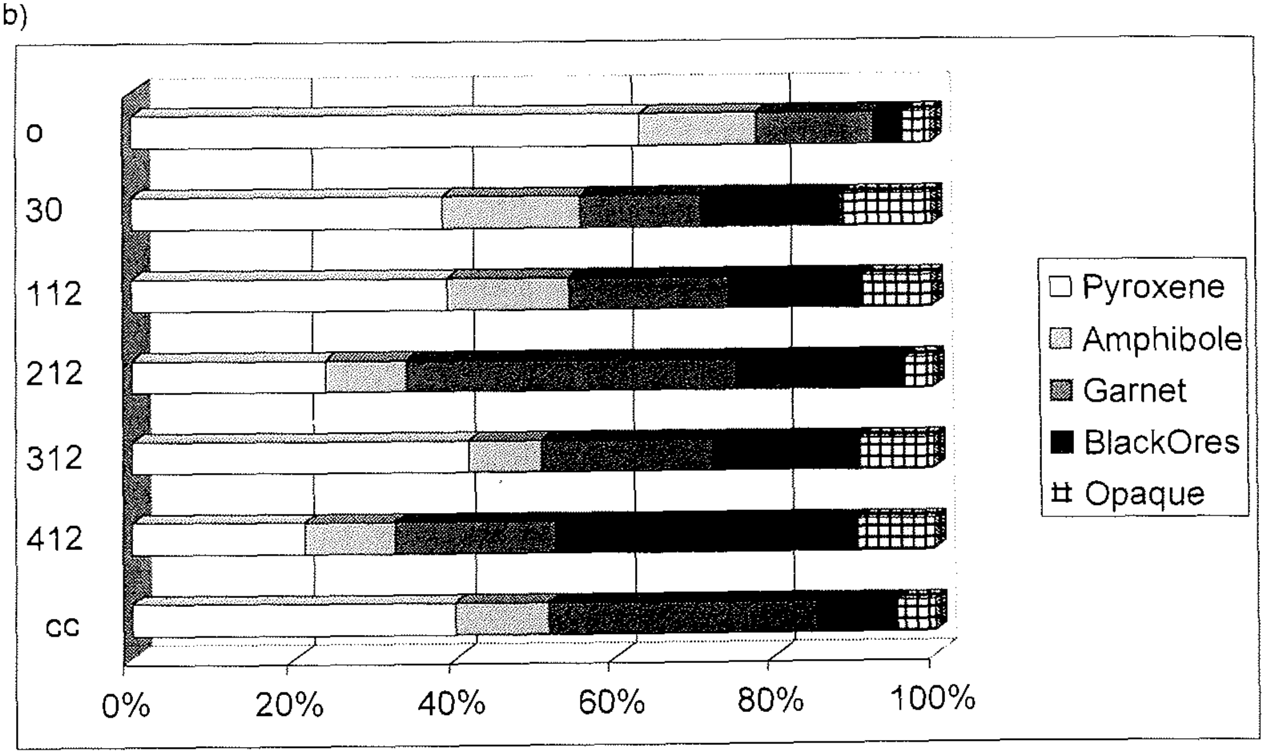


Fig. 4.4.1: (b) mineralogy of sediments from gravity core PS57/107-2, based on smear-slide counts

Tab. 4.4.1: List of multicorer samples from the expedition ARK-XVI/1 RV „POLARSTERN"

PS57/002-2	0-1	MUC
PS57/002-2	1-2	MUC
PS57/002-2	2-3	MUC
PS57/002-2	3-4	MUC
PS57/002-2	4-5	MUC
PS57/066-1	0-1	MUC
PS57/066-1	1-2	MUC
PS57/066-1	2-3	MUC
PS57/066-1	3-4	MUC
PS57/066-1	4-5	MUC
PS57/066-1	5-6	MUC
PS57/066-1	6-7	MUC
PS57/066-1	7-8	MUC
PS57/066-1	8-9	MUC
PS57/066-1	9-10	MUC
PS57/066-1	10-11	MUC
PS57/066-1	11-12	MUC
PS57/066-1	12-13	MUC
PS57/066-1	13-14	MUC
PS57/066-1	14-15	MUC
PS57/066-1	15-16	MUC
PS57/066-1	16-17	MUC
PS57/066-1	17-18	MUC
PS57/066-1	18-19	MUC
PS57/066-1	19-20	MUC
PS57/066-1	20-21	MUC
PS57/066-1	21-22	MUC
PS57/066-1	22-23	MUC
PS57/066-1	23-24	MUC
PS57/066-1	24-25	MUC
PS57/066-1	25-26	MUC
PS57/066-1	26-27	MUC
PS57/070-1	0-1	MUC
PS57/070-1	1-2	MUC
PS57/070-1	2-3	MUC
PS57/070-1	3-4	MUC
PS57/070-1	4-5	MUC
PS57/070-1	5-6	MUC
PS57/070-1	6-7	MUC
PS57/070-1	7-8	MUC
PS57/070-1	8-9	MUC
PS57/070-1	9-10	MUC
PS57/070-1	10-11	MUC
PS57/070-1	11-12	MUC
PS57/070-1	12-13	MUC
PS57/070-1	13-14	MUC
PS57/070-1	14-15	MUC
PS57/070-1	15-16	MUC
PS57/070-1	16-17	MUC
PS57/070-1	17-18	MUC
PS57/070-1	18-19	MUC
PS57/070-1	19-20	MUC
PS57/070-1	20-21	MUC
PS57/070-1	21-22	MUC

PS57/070-1	22-23	MUC
PS57/070-1	23-24	MUC
PS57/070-1	24-25	MUC
PS57/070-1	25-26	MUC
PS57/070-1	26-27	MUC
PS57/070-1	27-28	MUC
PS57/070-1	28-29	MUC
PS57/070-1	29-30	MUC
PS57/070-1	30-31	MUC
PS57/070-1	31-32	MUC
PS57/070-1	32-33	MUC
PS57/070-1	33-34	MUC
PS57/070-1	34-35	MUC
PS57/070-1	35-36	MUC
PS57/070-1	36-37	MUC
PS57/070-1	37-38	MUC
PS57/072-1	0-1	MUC
PS57/072-1	1-2	MUC
PS57/072-1	2-3	MUC
PS57/072-1	3-4	MUC
PS57/072-1	4-5	MUC
PS57/072-1	5-6	MUC
PS57/072-1	6-7	MUC
PS57/072-1	7-8	MUC
PS57/072-1	8-9	MUC
PS57/072-1	9-10	MUC
PS57/072-1	10-11	MUC
PS57/072-1	11-12	MUC
PS57/072-1	12-13	MUC
PS57/072-1	13-14	MUC
PS57/072-1	14-15	MUC
PS57/072-1	15-16	MUC
PS57/072-1	16-17	MUC
PS57/072-1	17-18	MUC
PS57/072-1	18-19	MUC
PS57/072-1	19-20	MUC
PS57/072-1	20-21	MUC
PS57/072-1	21-22	MUC
PS57/072-1	22-23	MUC
PS57/072-1	23-24	MUC
PS57/072-1	24-25	MUC
PS57/072-1	25-26	MUC
PS57/072-1	26-27	MUC
PS57/072-1	27-28	MUC
PS57/072-1	28-29	MUC
PS57/072-1	29-30	MUC
PS57/072-1	30-31	MUC
PS57/072-1	31-32	MUC
PS57/072-1	32-33	MUC
PS57/072-1	33-34	MUC
PS57/072-1	34-35	MUC
PS57/072-1	35-36	MUC
PS57/076-1	0-1	MUC

PS57/076-1	1-2	MUC
PS57/076-1	2-3	MUC
PS57/076-1	3-4	MUC
PS57/076-1	4-5	MUC
PS57/077-1	0-1	MUC
PS57/077-1	1-2	MUC
PS57/077-1	2-3	MUC
PS57/077-1	3-4	MUC
PS57/077-1	4-5	MUC
PS57/078-1	0-1	MUC
PS57/078-1	1-2	MUC
PS57/078-1	2-3	MUC
PS57/078-1	3-4	MUC
PS57/078-1	4-5	MUC
PS57/080-1	0-1	MUC
PS57/080-1	1-2	MUC
PS57/080-1	2-3	MUC
PS57/080-1	3-4	MUC
PS57/080-1	4-5	MUC
PS57/082-1	0-1	MUC
PS57/082-1	1-2	MUC
PS57/082-1	2-3	
PS57/082-1	3-4	
PS57/082-1	4-5	
PS57/083-1	0-1	MUC
PS57/083-1	1-2	MUC
PS57/083-1	2-3	MUC
PS57/083-1	3-4	MUC
PS57/083-1	4-5	MUC
PS57/084-1	0-1	MUC
PS57/084-1	1-2	MUC
PS57/084-1	2-3	MUC
PS57/084-1	3-4	MUC
PS57/084-1	4-5	MUC
PS57/085-1	0-1	MUC
PS57/085-1	1-2	MUC
PS57/085-1	2-3	MUC
PS57/085-1	3-4	MUC
PS57/085-1	4-5	MUC
PS57/086-1	0-1	MUC
PS57/086-1	1-2	MUC
PS57/086-1	2-3	MUC
PS57/086-1	3-4	MUC
PS57/086-1	4-5	MUC
PS57/087-1	0-1	MUC
PS57/087-1	1-2	MUC

PS57/087-1	2-3	MUC
PS57/087-1	3-4	MUC
PS57/087-1	4-5	MUC
PS57/088-1	0-1	MUC
PS57/088-1	1-2	MUC
PS57/088-1	2-3	MUC
PS57/088-1	3-4	MUC
PS57/088-1	4-5	MUC
PS57/090-1	0-1	MUC
PS57/090-1	1-2	MUC
PS57/090-1	2-3	MUC
PS57/090-1	3-4	MUC
PS57/090-1	4-5	MUC
PS57/091-1	0-1	MUC
PS57/091-1	1-2	MUC
PS57/091-1	2-3	MUC
PS57/091-1	3-4	MUC
PS57/091-1	4-5	MUC
PS57/092-1	0-1	MUC
PS57/092-1	1-2	MUC
PS57/092-1	2-3	MUC
PS57/092-1	3-4	MUC
PS57/092-1	4-5	MUC
PS57/093-1	0-1	MUC
PS57/093-1	1-2	MUC
PS57/093-1	2-3	MUC
PS57/093-1	3-4	MUC
PS57/093-1	4-5	MUC
PS57/097-1	0-1	MUC
PS57/097-1	1-2	MUC
PS57/097-1	2-3	MUC
PS57/097-1	3-4	MUC
PS57/097-1	4-5	MUC
PS57/098-1	0-1	MUC
PS57/098-1	1-2	MUC
PS57/098-1	2-3	MUC
PS57/098-1	3-4	MUC
PS57/098-1	4-5	MUC
PS57/099-1	0-1	MUC
PS57/099-1	1-2	MUC
PS57/099-1	2-3	MUC
PS57/099-1	3-4	MUC
PS57/099-1	4-5	MUC
PS57/100-1	0-1	MUC
PS57/100-1	1-2	MUC
PS57/100-1	2-3	MUC
PS57/100-1	3-4	MUC

PS57/100-1	4-5	MUC
PS57/101-1	0-1	MUC
PS57/101-1	1-2	MUC
PS57/101-1	2-3	MUC
PS57/101-1	3-4	MUC
PS57/101-1	4-5	MUC
PS57/101-1	0-1	MUC
PS57/101-1	1-2	MUC
PS57/101-1	2-3	MUC
PS57/101-1	3-4	MUC
PS57/101-1	4-5	MUC
PS57/104-3	0-1	MUC
PS57/104-3	1-2	MUC
PS57/104-3	2-3	MUC
PS57/104-3	3-4	MUC

PS57/104-3	4-5	MUC
PS57/105-1	0-1	MUC
PS57/105-1	1-2	MUC
PS57/105-1	2-3	MUC
PS57/105-1	3-4	MUC
PS57/105-1	4-5	MUC
PS57/127-1	0-1	MUC
PS57/127-1	1-2	MUC
PS57/127-1	2-3	MUC
PS57/127-1	3-4	MUC
PS57/127-1	4-5	MUC
PS57/130-1	0-5	MUC
PS57/094-2	0-1	GKG
PS57/104-1	0-1	GKG

Tab. 4.4.2: Bulk (a) and heavy (b) mineralogy of sediments from gravity core PS57/107-2, based on smear-slide counts

Depth-core, cm	Quartz	Feld-spars	Clay miner-als	Organic Remains	Mica	Volc. glass	Pyrox-ene	Amphi-bole	Garnet	Black Ores	Opaque
cc	50,1	9,4	13,	10,2	2,1	2,4	5,1	1,5	4,3	1,3	0,6
412	55,1	5,2	5,2	8,2	2,5	2,6	4,5	2,4	4,2	8,1	2
312	52,3	6,1	4	4,2	4,2	3,2	10,8	2,4	5,6	4,8	2,4
212	54,5	8,2	14,9	6,1	3,1	2,3	2,6	1,1	4,5	2,3	0,4
112	50,6	7,3	18	7,6	3,6	2,4	4,1	1,6	2,1	1,8	0,9
30	52,6	6,3	16,7	5,3	3,2	2,1	5,3	2,4	2,1	2,4	1,6
0	48,4	8	4,3	15,6	2,5	2,1	12,1	2,8	2,8	0,7	0,7

4.4.3 HIGH-RESOLUTION RECONSTRUCTIONS OF HOLOCENE WARM WATER INFLOW INTO THE EASTERN ARCTIC OCEAN

(D. Birgel, J. Matthiessen, S. Daschner, C. Kierdorf, N. Koukina, U. Langrock, J. Vernaleken)

In the eastern Fram Strait along the Spitsbergen continental slope, surface sediments were collected from fjord, shelf and slope environments in order to study the variability of organic geochemical parameters with respect to surface water mass conditions, plankton productivity and input of terrestrial organic matter. These data will be used to interpret high-resolution Holocene and Late Glacial organic geochemical records located along the path of the warm water inflow into the Eastern Arctic Ocean through Fram Strait. A more detailed description of the programme will be given in the cruise report of ARKXVI/2.

4.5 BENTHIC DISTRIBUTION PATTERNS AND TURNOVER PROCESSES

4.5.1 BACTERIA AND MEIOFAUNA

(C. Hasemann, N. Queric, M. Weber)

Channel systems characterising the east Greenland continental rise are dynamic areas with varying particle-loaded current patterns. We hypothesise that the distribution as well as the activity of small benthic organisms are corresponding to the topographic and biochemical features of such systems in terms of depth and distance to the channel center area. Benthic microbial processes are suspected to be directly connected to the occurrence of meio- and macrofaunal organisms.

Sampling was performed by using a multicorer sampling system allowing the investigation of an undisturbed sediment surface. The sampling programme for the cruise ARK XVI/1 was divided into two main topics of large-scale heterogeneity. For questioning of depth-related distribution patterns of benthic bacteria and meiofauna we followed a 500m-step transect downwards the continental slope off east Greenland towards the channel system. A crosswise profile along the channel was also investigated to compare three different regions of the channel course. A total of 19 stations at this channel system were sampled within this project. Subsamples for faunistic investigations and for biochemical analyses were taken using 5 ml and 20 ml syringes with cut off ends. Subsamples were sectioned horizontally in 1 cm-layers and analysed separately to investigate gradients within the sediment column.

The parameters which are suspected to follow a gradient are mainly abundance, diversity and activity of bacteria and meiofauna, as well as the biogenic sediment composition (see table 4.5.1).

Bacterial production was measured via labelled leucine incorporation. To evaluate microbial exoenzymatic activities, esterase turnover rates were determined with the fluorogenic substrates fluorescein-di-acetate (FDA). Sediment samples were preserved for later investigations in the home laboratory. Their sediment-bound chloroplastic pigment equivalents (CPE) will be determined to quantify organic matter input from primary production. Analyses of phospolipids and proteins will contribute to the assessment of living organisms and the proportion of detrital organic matter in the sediments.

Table 4.5.1

Parameter	Station PS 57/																		
	66	67	68	69	70	72	76	77	80	82	83	85	86	87	94	95	102	104	105
CPE	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
Proteine	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
FDA				x	x	x			x				x	x	x	x	x	x	x
Extra	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
H2O	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
Lipide	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x

Meiofauna	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
(Diversität/ Abundanz)																			
Bakterien	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
(Diversität/ Abundanz)																			
Bakterien													x		x		x	x	x
Bakterien (Produktion)		x		x	x	x			x	x			x		x	x	x	x	x

4.5.2 MEGA-/EPIFAUNA

(K. v. Juterzenka, F. Kulescha)

The Mega-/Epifauna in the vicinity of the channel system was observed by means of the Ocean Floor Observation System (OFOS), which is suitable for seafloor imaging in water depth down to 6000 m. The OFOS frame is equipped with a still camera (Benthos), a black-and white video camera (Deep- Sea Power & Light), two floodlights with 250 W each, flashes (600 WS) and three laser pointers in a fixed distance of 40 cm from each other as a size reference. The still camera was triggered on command or timer-controlled in 30s intervals and was loaded with Kodak Ectachrome 100 ASA film, providing up to 800 shots per deployment. The whole system was towed across the seafloor in a distance of approx. 1.50 m with a drift velocity of approx. 0.5 knots. The distance to the bottom has to be controlled by the winch operator according to the video display.

During the cruise 8 OFOS transects had been performed. At St. 02, a first survey was carried out at the continental slope off Bear Island during which adjustments were made to optimise the distance to the seafloor, camera specifications, timer-controlled operation and to check laser performance. During this first transect, the distance to the seafloor was about 3 m. Seven transects were occupied in the main investigation area off East Greenland on stations 71, 81, 89, 96, 106 in a direction across the "ARKTIEF" channel where they followed the course of the channel on stations 85 and 103 (compare fig. 4.2.1). After investigating the section of the channel which had been studied in 1999 by the ROV "VICTOR6000" and after sediment sampling at stations 71, 81, 85, a second area for detailed studies had been selected based on HYDROSWEEP information and PARASOUND profiles at the proposeq origin of the channel at the continental slope (St. 89, 96, 103). A single transect was performed across the channel between section "1" and "2" (St. 106). In the course of the transects, multicorer samples had been taken inside and outside of the channel to analyse small biota (see above).

The obtained photo and video material consists of approx. 42 hours of video and approx. 5800 colour slides. Image analysis will be done at the home institute. A first impression of the benthos fauna in the vicinity of the channel system is given by video information and short series of colour pictures, which were developed on board for quality control reasons. Seafloor images revealed two species of holothurians (Elpidia glacialis and a second elpidiid species), asteroids, ophiuroids, stalked filter feeders (probably Pennatulacea, Umbellula sp., Crinoidea), actinaria, gastropods, small pantopods, and shrimps. The irregular echinoid Pourtalesia jeffreysi could be observed together with its tracks at the sediment surface. Some ball-shaped sediment-coloured and bright structures are thought to represent several species of deep-sea sponges (c.f. Thenea abyssorum, Tentorium c.f. suberites) which had been found on the surface of sediment cores in the area as well. Small pieces of solid substrate (e.g. dropstones) are colonised by anthozoans. At least two fish species could be observed during the transects.

Transects across the channel covered at least the bottom of the channel, slope and the adjacent seafloor (water depth about 3000 - 3200m; transect length 2 to 3 nm). The flat bottom section of the channel in both areas seemed to show a more dense colonisation by megafaunal organisms which are big enough or produce burrows and traces to be recognised by means of the b/w video. At the westernmost station 89 at the slope foot (water depth about 2800), where the "channel" had a less pronounced profile and appeared as a wide depression, the seafloor seemed to be more densely colonised and the megafaunal community seemed to be more diverse. During the first hour of the OFOS transect (covering approx. 0.5 nm), at least ten fish specimens could be detected. In the vicinity of the southern slope of the channel at section "2" occurred a structure that looked like a dense aggregation of clams. These impressions have to be confirmed by a detailed image analysis of the still photographs. However, this area seems to be a suitable region for further detailed studies of deep-sea gradients.

The results of quantitative and qualitative evaluation of bacteria, meiofauna and epi-/megafaunal organisms will contribute to the knowledge on the habitat heterogenity, distribution patterns, as well as biomass and activity patterns of benthos communities in channel systems in the deep Greenland Sea.

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ANNEX 5.1 PARTICIPANTS

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2.	Adam	Susanne	Uni Oldenburg
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7.	Chiaventone	Birgit	AWI
8.	Damm	Ellen	AWI
9.	Deckelmann	Holger	AWI Potsdam
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11.	Fencker	Kale	GSDG
12.	Hasemann	Christiane	AWI
13.	Hartmann	Carmen	AWI
14.	Hoheisel-Huxmann	Reinhard	DSM Brhv.
15.	Juterzenka	Karen von	
16.	Kierdorf	Christop	AWI
17.	Köhler	Herbert	DWD
18.	Koukina	Natalja	MMBI/RAS
19.	Kulescha	Friedhelm	Oktopus
20.	Lakaschus	Sönke	AWI
21.	Langrock	Uwe	AWI
22.	Larionov	Victor	MMBI/RAS
23.	Matthiessen	Jens	AWI
24.	Plugge	Rainer	AWI
25.	Pols	Hans-Arnold	AWI
26.	Queric	Nadia Valerie	AWI
27.	Ronski	Stephanie	AWI
28.	Stürcken-Rodewald	Marthi	AWI
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30.	Terbrüggen	Anja	AWI
31.	Vernaleken	Jutta	AWI
32.	Weber	Melanie	AWI
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34.	Zeeb	Dorte	GSDG
35.	Daschner	Stefan	

ANNEX 5.2

SCHIFFSBESATZUNG / SHIP'S CREW ARK XVI/1 AND 2

1.	Master	Dr. Boche, Martin
2.	1. Offic	Schwarze, Stefan
3.	Ch.Eng.	Pluder, Andreas
4.	2. Offic	Thieme, Wolfgang
5.	2. Offic	Fallei, Holger
6.	2. Offic	Spielke, Steffen
7.	Doctor	Walther, Anke
8.	R. Offic	Koch, Georg
9.	1. Eng	Erreth, Mon.Gyula
10.	2. Eng	Ziemann, Olaf
11.	3. Eng	Richter, Frank
12.	Electron.	Bretfeld, Holger
13.	Electron.	Muhle, Helmut
14.	Electron.	Greitemann-Hackl, A.
15.	Electron.	Roschinsky, Jorg
16.	Electr.	Muhle, Heiko
17.	Boatsw.	Clasen, Burkhard
18.	Carpenter	Reise, Lutz
19.	A. B.	Gil Iglesias, Luis
20.	A. B.	Pousada, Martinez, S.
21.	A. B	Kreis, Reinhard
22.	A. B.	Schultz, Ottomar
23.	A. B	Burzan, G. Ekkehard
24.	A. B.	Schröder, Norbert
25.	Trainee	Leason, Robin
26.	Trainee	Henninga, Claus
27.	Starek.	Preußner, Jörg
28.	Mot-man	Ipsen, Michael
29.	Mot-man	Voy, Bernd
30.	Mot-man	Grafe, Jens
31.	Mot-man	Hartmann, Ernst-Uwe
32.	Mot-man	Elsner, Klaus
33.	Cook	Haubold, Wolfgang
34.	Cooksmate	Völske, Thomas
35.	Cooksmate	Siiinski, Frank
36.	Cooksmate	Möller, Wolfgang
37.	1. Stwdess	Jürgens, Monika
38.	Stwdss/KS	Wöckener, Martina
39.	2. Stwdess	Czyborra, Bärbel
40.	2. Stwdess	Silinski, Carmen
41.	2. Stwdess	Neves, Alexandre
42.	2. Steward	Huang, Wu-Mei
43.	Laundrym.	Yu, Kwok, Yuen
44.	Apprentice	Kruse, Lars
45.	Apprentice	Wanke, Steffen

ANNEX 5.3 STATION LIST (see data files)

ARK XVI/2

30.07. -26.08.2000
Longyearbyen - Bremerhaven

FAHRTLEITER/CHIEF SCIENTIST
Ursula Schauer

KOORDINATOR/CO-ORDINATOR
Wolfgang Arntz

CONTENTS

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Der Fahrtabschnitt ARK XVI/2 führte in den nördlichen Teil des Europäischen Nordmeers, in die Framstrasse, für physikalische, biologische und geologische Arbeiten und Untersuchungen des Ökosystems Meereis (Abb. 1). Die Arbeiten konzentrierten sich auf einen Schnitt entlang 79°N von Spitzbergen bis Grönland, auf den Westhang des Yermakplateaus, das Molloytief und ein Gebiet östlich davon, das 1999 auf der Polarsternreise ARKXV/1 mil dem ROV (Remote Operating Vehicle) "VICTOR 6000" untersucht warden war (Krause, 1999 Cruise Report ARRKXV/1, Reports on Polar Research 339, 1999) und seitdem vom AWI als sogenannter "Hausgarten" für biologischen Langzeituntersuchungen genutzt wird.

Das Europaische Nordmeer und das Nordpolarmeer stellen ein System von Becken dar, die miteinander in Austausch stehen; die tiefste Verbindung dafür ist die Framstraße Aus dem Atlantik wird warmes, salzreiches Wasser in das Arktische Mittelmeer geführt und dart durch Wärmeabgabe und Eisbildung umgewandelt. Die umgewandelten Wassermassen werden im Ostgrönlandstrom nach Süden transportiert und leisten einen erheblichen Beitrag zur Erneuerung des Tiefenwassers des Weltmeeres. Entlang von 79°N wurden auf unserer Reise zum dritten Mal 14 ozeanographische Langzeitverankerungen ausgetauscht, die dazu dienen, über mehrere Jahre kontinuierliche Meßzeitreihen des Wasser-, Wärme- und Salzaustausches zwischen dem Nordpolarmeer und dem europäichen Nordmeer zu erhalten. Zusätzlich wurden hier in hoher horizontaler Auflösung Temperatur und Salzgehalt mil einer CTD-Sonde (Conductivity, Temperature, Depth) gemessen. Mil Großwasserschopfern wurden an ausgewählten Positionen Proben für die Bestimmung des Gehalts und der Zusammensetzung an künstlichen Radionu.kliden genommen, die aus Einleitungen und Fallout von europäischen Kernenergieanlagen stammen und die so als Spurenstoffe benutzt werden können, um die Ausbreitung von Wassermassen zu verfolgen.

Mit zwei neu entwickelten Landersystemen wurden im AWI-"Hausgartengebiet" erstmals mehrtägige Respirations- und Köderexperimente auf dem Tiefseeboden der Arktis durchgeführt. Die Experimente wurden durch Kastengreifer- und Multicorerprofile von der Schelfkante bis in das Molloytief sowie durch bodennahe Netzfange ergänzt. Die Rolle von Bryozoen im benthischen Oekosystem der Arktis ist weitgehend unbekannt und wurde anhand von Fängen auf dem Ostgrönlandschelf untersucht. Geologische Arbeiten dienten der Rekonstruktion von paleoklimatischen Parametern und den Umweltbedingungen in der Arktis im Spätquartär. Das Yermakplateau bietet durch seine hohe Sedi- mentationsrate und die damit verknüpfte hohe zeitliche Auflösung des Holozäns und des Eem- lnterglazials hervorragende Bedingungen, so daß dart nach vorangehenden Parasoundunter- suchungen mit dem Schwerelot 8 Sedimentkerne von bis zu 1O m Länge gezogen werden konnten.

Aul 4 Eisstationen vom Schiff aus wurden biologische Prozesse in und unter dem Eis auf verschiedenen zeitlichen und räumlichen Skalen untersucht und die auf dem Eis abgelagerten Sedimente beprobt. Mit Hubschraubereinsätzen konnten diese Programme durch weitere Eisbohrungen ergänzt werden. Ein mikrobielles Programm konzentrierte sich einerseits auf bakterielle Aktivitaten im Meereis und in seinen Schmelztumpeln, als auch auf die bakterielle Struktur der arktischen Tiefsee und Sedimentoberfläche, die entsprechend durch Wasser- und Sedimentproben analysiert wurde. Arktisches Meereis enthalt z.T. große Mengen an feinkörnigen Sedimenteinschlüssen aus den nordamerikanischen und sibirischen Schelfmeeren, die dart durch turbulente Prozesse während der Eiskristallbildung in das Meereis eingebunden werden. Das inkorporierte Material wird aus den Schelfmeeren exportiert und trägt somit bedeutend zum Sedimentbudget des Nordpolarmeeres und des Nordatlantiks bei. Die Meereissedimente enthalten zum Teil deutlich erhöhte Konzentrationen künstlicher Radionuklide, möglicherweise aus der Kara- und Laptevsee. Sedimentproben im Eis wurden gewonnen, um das Vorhandensein von Partikeln aus dem Meereis in den Ablationsgebieten der Barentssee und der östlichen Framstraße zu untersuchen.

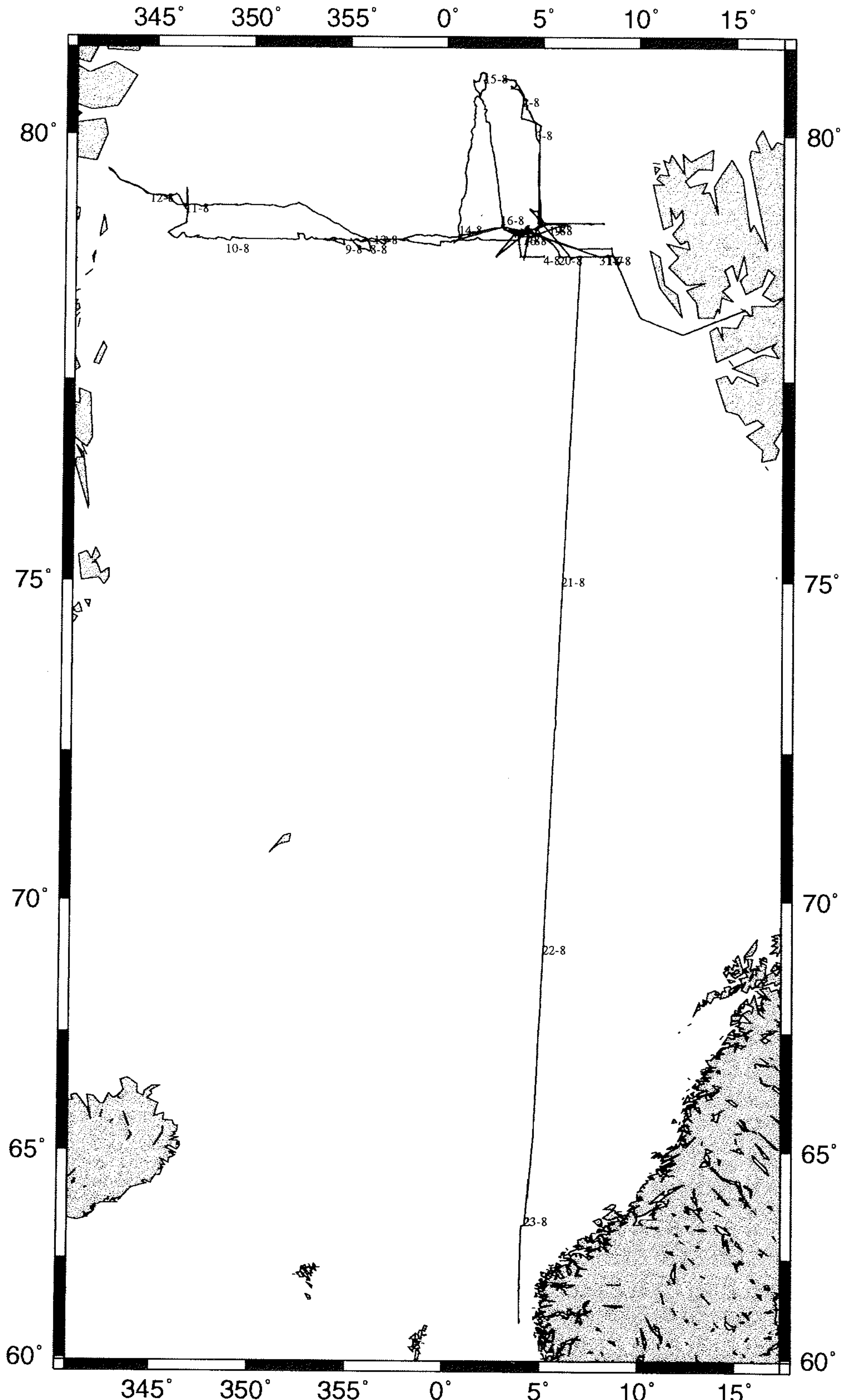
Zur Verbesserung von Strahlungsmodellen muss die regionale Verteilung des Absorbtionsspektrums bekannt sein. Die Kenntnis ist besonders in polaren Gebieten sehr lückenhaft. Dazu wurden bei geeignetem Wetter die Globalstrahlung und die direkte Sonneneinstrahlung vom Peildeck aus gemessen.

Die Reise begann am 30. August 2000 in Longyearbyen auf Spitzbergen (Abb. 1). Bei 78° 50'N wurden zunächst 5 Verankerungen aufgenommen. In den folgenden Tagen konnten wir am Westhang des Yermakplateaus nördlich von 80°N in weitgehend eisfreiem Wasser einen Großteil der geologischen Arbeiten absolvieren, Dennoch war die Eisgrenze nahe genug, um auch eine erste Eisstation durchzuführen. In der zweiten Wochenhälfte waren beide Lander einsatzbereit und konnten zusammen mit drei mit Ködern besetzte Reusen im Hausgarten für zwei Tage ausgesetzt werden. Die Lander konnten auf Anhieb wieder geborgen werden, aber die Reusen tauchten auch nach mehrfachen Auslbseversuchen nicht wieder auf, obwohl sie am Boden einwandfrei geortet werden konnten.

In der zweiten Woche verlierßen wir das Hausartengebiet in Richtung Westen, um auf 79° die Aufnahme von Verankerungen und die Hydrographie fortzusetzen und eine weitere intensive Eisstation durchzuführen. Ähnlich wie im vergangenen Jahr war im Sommer 2000 die Eisbedeckung in der Framstraße gering. Diese Situation erlaubte es, die hydrographischen Arbeiten bis weit auf den ostgrönlandischen Schelf fortzusetzen; erst bei 14°30'W stießen wir an die Festeisgrenze, die natürlich für eine dritte Eisstation genutzt wurde. Die Eiskarte des Norwegian Meteorological Institute zeigte auf 79°30'N eine Polynya, die es uns erlaubte, nördlich der 1999 auf einer Polarsternreise entdeckten Tobiasinsel bis zum Kap Anna Bistrup an der Küste Gronlands vorzudringen. Über die gesamte Schelfbreite wurden auf dem Hinweg in engem Abstand CTD-Stationen gefahren und auf dem Rückweg 10 Agassiz-Trawls auf der Suche nach Bryozoen genommen, z. Tl. an Positionen mit bekannten Vorkommen.

Östlich der Schelfkante arbeiteten wir uns wieder mil Verankerungsarbeiten nach Osten vor, bis Anfang der dritten Woche einer der Lander in 5500 m Tiefe im Molloy Deep ausgesetzt wurde. Die Zeit bis zu seiner Wiederaufnahme wurde für den Versuch genutzt, eine Geologieposition auf 81°30'N anzufahren. Dieser Versuch mußte jedoch auf 80°30'N bei 100-prozentiger Eisbedeckung aufgegeben werden. Da hier besonders viel Sediment auf und in dem Eis war, wurde die Gelegenheit für die letzte mehrstündige Eisstation genutzt. Nachdem wir das Eis endgultig verlassen hatten, wurden der Lander im Molloytief geborgen und benthologische Arbeiten dort mil Kastengreifer und Multicorer, sowie für mikrobiologische Arbeiten mil der Rosette fortgesetzt. Um der Frage nachzugehen, inwieweit der Verlust der Reusen auf ein Versagen der akustischen Auslöser zurückzuführen war und um gegebenenfalls dem Verlust weiterer Verankerungen vorzubeugen, wurde eine Testverankerung mil 6 gleichartigen Auslösern für zwei Tage ausgebracht. Zurn Ende der dritten Woche wurden beide Lander ein letztes Mal für 48 Stunden im Hausgartengebiet ausgesetzt und durch weitere benthologische Arbeiten ergänzt. Auf einer Position mil besonders gunstigen Sedimentablagerungen, auf der wir im ersten Teil der Reise ein Schwerelot mit 10-m-Rohr eingesetzt hatten, versuchten wir mit Erfolg, eine Erweiterung um ein paar Meter und damit einige zehntausend Jahre Ablagerungsgeschichte zu erbeuten. Bis zur Aufnahme der Lander und der Testverankerung wurden weitere ozeanographische Verankerungen auf 78° 50'N im Bereich des Westspitzbergenstromes ausgesetzt. Im Kern der nordwärts setzenden Strömung wurden mit Grosswasserschöpfern Proben für die Radionuklidmessungen genommen. Nach der erfolgreichen Aufnahme der Lander und der Testverankerung ging die Arbeit im Hausgarten mil dem Ausbringen einer biologischen Langzeitverankerung zu Ende.

Mit dem Auslegen der letzten Langzeitverankerungen vor Spitzbergen schlossen wir am 20. August die Forschungsarbeiten ab. Auf dem Heimweg wurden Mitarbeiter des Germanischen Lloyds eingeflogen, die in der Nordsee das Abgas von POLARSTERN beprobten. POLARSTERN kehrte am 26. August nach Bremerhaven zurück. Tabelle 1 gibt eine Übersicht über die durchgeführten Arbeiten.



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11-8
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14-8
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4-8
20-8
21-8
22-8
23-8

Tabelle 1/Table 1

List of Station work

11	Agassiz Trawls
5	Epibenthos sledges
3	deployments of food falls
5	deployments and recoveries of landers
13	Box cores
15	Multi-cores
4	Ice stations
2	Rectangular Midwater Trawls
11	Multi-nets
2	Bongo nets
12	moorings recovered
16	moorings deployed
67	CTD stations
3	Gerard Bottle stations
8	gravity cores

ITINERARY AND SUMMARY

The "POLARSTERN-cruise ARK XVI/2 took place in Fram Strait in the northern part of the Nordic Seas (Fig. 1) to carry out physical and biological oceanography investigations as well as geological work and studies of the sea ice ecosystem. Work was done along a section at about 79°N between Spitsbergen and Greenland, at the western slope of the Yermak Plateau, in the Molloy Deep-and at a site east of Molloy Deep which had been investigated extensively with the ROV (Remote Operating Vehicle) "VICTOR 6000" during ARKXV/1 in 1999 (Krause, 1999) and which is used as "AWI- Hausgarten" since then.

The Fram Strait represents the only deep connection between the Arctic Ocean and the Nordic Seas. Just as the freshwater transport from the Arctic Ocean is thought to be of major influence on convection in the Nordic Seas and further south, the transport of warm and saline Atlantic water significantly affects the water mass characteristics in the Arctic Ocean and therefore possibly influences also ice and atmosphere. Since 1997, velocity and hydrography measurements were carried out to estimate heat and salt fluxes through the strait as well as fluxes of dissolved substances, and in combination with a regional model, to investigate the nature and origin of the transport fluctuations on seasonal to decadal time scales. During our cruise, for the 4th time 14 oceanographic moorings were exchanged. In addition, temperature and salinity were measured with a CTD-system in high horizontal resolution, sometimes in combination with taking water samples for the determination of radionuclide contents or microbiological studies. Enhanced values of several radionuclides in Fram Strait result from release and fallout from European nuclear power plants. They can be used to trace the spreading of water masses to which they were imprinted. To measure the contents, large volumes had to be sampled at selected key areas like the cores of the West Spitsbergen current, the East Greenland Current and the return flow of Atlantic Water in central Fram Strait.

Two newly developed Lander systems were used for the first time for respiration and food fall experiments at the deep sea bottom in the "AWI-Hausgarten". To investigate the influence of water depth on benthic life, the experiments were comprehended through box core and Multicorer samples as well as net hauls close to the bottom along a line from the shelf edge off Spitsbergen down to the Molloy Deep. The role of bryozoans in the Arctic benthic ecosystem is largely unknown. It was investigated along samples taken with the Agassiz trawl at the east Greenland Shelf. Geological work was aimed to allow reconstruction of the sea-ice cover, paleoproductivity and paleocurrents in the late Quarternary Arctic. Due to its high sedimentation rate and the related high temporal resolution, the Yermak Plateau is extremely well suited to obtain records of the Holocene and the Eemian interglacial. Supported by extensive parasound surveys, 8 sediment cores of up to 10 m length have been taken.

The multiyear ice of the Arctic Ocean constitutes a very specific ecosystem. The biological investigations addressed the qualitative and quantitative description of the community within and below the sea ice. During 4 ship based ice stations, in a multidisciplinary approach the organism biomass and abundance in different size classes were studied in relation to physical and chemical conditions. A number of additional ice flows could be investigated with the help of helicopters. Bacteria are the dominating heterotrophic component in the sea ice of polar systems. Samples of ice and under ice water were taken to give insights into which bacterial species are specific for the sympagic system and which physiological performances and processes are characteristic.

Arctic sea ice widely contains fine-grained sediments which are entrained into newly forming ice through turbulent processes like suspension freezing in the Canadian and Siberian shelf seas. The incorporated material is exported from the shelf seas thereby contributing significantly to the sedimentary budget of the Arctic Ocean and the Northern European Atlantic. The occurrence of sea ice sediments in the ablation areas of the Fram Strait was studied with regard to their biological impact and their content of radionuclides. Thereby, the radionuclide concentration of sea ice- and bottom sediments will be used to identify potential source regions and to trace transport pathways of ice.

To improve radiation models, knowledge of the regional distribution of absorbtion spectra is necessary. This knowledge is especially poor in polar seas. Therefore, at appropriate weather conditions, the global radiation and the direct solar radiation was measured.

The cruise started at 30 August in Longyearbyen, Svalbard (Fig. 1). The first operation was the recovery of 5 oceanographic moorings at 78°50'N. Ice-free waters north of 80°N at the western slope of the Yermak Plateau allowed us to carry out most of the geological program. On the other hand, the ice edge was close enough to have a first ice station of more than 10 hours. In the second half of the week, the two lander systems were ready to be deployed in the "Hausgarten", together with three food falls. After two days, the landers could be recovered whereas the food falls did not emerge although we had no problems to locate them acoustically at the sea bottom.

In the second week, we left the "Hausgarten" area towards west and continued the recovery of oceanographic moorings and hydrographic stations. Reaching the ice edge at 4°W was the occasion for a second, long ice station. Similarly, as in the previous year, the ice coverage was low in summer 2000. This situation enabled us to extend our hydrographic section along 79°N onto the East Greenland shelf; only at 14°30'W, we met the fast ice border and had a third ice station. Ice charts from the Norwegian Meteorological Institute showed a polynya at 79°30'N which allowed us to reach the Greenland coast at Cape Anna Bistrup north of the small Tobias Island which was discovered only one year ago during a POLARSTERN cruise. All across the shelf width, closely spaced CTD stations were taken, and on the way back towards east, 10 Agassiz trawls were taken searching for bryozoans. East of the shelf edge, we continued recovering and redeploying moorings, until at the beginning of the third week one of the landers was ready for deployment in the Molloy Deep at 5500 m water depth. While it was sitting at the sea floor, we tried to reach a position for sediment coring at 81°30'N. Due to 100% ice coverage already at 80°30'N, we had to give up. Since at the point of return the ice was particularly heavy covered with sediment, it was the right occasion for the last ice station. Having left the ice finally, the lander in the Molloy Deep was recovered successfully. Box core, Multicorer and Rosette samples were taken around that location.

To check whether or not the loss of the food falls was due to systematic failure of the used acoustic releaser type, a test mooring with 6 releasers was moored for several days. At the end of the third week, both landers were deployed for the last time. One geological position taken in the first week had proven to be very suitable for long cores and we tried here to obtain core longer than 10 m. We gained a couple of decimetres more than the previous core, valid a considerable extension of the paleorecord. Before recovering the landers and the test mooring, more mooring work could be done in the West Spitsbergen Current. In its core, large volume samples were taken with Gerard

Bottles for the radionuclide program. The landers and the test mooring emerged without problems and the work in the "Hausgarten" was finished with the deployment of a biological long-term mooring.

At 20 August, the field work of the cruise was terminated with the deployment of the last oceanographic moorings. On the way home, a team of technicians of the Germanischer Lloyd were brought onboard who carried out tests on the exhaust of POLARSTERN in the North Sea. POLARSTERN returned to Bremerhaven on 26 August.

See Table 1 for an overview of the station work.

Krause, G., (Ed.), 1999, Die Expedition ARKTIS XV/1, Reports on Polar Research, 339, Bremerhaven, 1999.

THE METEOROLOGICAL CONDITIONS

Behr

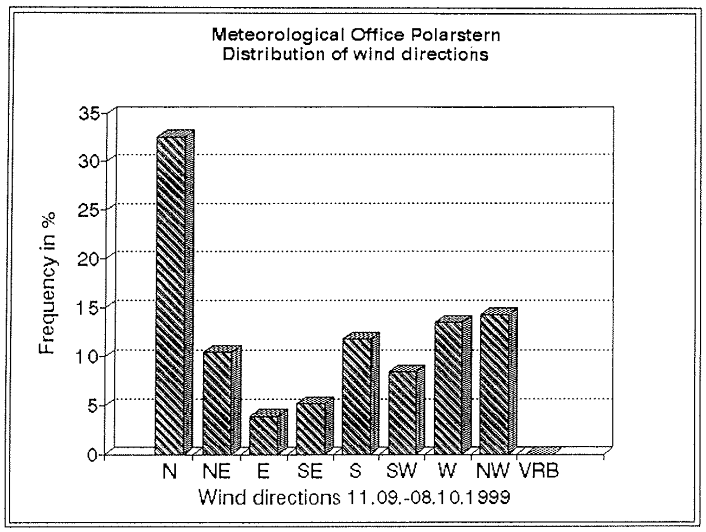
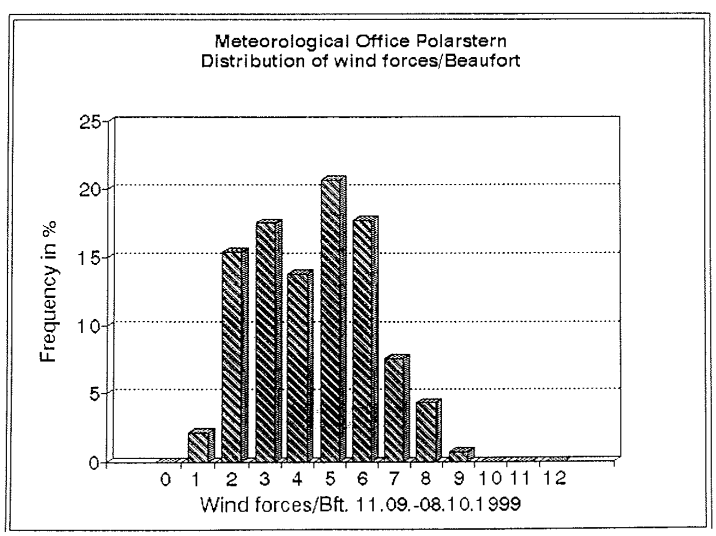


Fig. 3: Histogramm of wind direction



2. EXCHANGES THROUGH FRAM STRAIT

2.1 THE FLOW THROUGH FRAM STRAIT AND HYDROGRAPHIC CONDITIONS IN SUMMER 2000

(Eriksson, Fossan, Kruse, Langreder, Richter, Schauer, Schütt, Werft, Witte)

Exchanges between the North Atlantic and the Arctic Ocean result in the most dramatic water mass conversions in the World Ocean: warm and saline Atlantic waters, flowing through the Nordic Seas into the Arctic Ocean, are modified by cooling, freezing and melting to become shallow fresh waters, ice and saline deep waters. The outflow from the Nordic Seas to the south provides the initial driviflg of the global thermohaline circulation cell. Knowledge of these fluxes and understanding of the modification processes is a major prerequisite for the quantification of the rate of overturning within the large circulation cells of the Arctic and the Atlantic Oceans, and is also a basic requirement for understanding the role of these ocean areas in climate variability on interannual to decadal scales.

The Fram Strait represents the only deep connection between the Arctic Ocean and the Nordic Seas. Just as the freshwater transport from the Arctic Ocean is thought to be of major influence on convection in the Nordic Seas and further south, the transport of warm and saline Atlantic water significantly affects the water mass characteristics in the Arctic Ocean and therefore possibly influenc·es also ice and atmosphere. Since 1997, velocity and hydrography measurements are carried out in Fram Strait with the aim to estimate mass, heat and salt fluxes through the slrait as well as fluxes of dissolved substances; until July 2000 this was done in the framework of the European Union project "VEINS" (Variability of Exchanges in Northern Seas). In combination with regional models, the results will be used to investigate the nature and origin of the transport fluctuations on seasonal to decadal time scales.

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 parts. One part 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 part 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. Therefore, our mooring array is designed to cover the deep part of the Fram Strait from the eastern to the western shelf edge. The hydrographic work, however, was always extended as far onto the East Greenland shelf as the ice allowed.

Work at Sea

To measure time series of the current, temperature and salinity field between East Greenland and West Spitsbergen, in summer 1999, 11 moorings have been deployed across Fram Strait at 79°N, in water depths between 200 m and 2600 m (Appendix 5). All moorings were equipped with two acoustic releasers; however, all releasers responded at the first trial and all moorings were recovered successfully. The records provide the third set of year-long time series after similar arrays were moored from 1997 to 1999. Evaluation of the data sets from the first years have proved the necessity of high horizontal coverage in the central Fram Strait to capture the western extent of the West Spitsbergen Current which is highly variable in its position, and to cover the the return flow. Therefore, moorings were deployed for another year at 14 instead of only 11 locations.

The instrumentation of the moorings remained the same as in the previous years with only minor exceptions (Appendix 5). For a sufficient vertical resolution, each mooring carried 3 to 7 instruments like current meters from Aanderaa and FSI, acoustic current profilers from ROI and Aanderaa, Seacats and Microcats from Seabird, Upward

Looking Sonars from APL and CMR. Temperatures and salinities were measured together with the currents, to allow derivation of the heat and salt transports.

Hydrographic stations were conducted along the mooring line to supply temperature and salinity at a much higher spatial resolution than given through the moorings. The section was continued westward beyond the shelf edge (Fig. Station map) and, because of favourable ice conditions, could be extended up to the East Greenland coast.

We used a Seabird Electronics SBE9plus probe for the hydrographic measurements. Due to technical problems, the system and its components had to be changed various times during the cruise (Table, 2.1). The following systems and components have been used: Seabird Electronics SBE9plus probes: SN 09P16392-0485 and SN 09P7396-0287 with standard conductivity, temperature and pressure sensors, SN 03P2417 and SN 03P2423 for temperature, SN 042055 and SN 042078 for conductivity and SN 51197, SN 68997 for pressure, and in addition a Wetlabs light transmissiometer, SN CST-267 DR. The CTD was used in combination with a SBE32 Carousel Water Sampler, SN 3217673-0202, which operated 24 12-liter Ocean-Test-Equipment bottles. For determining the distance to the bottom, a mechanical bottom contact with a weight tied to a rope was used which allowed all profiles to reach the bottom within 10 m above the sea floor.

The temperature and conductivity sensors were calibrated by the manufacturer immediately before and after the cruise. According to the manufacturer, the sensor accuracy is about 1dbar for the pressure sensor, 0.001 C for the temperature sensor and 0.003mS/cm for the conductivity sensor. In addition to the lab calibration, salinity values derived from the CTD measurements were calibrated with the aid of water samples. During the cruise a total number of 571 samples were analysed with a Guildline Autosal 8400A salinometer, and IAPSO standard seawater Batch number P136, K15=0.99996. Although it was difficult to achieve stable temperature conditions for the salinometer, preliminary comparisons between sensor and bottle data indicated that the conductivity sensor measured 0.002-0.003 mS/cm too much values. As a check that the bottles were fired at the right depths, SIS Kiel electronic thermometers and pressure meters were mounted on 3 of the bottles, and their readings were recorded after each cast.

Preliminary results of the CTD survey in the Fram Strait

With the section between Svalbard and Greenland along 79°N the fourth high-resolution survey in a year to year sequence was performed (Fig. T and S section). The Atlantic Water in the West Spitsbergen Current showed similar enhanced values as it did in summer 1999 and warm water penetrated even further to the east.

Table 2.1: Modification of the CTD system during the cruise

Stn.	**Depth (CTD)**	**Cast**	**Pressure sensor**	**DeckUnit**	**Temp. Sensor**	**Cond. Sensor**	**Pump**	***.con**	**Alti-meter attached**	**Qualilty of cast/remarks**
146	251	1	68997	11P16392-0457	2417	2055	1954	ark1621	X	spikes
147	771	1	68997	11P16392-0457	2417	2055	1954	ark1621	X	spikes
148	1019	1	68997	11P16392-0457	2417	2055	1954	ark1621	X	great difference upcast and downcast
149		1	68997	11P16392-0457	2417	2055	1954	ark1621	X	great difference upcast and downcast
150	1973	1	68997	11P16392-0457	2417	2055	1954	ark1621	X	great difference upcast and downcast
155	1236	1	68997	11P16392-0457	2417	2055	1954	ark1621	X	great difference upcast and downcast
166	1470	1	68997	11P16392-0457	2417	2078	1954	ark1622	X	great difference upcast and downcast
168		1	68997	11P16392-0457	2417	2078	2253	ark1622		great difference upcast and downcast
173	2310	1	68997	11P16392-0457	2417	2078	2253	ark1622		great difference upcast and downcast
173	500	2	68997	11P16392 0457	2417	2078	2253	ark1622		great difference upcast and downcast
173	152	3	68997	11P16392-0457	2417	2078	2253	ark1622		great difference upcast and downcast
174	2638	1	51197	11P16392-0457	2417	2078	2253	ark1623		great difference upcast and downcast
176	2812	1	51197	11P16392-0457	2423	2078	2253	ark1624		spikes + great difference upcast and downcast

181	3370	1	51197	11P16392 0457	2423	2078	2253	ark1624		pump went off at 2300 m
181	3370	2	51197	11P16392-0457	2423	2078	2253	ark1624		deck unit turned off when CTD at bottom
182	3766	1	51197	11P16392 0457	2423	2078	1954	ark1624		pump off at 2700 m
183	2460	1	51197	11P16392-0457	2423	2078	1954	ark1624		pump off at 2245 m/Cable exchange of Cond. Sensor
187	2292	1	51197	11P16392-0457	2423	2055	1954	ark1625		
190	2382	1	51197	11P16392 0457	2423	2055	1954	ark1625		spikes
192	2363	1	51197	11P16392 0457	2423	2078	1954	ark1626		small spikes
193	2094	1	51197	11P16392-0457	2423	2078	1954	ark1626		small spikes
194	1424	1	51197	11P16392 0457	2423	2078	1954	ark1626		small spikes
195	1880	1	51197	11P16392 0457	2423	2078	1954	ark1626		small deviations
198	780	1	51197	11P16392-0457	2423	2055	1954	ark1625		
199	430	1	51197	11P16392 0457	2423	2055	1954	ark1625		
200	288	1	51197	11P16392 0457	2423	2055	1954	ark1625		
201	263	1	51197	11P16392 0457	2423	2055	1954	ark1625		
202	965	1	51197	11P16392-0457	2423	2055	1954	ark1625		
204	253	1	51197	11P16392-0457	2423	2055	1954	ark1625		
205	237	1	51197	11P16392-0457	2423	2055	1954	ark1625		
207	179	1	51197	11P16392 0457	2423	2055	1954	ark1625		
208	201	1	51197	11P16392-0457	2423	2055	1954	ark1625		CTD at bottom without alarm, sensors not dirty
209	144	1	51197	11P16392-0457	2423	2055	1954	ark1625		
210	240	1	51197	11P16392-0457	2423	2055	1954	ark1625		
211	208	1	51197	11P16392-0457	2423	2055	1954	ark1625		
212	242	1	51197	11P16392-0457	2423	2055	1954	ark1625		
213	293	1	51197	11P16392-0457	2423	2055	1954	ark1625		
214	300	1	51197	11P16392-0457	2423	2055	1954	ark1625		
215	131	1	51197	11P16392-0457	2423	2055	1954	ark1625		
216	238	1	51197	11P16392-0457	2423	2055	1954	ark1625		
217	183	1	51197	11P16392-0457	2423	2055	1954	ark1625		CTD at bottom without alarm, sensors not dirtv
218	145	1	51197	11P16392-0457	2423	2055	1954	ark1625		
219	184	1	51197	11P16392-0457	2423	2055	1954	ark1625		
221	155	1	51197	11P16392-0457	2423	2055	1954	ark1625		
222	91	1	51197	11P16392-0457	2423	2055	1954	ark1625		CTD at bottom without alarm, sensors not dirtv
223	65	1	51197	11P16392-0457	2423	2055	1954	ark1625		
224	116	1	51197	11P16392-0457	2423	2055	1954	ark1625		
225	172	1	51197	11P16392-0457	2423	2055	1954	ark1625		
226	151	1	51197	11P16392-0457	2423	2055	1954	ark1625		
229	90	1	51197	11P16392-0457	2423	2055	1954	ark1625		
230	90	1	51197	11P16392-0457	2423	2055	1954	ark1625		
231	59	1	51197	11P16392-0457	2423	2055	1954	ark1625		
232	38	1	51197	11P16392-0457	2423	2055	1954	ark1625		
233	142	1	51197	11P16392-0457	2423	2055	1954	ark1625		
234	237	1	51197	11P16392-0457	2423	2055	1954	ark1625		
235	214	1	51197	11P16392-0457	2423	2055	1954	ark1625		
236	286	1	51197	11P16392-0457	2423	2055	1954	ark1625		
238	105	1	51197	11P16392-0457	2417	2078	1954	ark1627		test CTD
245	2538	1	51197	11P8656-0311	2417	2078	1954	ark1627		deck unit changed (11P8656-0311), profile as before
251	5532	1	51197	11P16392-0457	2417	2078	1954	ark1627		switched back to former deck unit
260	1020	1	51197	11P16392-0457	2417	2078	1954	ark1627		
261	784	1	51197	11P16392-0457	2417	2078	1954	ark1627		
262	237	1	51197	11P16392-0457	2417	2078	1954	ark1627		
264	503	1	51197	11P16392-0457	2417	2078	1954	ark1627		
264	20	2	51197	11P16392 0457	2417	2078	1954	ark1627		
266	994	1	51197	11P16392-0457	2417	2078	1954	ark1627		
279	994	1	51197	11P16392-0457	2417	2078	1954	ark1627		
280	994	1	51197	11P16392-0457	2417	2078	1954	ark1627		

2.3 TRANSPORT OF ARTIFICIAL RADIONUCLIDES WITH OCEAN CURRENTS, SEA ICE AND PARTICULATE MATTER

(Gerland, Grøttheim)

Background

Several sources have contributed to radioactive contamination of the Arctic marine environment. According to present knowledge, the dominating sources are global fallout from previous atmospheric nuclear weapons tests, discharges from European nuclear reprocessing plants at Sellafield (UK) and La Hague (France), and fallout from the Chernobyl reactor accident (Ukraine). The atmospheric nuclear bomb tests, mainly conducted during the 1950ies and 1960ies, resulted in an injection of radioactive debris into the atmosphere, which subsequently deposited onto the ocean surface through global fallout. Global fallout has contributed to a quite uniform distribution of radionuclides in the surface mixed layers of the oceans. In contrast to this, the continuously, but fluctuating discharges from Sellafield of low level liquid effluents into the Irish Sea, transported to the Arctic with ocean currents, have created a more variable radionuclide distribution of the oceans. Parts of the Baltic and adjacent areas were heavily contaminated as a result of the Chernobyl accident in 1986. Currently, Chernobyl-derived radionuclides originate from the out-flowing surface water from the Baltic Sea, and are transported with the Norwegian Coastal Current to the Arctic. Therefore, the contribution of Chernobyl-derived radioactivity to the Arctic marine environment depends on the extent of annual river run-off and outflow from the Baltic. Other possible sources to radioactive contamination in the Arctic are nuclear installations on the Kola peninsula and in the tributaries of the Russian rivers Ob and Yenisey, handling and storage of spent nuclear fuel, and dumped radioactive waste in the Kara Sea. Radionuclides from these sources might be transported downstream into the Kara sea and subsequently across the Arctic Ocean, to the Fram Strait and the North Atlantic by ocean currents and sea ice.

Sampling

By sampling during ARK XVI-2, we aimed to study the contemporary transport of artificial radionuclides with ocean currents, sea ice and sediments from and into the Arctic Ocean by the East- Greenland Current (EGG) and West Spitsbergen Current (WSC) in the eastern part of the Fram Strait. All sampling sites for the NRPA are shown in Fig. 2.3.1.

Sea water

Our aim was to sample water for the measurement of both conservative and particle-reactive radionuclides in the water column on a sufficient number of stations along the 79°N latitude section.

Seawater was collected at 12 stations (149, 150, 155, 173, 174, 175, 192, 197, 245, 264, 266, and one location in the North Sea) using both large water samplers (Gerard-Ewing design, GWS) and a CTD sampler rosette: The maximum volume of water that was taken included 50-100 litres for determination of the conservative tracers technetium (99Tc) and iodine (1291) respectively, 200 litres for radiocaesium (137Cs + 134Cs) determination and 200 litres for determination of radioactive isotopes of the particle reactive element plutonium (Pu) were collected. A complete sampling was realized at Station 197 and 264/266. In addition to this, 200 litres seawater samples were collected for strontium (90Sr) determination at Station 264 in the WSC. At most of the water sampling stations, water was collected at four different depths, usually surface, subsurface, deep and bottom water.

At Station 173 and 174, water was collected for Apparent Nitrate Utilization (ANU) and oxygen isotopes (d180) determination (100 ml per sample), using the CTD sampler rosette. ANU is a tracer that is useful for identifying flow patterns of water masses of different origin.

Sea ice

Melted sea-ice cores, water from melt ponds, water drawn from below the ice and sediment obtained from ice floes can give us indications on ice-transported radionuclides reaching the Fram Strait. In order to study this transport mechanism, samples of multi-year sea ice were collected on all four large ice stations. Depending on the ice thickness, we retrieved in total between 15 and 20 complete ice cores (4" corer) per station, resulting in at least 200 litres of melted ice water. At ice station 2 and 3, water was collected from melt ponds (200 litres each), and at ice station 2, 3 and 4, sea water was obtained through drill holes from beneath the ice. At ice station 4 it was also possible to take sediment samples from the ice surface. 11 further sediment samples from "dirty" ice were obtained with the help of the helicopter from floes in the local area around RV POLARSTERN. All ice cores for radionuclide measurements were melted onboard RV POLARSTERN. The sediments from sea-ice surfaces will be analysed using the methodologies adopted for seafloor sediments (alpha and gamma spectrometry measurements). Basic sea-ice parameters (e.g., salinity, temperature) were measured by collaborating groups.

Sediments

The marine sediments in the Fram Strait contain significant amounts of ice-transported components, originating from multi-year sea ice that melts when reaching warmer areas. Seafloor sediments can provide a valuable record of historically events of radioactive contamination. Non-conservative radionuclides might be removed from the water-column as a result of adsorption to sinking particles or by uptake by phytoplankton. In this way, they become a part of the biological cycle, and are transferred to sediments by sinking detritus. In total 11 sediment cores from five different locations were collected (upper 20 cm) using box- (GKG) and multi corers (MUC, Stations 151, 157, 175, 197, 227, and 254). The seafloor sediments were usually collected at the same or nearby locations as those for seawater. One additional sediment sample was obtained at Station 263. The sediments will be subsequently analysed for alpha- (plutonium and americium isotopes) and gamma-emitters at the NRPA's laboratory in Norway. Sedimentological parameters such as sedimentation rates by means of radiochronological dating, and grain-size distributions will be determined as well.

Further sampling and measurements

On two of the four large ice stations (3 and 4), CTD profiles were measured through boreholes using a handheld conductivity meter with additional temperature sensor. The profile length was limited to 20 m by the cable length. These profiles should be insignificantly disturbed compared with near-surface profiles measured from RV POLARSTERN.

On eight stations fish samples were obtained from Agassiz trawls (AGT). These fish samples were frozen and will be analysed by gamma spectrometry.

Sample processing and measurements

The seafloor-sediment cores were sliced into 1-cm layers and stored in plastic tins at +4°C for later alpha and gamma measurements. Sediments from sea ice were sealed in plastic bags and stored in the same way as the seafloor sediments. Seawater collected for determination of the conservative radionuclides (99Tc and 129I) was stored aboard in 25 litre plastic cans without any pre-treatment. For radiocaesium determination, seawater was pumped into a filtration rig containing caesium-sorbent filters. On these filters, the radionuclide measurements will be made. Sea water from Station 173 and 266 and from melted sea ice (ice stations 3 and 4) was already on board filtered through the caesium rig. Seawater collected for Pu determination was partly pre-treated involving precipitation and subsequently reduction of sampling volume from 200 to 10 litres (two stations with four samples each). Selected water samples for Pu measurements were additionally filtered (0.45 _m) in advance, in order to separate those radionuclides connected to particles and those that are in solution.

When the sample treatment and radionuclide concentration measurements on water and sediments are finished we plan to link our data with background data from same stations (e.g., oceanography, sea ice physics and biology) and integrated within a GIS database.

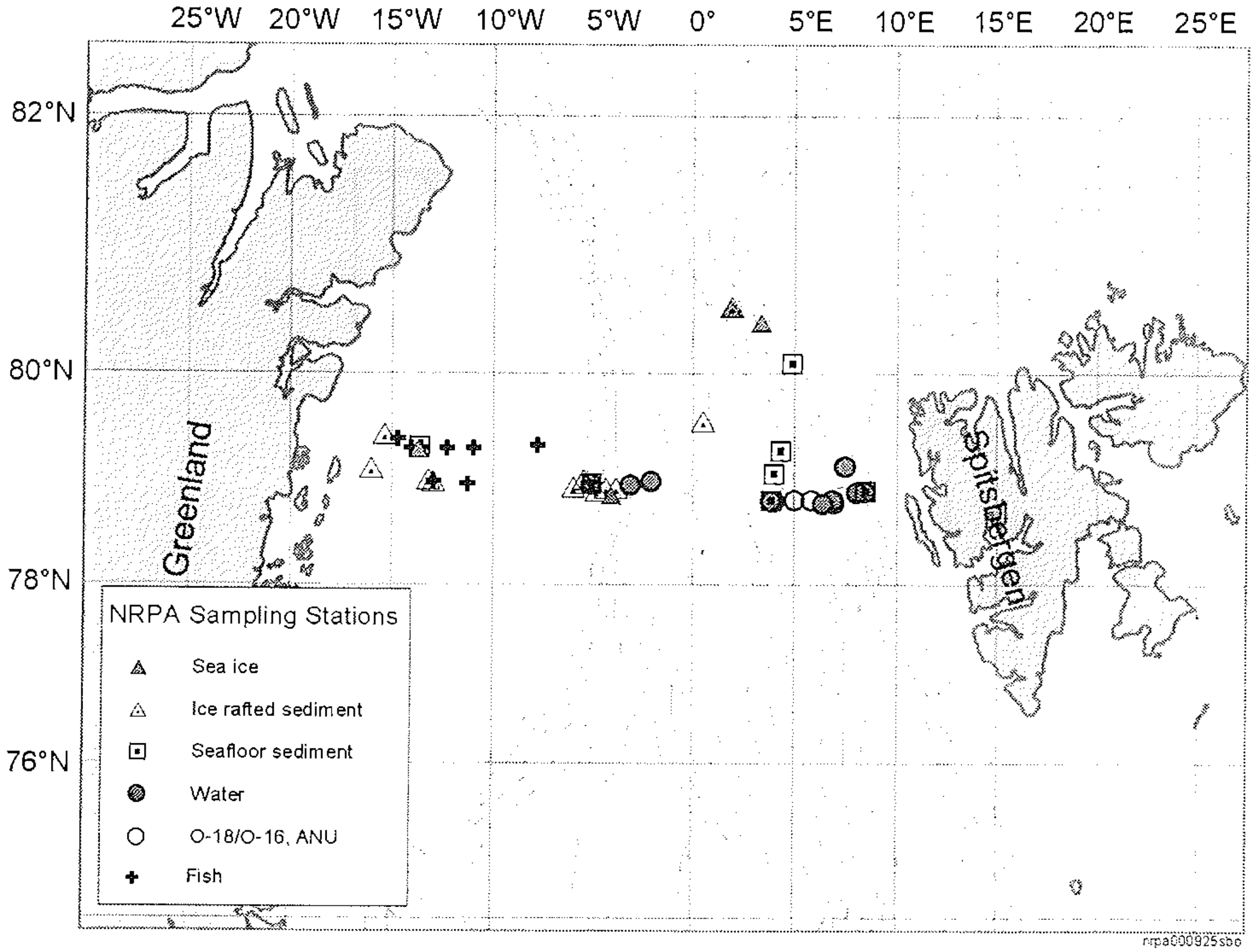


Fig. 2.3.1: Sampling locations for the NRPA group during ARK XVI-2.

3. BENTHIC INVESTIGATIONS AT THE AWI-"HAUSGARTEN"

In 1999, the project group "Deep sea gradients" decided to focus its multidisciplinary research efforts on causes and effects of gradients in the deep sea at a long-term benthic deep sea station, internally called AWI-"Hausgarten". This site is located west off Svalbard at 79° N and about 4° W at 2500 m water depth. Following the last years cruise where video/photograph surveys and sampling of surface sediment cores was carried out with the French Remotely Operated Vehicle "VICTOR 6000" during the present expedition gears such as Agassiztrawl (AGT), Epibenthic sledge (EBS), giant box corer (GKG) and Multicorer (MUC) were used. However, other instruments used included two free falling lander systems prepared for detailed in situ studies. One system was equipped with a preprogrammed respirometer, the other one with a time-lapse camera, current meter and a scanning sonar system (for details of both systems see text below). At the end of the cruise a sediment trap mooring with two traps and one current meter was deployed and programmed for one year.

During the cruise one station was sampled using the Agassiztrawl, five stations by means of the Epibenthic sled and a total of 9 giant box corers and 16 MUC stations were sampled (see Figure 3.1.1). Four of the giant box corers were taken in the centre of the long-term station whereas the others were taken along a depth gradient from 500 m down to about 3000 m.

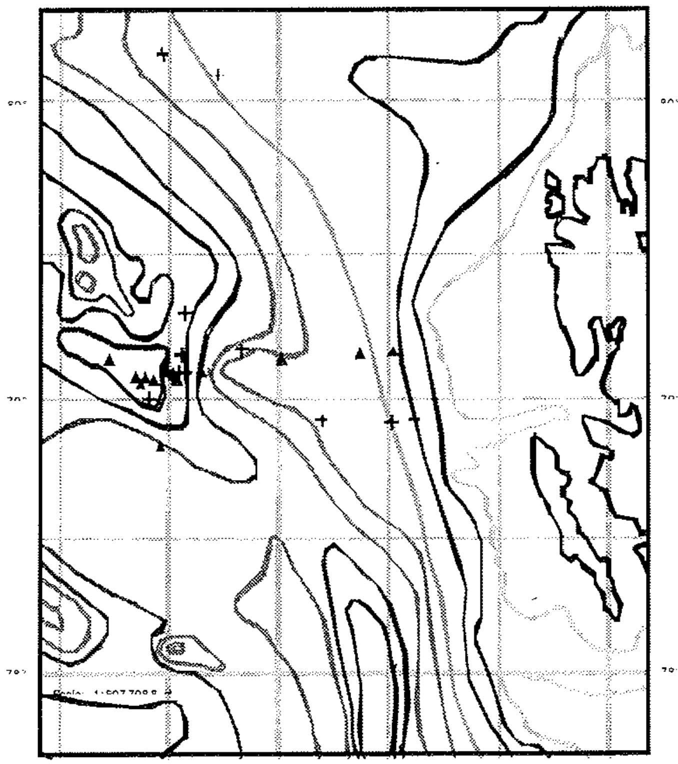


Fig. 3.1.: Map of the locations where GKG (crosses) and MUC (triangles) were taken.

3.1 QUANTITATIVE AND QUALITATIVE SAMPLING OF BENTHIC DEEP SEA COMMUNITIES

(M. Wlodarska-Kowalczuk, M. Klages)

As a part of a joint research project between AWI and IOPAS part of our quantitative sampling during this study was aimed to extent the range of faunistic surveys carried out in Kongsfjorden during the last 4 years. The material collected in 1997-1999 served to study the changes in benthic fauna along the inner-outer fjord transect in Kongsfjorden. The present study aimed to follow the changes along the depth gradient from shelf out of Kongsfjorden, along the slope, down to abyssal plain. The study will focus on meio-and macrofauna with regard to its:

• taxonomic composition, faunistic communities,
• biodiversity (both species- and dominance components of diversity),
• total abundance and biomass,
• feeding and mobility types.

The granulometric composition, chlorophyll-a, TOC, TON content in sediments will be analysed as well to provide information on environmental conditions in the habitats studied.

The sampling has been carried out both by R/V "Polarstern" and by the polish ship "Oceania". R/V "Oceania" has sampled the sediments down to 400 m using van Veen grab (0.1 m^2) at the end of July. The work on board of "Polarstern" comprised sampling on depths from 500 to 4000 m, using box corer and multicorer. The samples from box-corers were subsampled for:

• 2 subsamples taken by inserted boxes of 0.1 m2 for macrofauna,
• 3 subsamples of upper 5 cm of sediment for meiofauna,
• 1 subsample of upper 5 cm of sediment for granulometric analysis,
• 2 subsamples of upper 2 cm of sediment for CHN and chlorophyll a content analysis.

The samples obtained from multicorer included two cores:

• one core for macrofauna,
• one core subsampled for meiofauna and sediment analysis as described above.

The samples for quantitative macrofauna analysis have been sieved over 500 µm mesh size. Macrofauna and meiofauna samples were preserved in 4% buffered formaline. Sediment samples were frozen at -20°C. All the analysis will be performed in the home lab.

The EBS was used with nets of 500 µm mesh size in the epi-net and 300 µm in the upper supra-net. The material collected was fixed with 4% buffered formaline immediately after recovery of the system. At all stations sampled (water depths between 2285 and 2455 m) we found unexpected high numbers of calanoid copepods (Ca/anus hyperboreus) in the upper supra-net, however, in lower numbers also in the epi-net. Although the closing mechanism of the sled worked properly we decided onboard to verify whether C. hyperboreus occurs in similar abundances in the water column or not by using the multinet at a location close to one of the last EBS stations (station 259). Starting the multinet at 2250 m (water depth 2366 m) there were few individuals in the water column but with increasing numbers at greater depths confirming the results of the EBS. For further details see chapter 7.3 (Holger Auel). In general, the material collected with the EBS indicates that there is a diverse fauna of motile invertebrates close to tile seafloor. The most obvious elements among these rather small individuals are peracarid crustaceans such as amphipods, isopods, mysids and cumaceans. At all stations also several specimens of natant decapods were collected. At two stations (nos. 151 and 255) at 2430 and 2295 m water depth, respectively, single specimen of adult eelpout (most likely Lycodes frigidus) were collected with the supranet.

Due to the bow wave produced by the sled while trawling there were also sessile organisms collected with the EBS. Together with the single AGT sample taken in the house-garden area we now have material at hand to identify the most common and obvious species which were recorded on videotape while operating the ROV "VICTOR 6000" in 1999 there.

3.2 SMALL-SCALE DYNAMICS OF BACTERIA AND MEIOFAUNA IN ARCTIC DEEP SEA SEDIMENTS

(C. Hasemann, N. Queric, T. Soltwedel)

Topographic-geochemical features are connected with the varying occurrence of megafaunal populations, which in turn play an important role in the distribution of nano- and meiofauna. The Molloy Deep - as an example for deep isolated areas - shows a complete different faunal distribution compared to the so-called AWI-"Hausgarten"; the benthos of the Molloy Deep is dominated by holothurians, which produce tracks, feeding traces and faeces. The sediment there is characterized by small grain sizes. the area of the "Hausgarten" shows a wide range of biologically produced habitat structures. There are different bioturbating species creating tubes, burrows, sea mounds and other biogenic structures.

We hypothesize that the distribution as well as the activity of small benthic organisms are corresponding to the topographic and biochemical features of deep sea sediment systems in terms of depth. Benthic microbial processes are suspected to be directly connected to the occurrence of meio- and macrofaunal organisms.

Sampling was performed by using a multicorer sampling system allowing the investigation of an undisturbed sediment surface. The observation and sampling program was adjusted to the requirements of the entire cruise schedule. The sampling program for the cruise ARK XVI/2 was divided into two main topics of large-scale heterogeneity; for the questioning of depth-related distribution patterns of benthic meio- and nanofauna we followed a 500m-step transect. The two main sampling areas, Molloy Deep and the so called "Hausgarten" were positioned in the course of the transect. A total of 13 stations on the transect were sampled within this project. Subsamples for faunistic investigations and for biochemical analyses were taken using 1 ml, 5 ml and 20 ml syringes with cut off ends. Sub-samples were sectioned horizontally in 1 cm-layers and analyzed separately to investigate gradients within the sediment column.

The parameters which are suspected to follow a gradient were mainly abundance, diversity and activity of bacteria and meiofauna, as well as the biogenic sediment composition. Bacterial production was measured via labeled /eucine incorporation. To evaluate microbial exoenzymatic activities, esterase turnover rates were determined with the fluorogenic substrates fluorescein-di-acetate (FDA). Sediment samples were preserved for later investigations in the home laboratory. There sediment- bound chloroplastic pigment equivalents (CPE) will be determined to quantify organic matter input from primary production. Analyses of phospholipids and proteins will contribute to the assessment of living organisms and the proportion of detrital organic matter in the sediments.

Preliminary results show a trend of decreasing benthic microbial activity in dependence of the increasing depth in terms of water column as well as sediment column at centimeter scale.

3.3 ORGANIC CARBON FLUX TO THE DEEP SEA-THE RELEVANCE OF LARGE FOOD FALLS

(M. Klages, C. Arndt, S. Muyakshin, K. Premke, F. Robert, J. Wegner)

With the finding of rapid sinking of phytodetritus to the deep sea several years ago it became obvious that this remote ecosystem is much stronger coupled to processes occurring at the oceans surface than formerly assumed. Some experiments with baited traps carried out in the past revealed that there exists a highly motile and efficient scavenging community even at the greatest depth of the world ocean. However, the relevance and significance of natural food falls for organic carbon flux is rather unknown. There is no data available about the amount of organic carbon reaching the seafloor by means of carcasses either of invertebrates or vertebrates. There are several assumptions about food finding strategies in scavenging amphipods which belong to the most efficient deep sea scavengers. In our approach, we used one of the free falling landers as a platform for a time-lapse camera able to take about 800 still photographs at preprogrammed time intervals while deployed. Additionally, we used a scanning sonar head at a transmitting frequency of 675 KHz allowing us the detection of particles and organisms larger than 1 cm at maximum distances of about 50 m in all directions. This sonar system is a prototype of which only the sonar head is commercially available, all the other electronics, soft- and hardware was developed by us. In order to get additional information on bottom current speed and direction a current meter was attached to the lander at 2.5 m height above the seafloor. At one m distance to the camera a metal frame was attached carrying the bait (thawed salmon heads and several individuals of cod). The whole system in its final configuration is illustrated in Fig. 3.3.1, also showing the position of floaters, acoustic releasers, flash light and radio transmitter.

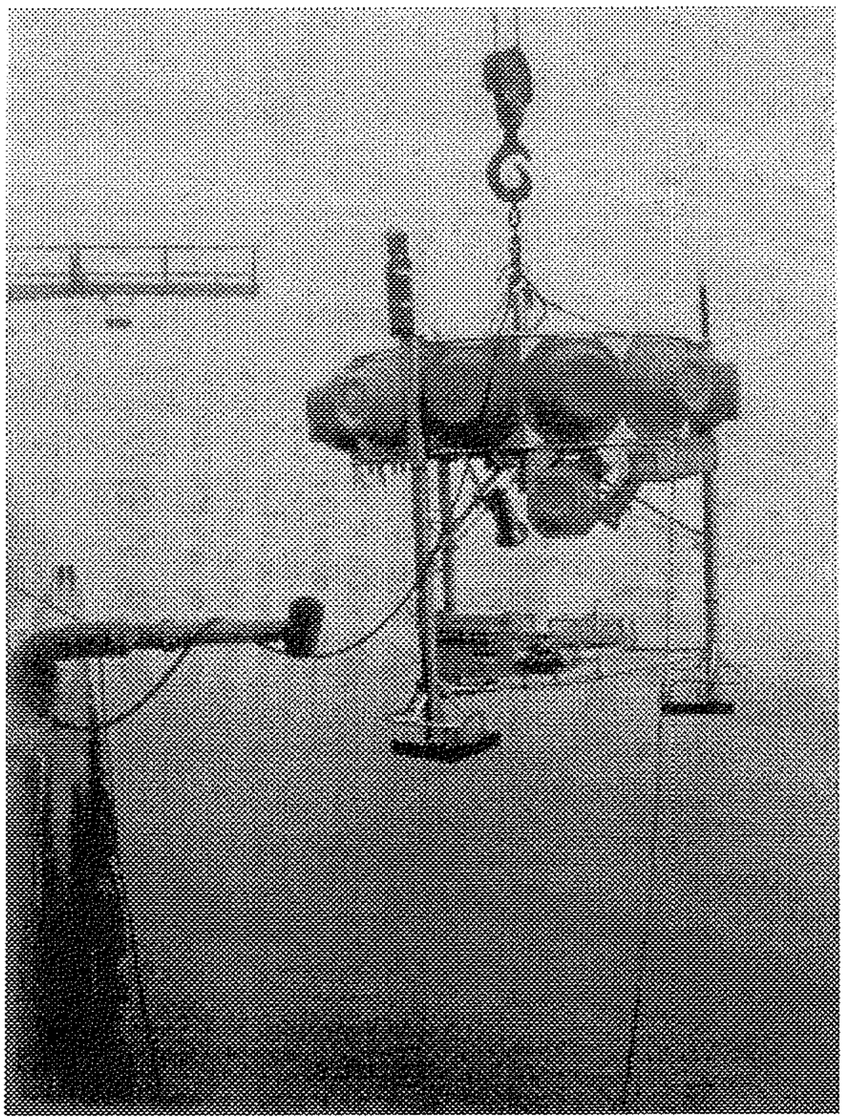


Fig. 3.3.1: Picture of the time-lapse camera and sonar head lander short before deployment.

The lander was deployed two times at locations in the area of the long-term station at water depths of about 2300 m (station 169 and 258). During the first mission the lander was deployed for about 64 hours during the second mission for about 31 hours. The current meter data shows that current speed 2.5 m above the seafloor varies between 1.5 to 18 cm s-1 (see Figure 3.3.2) obviously reflecting tidal cycles.

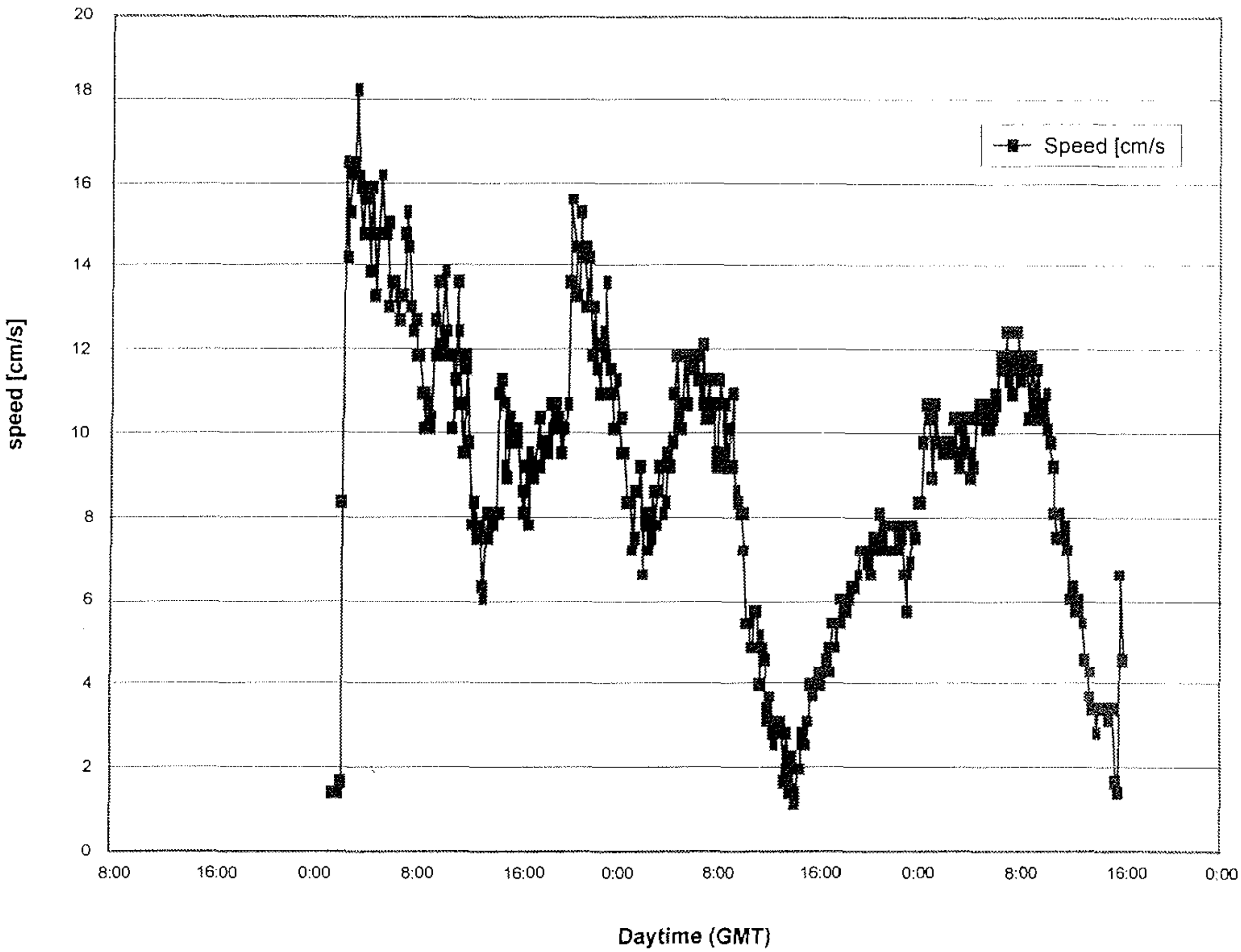


Fig. 3.3.2: Current speed measured at 10 min. intervals approx. 2.5 m above seafloor during Lander deployment at station 169.

About 70 individuals of the scavenging lysianassoid amphipod Eurythenes gryllus were still clinging at the bait at the end of the first lander mission. After the second mission additional live individuals of E. gryllus were collected. As during the first deployment the bait was totally consumed and only the skeleton of fishes remained (see Figure 3.3.3). All amphipods were in good physical condition and immediately transferred into aquaria inside a cool-container. Two weeks later they were still alive so that we should keep them alive for further detailed experiments at the AWI with regard to behaviour, physiology, food finding capabilities and biochemistry.

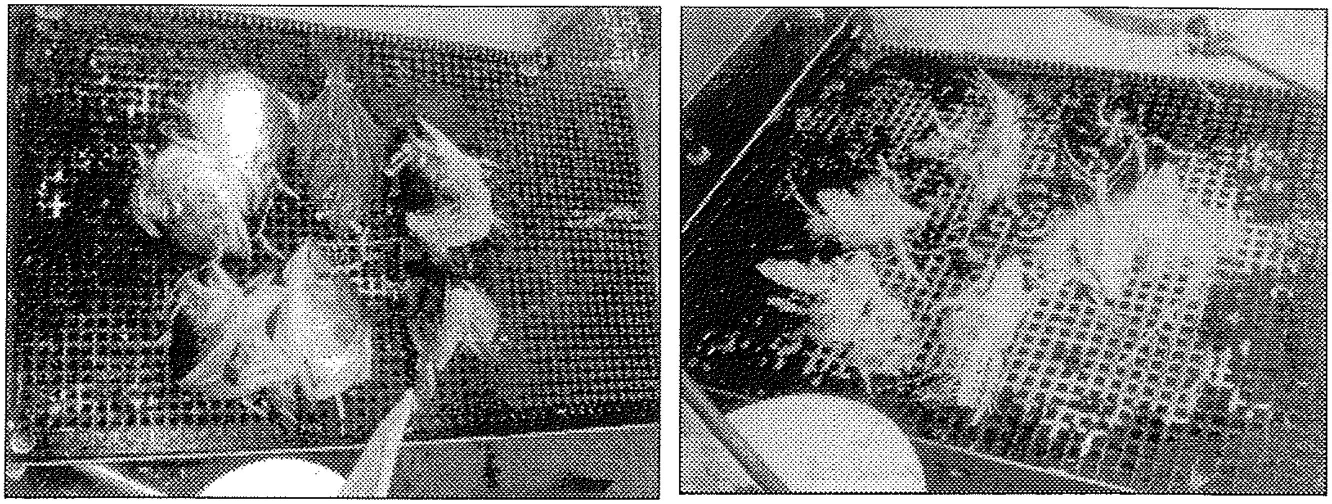


Fig. 3.3.3: Result of a 31 hours deployment of fish bait at 2340 m water depth indicating rapid utilization of large food falls by gammaridean amphipods (a: salmon heads before deployment, b: skeleton remains after lander retrieval).

3.4 CARBON REMINERALISATION BY THE BENTHIC COMMUNITY

(Soltwedel, Sablotny)

The seafloor plays an important role in the regulation of the chemical composition of the world's oceans. The seabed inhabits a great variety of organisms, and thus constitutes a distinct stratum for various biological processes. The conventional approach to study these processes is to collect sediment samples from the seafloor, bring them up to the surface and to carry out chemical analyses in the ship's laboratories. However, such an approach will lead to biased results because artefacts are induced when the samples (i.e. the organisms) are subjected to large changes in hydrostatic pressure and temperature during recovery. Therefore, to obtain accurate data from the seabed, it's preferable to carry out experiments and measurements directly at the seafloor.

To assess and quantify the role of the benthos in the recycling of carbon, measurements of in situ oxygen consumption at the seafloor were performed using a freefalling system (Fig. 3.4.1). The bottom-lander consists of a tripod metal frame holding a working platform carrying 2 grab respirometers. Each grabs encloses 4-5000 cm_ of sediment and approx. 4-5 litres of water. The decrease of dissolved oxygen in the overlaying water is registered by polarographic oxygen sensors. A water sampling device attached to each grab allowed to sample the sediment overlaying waters at programmed periods of time. Soon after recovery of the instrument, the water samples were analysed chemically for oxygen concentrations (Winkler titration) for comparison with sensor readings. Sediments enclosed by the incubation chambers were subsampled for bacterial numbers, faunal components and various biochemical parameters indicating organic matter input to the seafloor, benthic activity and total biomass of sediment-inhabiting organisms.

A total of 3 bottom-lander deployments were performed during the expedition: two deployments at the AWI-"Hausgarten", a long-term station west of Spitsbergen (2500m water depth), and another deployment in the nearby Molloy Deep, the deepest depression of the Arctic Ocean (5500m water depth). Incubation times varied between 32 and 36 hours. A first glance at the data revealed 3-4 times higher respiration rates at AWI-"Hausgarten" compared to the Molloy Deep.

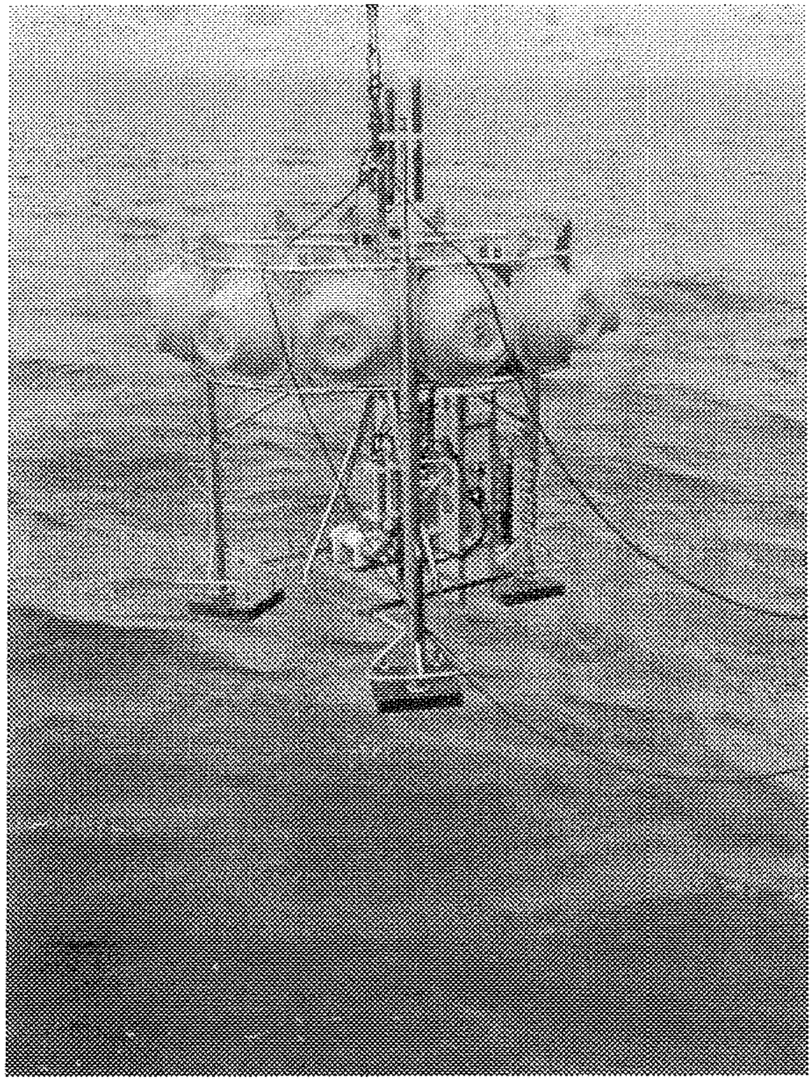


Fig. 3.4.1: Deployment of the freefalling grab respirometer

4. ANALYSIS OF BRYOZOAN COMMUNITIES OF THE NORTHEAST GREENLAND SHELF

(Bader)

Objectives

Bryozoans on subarctic shelves show a clear depth zonation controlled by substrate and hydrography. But in contrast to their systematics, the role of bryozoans in the Arctic benthic ecosystem is largely unknown. Also on the north-east Greenland shelf, the Belgica Bank, a depth zonation of the bottom species assemblage has been described, but bryozoans were not included in this investigation. So, the main purpose of this work is the study of bryozoan communities with regard to their distribution, density and structure. Investigations on the structural potential of bryozoan communities in forming different habitats and on the special settlement strategies and succession of bryozoans in bryozoan dominated benthos communities should evaluate the structure and history of these communities.

Work at sea

Bryozoans were collected, together with other benthic organisms in general, by means of Agassiz trawls (AGT) and one giant box corer (GKG). The fine elastic sediment was sieved through a 1 cm net and sorted out. Bryozoan colonies, stones and pantopods with encrusting bryozoans were collected. Only the vertical grab (GKG) sampled entire colonies; in the AGT all colonies were broken. After sorting out the bryozoan specimens, the different species were photographed with a digital camera. Bryozoans were fixed in 4% formalin or dried for comparative study.

Preliminary results

The most important thing for bryozoans is the existence of suitable substrate upon which bryozoan larvae may settle. The substrate may be hard or flexible. The mostly fine elastic sediment on the north- east Greenland shelf prevent the colonization of bryozoans because bryozoan larvae (0.1 to 0.3 mm in diameter) require a substrate at least that large to affix themselves, and the colony itself needs such an area, at least in th first stages of its growth. So the occurrence of coarse particles like pebbles, bivalve shells, agglutinated polychaet tubes and bryozoan colonies itself make it possible for bryozoan to settle (Fig. 1). Flexible hydrozoans and ascidians were encrusted and also on the mobile pantopods small bryozoan colonies were found (Fig. 2).
Different growth forms occur, whereby encrusting and erect fragile colony forms dominate. Within the erect bryozoans the Cyclostomata are common, while the Cheilostomata are dominant in the encrusting growth forms.

Fig. 1: Erect fragile cyclostome bryozoan (1) and encrusting cheilostome bryozoans on a pebble from the giant box core (St. 263) in 509 m water depth.

Fig. 2: Small erect and encrusting bryozoan colonies on a pantopod from the Agassiz trawl (St. 238) in 100 m water depth.

5. MICROBIOLOGY

(Brinkmeyer, Klein, Reuter)

Sea-ice cores and melt pond water samples were collected at four ice stations on multi-year ice floes. Additionally, samples from the water column (surface to 5500 m) at several stations as well as at the permanent AWI station (Hausgarten) were taken to observe possible bacterial population trends. Bacteria from ice and water samples were isolated with a variety of media specific for different groups of bacteria. Samples were also prepared for flourescent in situ hybridization, DNA extraction, and total counts. Nutrient concentration, chlorophyll a and total biomass of ice samples will be analyzed for correlations between bacterial and algal communities in the sea-ice. Molecular analyses of prepared samples will be conducted at the home laboratory in Bremerhaven. Radioisotope tracer experiments conducted during the cruise revealed high microbial activity in the sea-ice and melt ponds. 14C labelled dimethyl sulfide was rapidly taken up by sea-ice bacteria associated with ice algae. The combination of fluorescent in situ hybridization and microautoradiography will be applied to bacteria from radioisotope tracer experiments to determine which bacteria were responsible for the substrate utilization.

6. MARINE GEOLOGY

(H.C. Hass, D. Birgel, S. Daschner, M. Farwick, C. Kierdorf, U. Langrock)

The focus of the working program of the marine geology group includes paleoclimate and paleoenvironment reconstructions of the late Quaternary Arctic Ocean and the adjacent continental areas. Special emphasis is placed on the paleoceanographic development of the Yermak Plateau area at high temporal resolution during the Holocene and of the time period from the last interglacial (Eemian). Further emphasis is directed to the geochemical and physical-property signature of glacial and interglacial sediments of the working area for both, stratigraphic correlations and qualitative and quantitative analyses of organic material that form part of the sediment.

The transition from the last glacial to the modern interglacial was a period of strong and rapid fluctuations of the climate system. Warm and cold climate phases such as the Bølling/Allerød warm phase and the Younger Dryas cold spell left significant traces on land and in the marine realm. A number of minor Holocene climate fluctuations that were discovered in the North Atlantic area challenged the general view of a stable Holocene interglacial. Bond et al. (1997) and Bianchi and McCave (1999) related Holocene climate fluctuations to the intensity of thermohaline overturn in the Nordic Seas. To investigate whether or not Holocene climate fluctuations and associated changes in thermohaline overturn left significant traces in high-resolution sediments from the Yermak Plateau and the north-eastern Fram Strait is thus one of the major scientific tasks.

Sedimentation rates in the Arctic Ocean are generally low. All the locations selected for coring during ARK XVI/2 are under the influence of temperate Atlantic water masses that control the position of the summer ice margin at the sea surface and that also control sediment transport at the seafloor During ARK XV/2 it was attempted to discover the source and transport ways of the sediments that accumulate along the western Yermak Plateau. During ARK XVI-2 the scientific results of earlier expeditions were applied and used to retrieve sediment cores from areas influenced by the Yermak Slope Current This current appears to be least affected by recirculation and it can be inferred that it 1s responsible for the transport of sediment to high accumulation areas along the western slope shoulder of the Yermak Plateau.

Positions deeper than the upper shoulder of the slope were generally ruled out because of adverse effects of gravitative sediment transport. The investigations concentrated at a water-depth interval of c 1000 to 1500m. Sediment echosounding (PARASOUND) surveys were carried out along the shoulder of the slope of the western Yermak Plateau and partly also of the western Svalbard shelf

In particular the marine geologic research program comprises the following investigations:

- high resolution stratigraphy of the obtained sediment sections (isotope stratigraphy. AMS C-14 age determinations, magnetic susceptibility, physical properties, lithostratigraphy),
- terrigenous sediment supply and paleocurrent reconstructions (high resolution granulometry, bulk and clay mineralogy heavy minerals geochemical tracers),
- mapping of the sediment cover (PARASOUND),
- organic carbon flux, marine vs. terrigenous (organic geochemistry kerogen petrography), paleoproductivity in the Arctic Ocean (biomarkers),
- reaction of marine biota to environmental changes,
- correlation of marine sediment sequences with Greenland ice cores as well as with previously taken sediment cores from the broad area and the Nordic Seas.

Subbottom profiler used

- Atlas PARASOUND including an Atlas Deso 25 printer,
- PARADIGMA digitizing and post-processing software (Spiess, 1992).

Coring gear used

- GKG (giant box corer) 60cm long, 50cm x 50cm.
- MUC (multiple corer) 12/8 tubes, 60cm long. 6112cm internal diameter SL. (gravity corer) 10m/15m/20m long, 12cm internal diameter.

6.1 SUBBOTTOM PROFILING USING PARASOUND

(H.C. Hass. D. Birgel, U. Daschner, M. Forw1ck, C. K1erdorf, U. Langrock)

Introduction

The tasks of the PARASOUND surveys

- Providing information on the general acoustic characteristics of the sediments (sediment types). These include penetration depth (based on the wave velocity in water1, and structure of the sediment (ie layering, thickness of distinguishable layers) (continuous profiling).
- Providing information on the horizontal extension of different sediment types and distinct refiectors in the sediment column (short-distance parallel profiles).
- Providing information to aid selecting core locations (site surveys)
- Provide information on acoustic refiectors that shall be identified in sediment cores.

The goals include:

- Contribute to a mapping of sediment characteristics of the Yermak Plateau, classify sediment types,
- to discover areas with sediments of high temporal resolution,
- to reconstruct sediment-transport pathways to positions that are characterized by high sedimentation rates.

Technical features

The ship-mounted PARASOUND system (Krupp Atlas Electronics, Bremen, Germany) generates two primary sound waves at frequencies of 18 kHz and of 20-23.5kHz. As a result of the parametric effect, a secondary frequency between 2.5 and 5.5 kHz is produced at a very low angle of 4° which provides much higher resolution at a penetration depth comparable to that of other sediment-echosounding devices.

The PARASOUND device is attached to an analogue printer (Atlas DESO 25). The analogue signal is then digitized and postprocessed using the PC-based PARADIGMA software. Digital data are stored on tape and printed simultaneously on a color printer. Important data such as time, geographic position, and water depths are continuously plotted on a third printing device. During the expedition all PARASOUND data tapes were copied on compact disks.

The PARASOUND system was in 24h operation during part of the expedition. It had to be stopped during the recovery of oceanographic moorings and free-fall landers of the biology working group because the emitted sound frequency was in a similar range as the signals from the releasers used for the moorings and landers.

Although weather conditions were good during most of the time of the expedition, ice conditions were very heavy north of 80°N within the Fram Strait. PARASOUND records show the typical features including a high noise level and an artificial hummocky relief due to the ship's back and forth movement.

Sediment types, relief, and sediment-core positions

The upper shoulder of the western Yermak Plateau was investigated between 80°30' and 79°00'N. It shows generally a thick and acoustically well-structured sediment cover that tends to become thinner and diffuse upslope and slightly thicker below ca. 1000m water depth. The increase in sediment thickness with increasing water depth can often be attributed to gravity induced mass flows.

The western Svalbard shelf showed basically one acoustically hard layer and no or very limited sound penetration. Channels are common; some of them are filled with acoustically hard material of the surrounding areas. There are also smaller and larger ridges that can be interpreted as till or moraine material.

Thirteen sediment cores were taken from 4 Stations along the upper western slope shoulder of the Yermak Plateau in order to complete a transect that was started during ARK XV/2. Additionally, 18 box cores and multicores were taken during the expedition mainly for geochemical investigations of surface sediments.

6.2 GEOLOGICAL SAMPLING

(H.C. Hass, D. Birgel, U. Daschner, M. Farwick, C. Kierdorf, U. Langrock)

Rationale and planning

A total of ca. 65m of sediment was recovered (Figs. 6.2.1, 6.2.2, Tab. 6.2.1). Most of the stations were on the upper western shoulder of the Yermak Plateau. Gravity cores as well as giant box cores were taken at every station with the exception of Station PS57/157-1 (box core) where the PARASOUND data yielded very low sound penetration. Two stations (PS57/158, PS57/160) were exactly at positions of cores taken during ARK XV/2 in order to store the cores at -24°C for further geochemical investigations. At Station PS57/161 two gravity cores were recovered. One of them was stored at - 24°C. At Station PS57/153 (=PS57/271) four long gravity cores were recovered; one of them was stored at -24°C. At this position it was attempted to recover a very long core since PARASOUND suggested very high Holocene resolution. At this position a gravity core of 977 cm was recovered. The northernmost station planned was exactly on the position of Core PS2837 (81°14' N, 2°82' E) recovered during ARK XIII/2 (Stein and Fahl, 1997). It was planned to recover a longer core from this position. However, this position could not be reached due to heavy ice conditions.

During the cruise five positions on the Svalbard beach were sampled to build up a data base for provenance analyses of ice-rafted debris. Three positions were at the outer mouth of the lsfjorden, 2 further positions were at the outer southern mouth of Kongsfjorden. Gravel and sand samples were taken. Additionally, two samples from "dirty" ice floes were taken: one was about 12 miles east of the Greenland coastline, one was above the Yermak Plateau at 80°30' N.

In order to achieve undisturbed surficial sediments the multiple corer (MUC) was deployed at stations of interest for geochemical investigations. Recovery was between 20 and 40cm. The surficial sediments contained silty or sandy-silty clay at all stations. Relatively undisturbed samples of the upper 50 cm were obtained by means of a giant box corer (GKG). The GKG was deployed at all geological stations and at further stations for biological/geochemical purposes. Recovery was mostly at 50 cm which is the maximum core length that can be recovered using a GKG. The following working and sampling scheme was applied: Core description. Surface: two frames of 10 cm2 + Bengalrose (foraminifer analysis); 30-50 cm3 stored deep frozen in a glass bottle (geochemistry); 2*30-50 cm3 (sedimentology). Core: two 50 cm plastic liners (50*7*15 cm in diameter), one set of 25 cm liners (x- ray analyses). Surface sediments showed little variation throughout. The ultimate surfaces of the GKGs appeared to be undisturbed. On the surfaces living and dead fauna was still in live positions indicating undisturbed material. Several types of lebensspuren were found as well. Living brittle stars and polychaet tubes were abundant on all surfaces. Benthic foraminifers and arthropod holes were commonly found whereas bivalves, gastropodes and shrimps were rare. The common grain size was silty clay. Generally, there was an oxidized surface layer about 1 to 3cm in thickness.

The gravity corer (SL) was deployed at four geological stations. A total of 62 m of sediment were recovered. None of the other cores could be opened because the multi-sensor core logger was not available for this expedition. The cores were cut in meter pieces and stored at 4°C.

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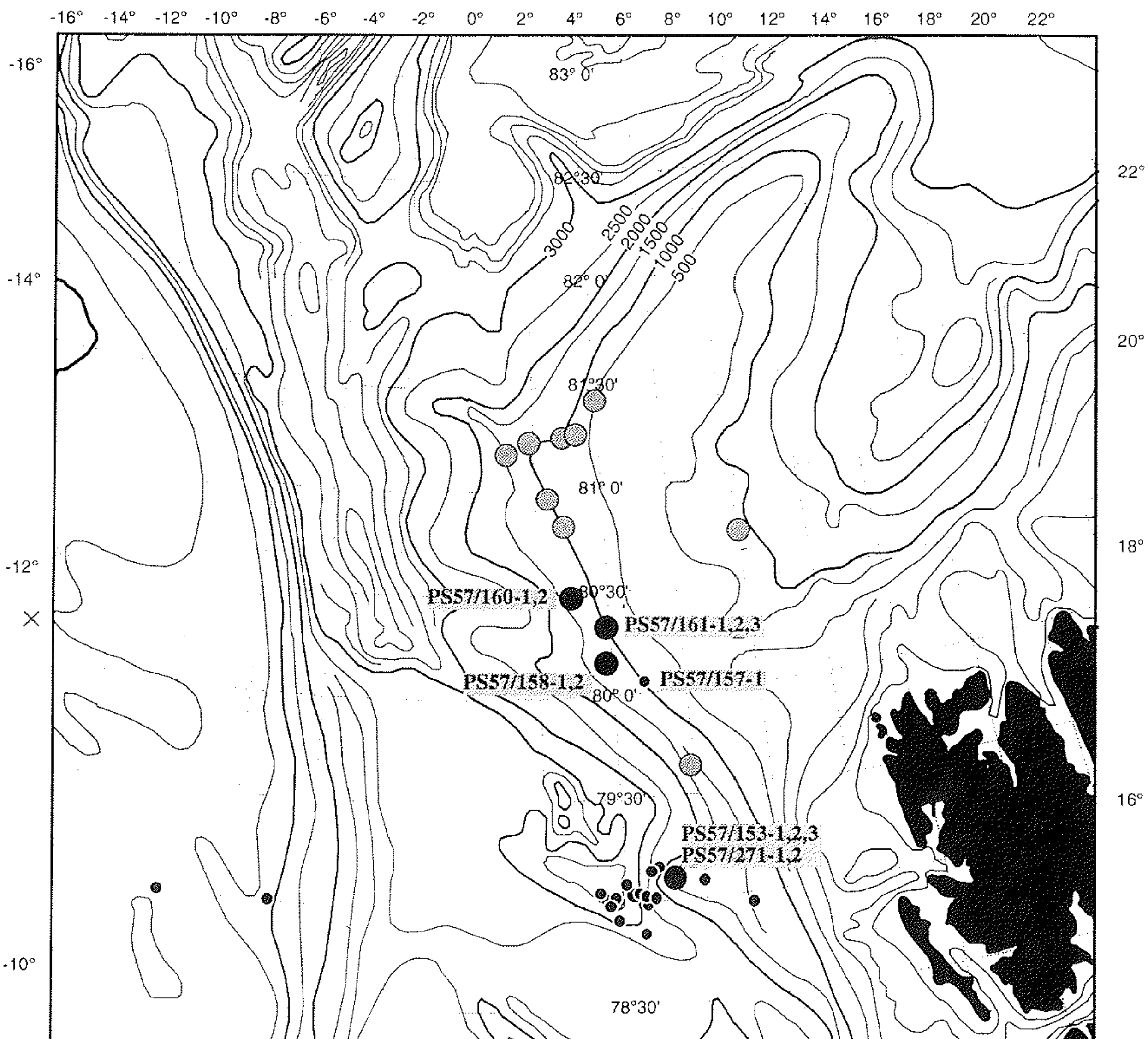


Figure 6.2.1: Working area and core locations. Big black dots with lables: gravity core locations; big gray dots: core locations during ARK XV/2; small black dots without lables: box core and multiple core locations (for identification see Table 6.2.1).

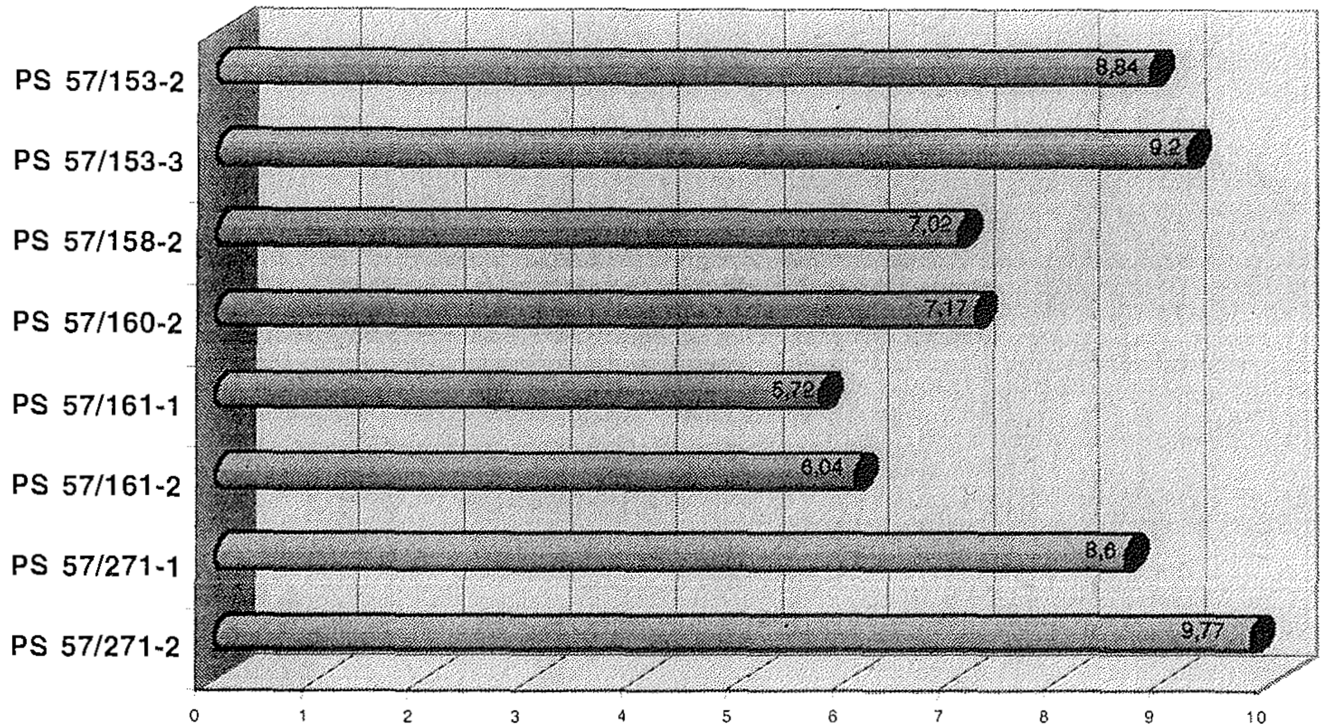
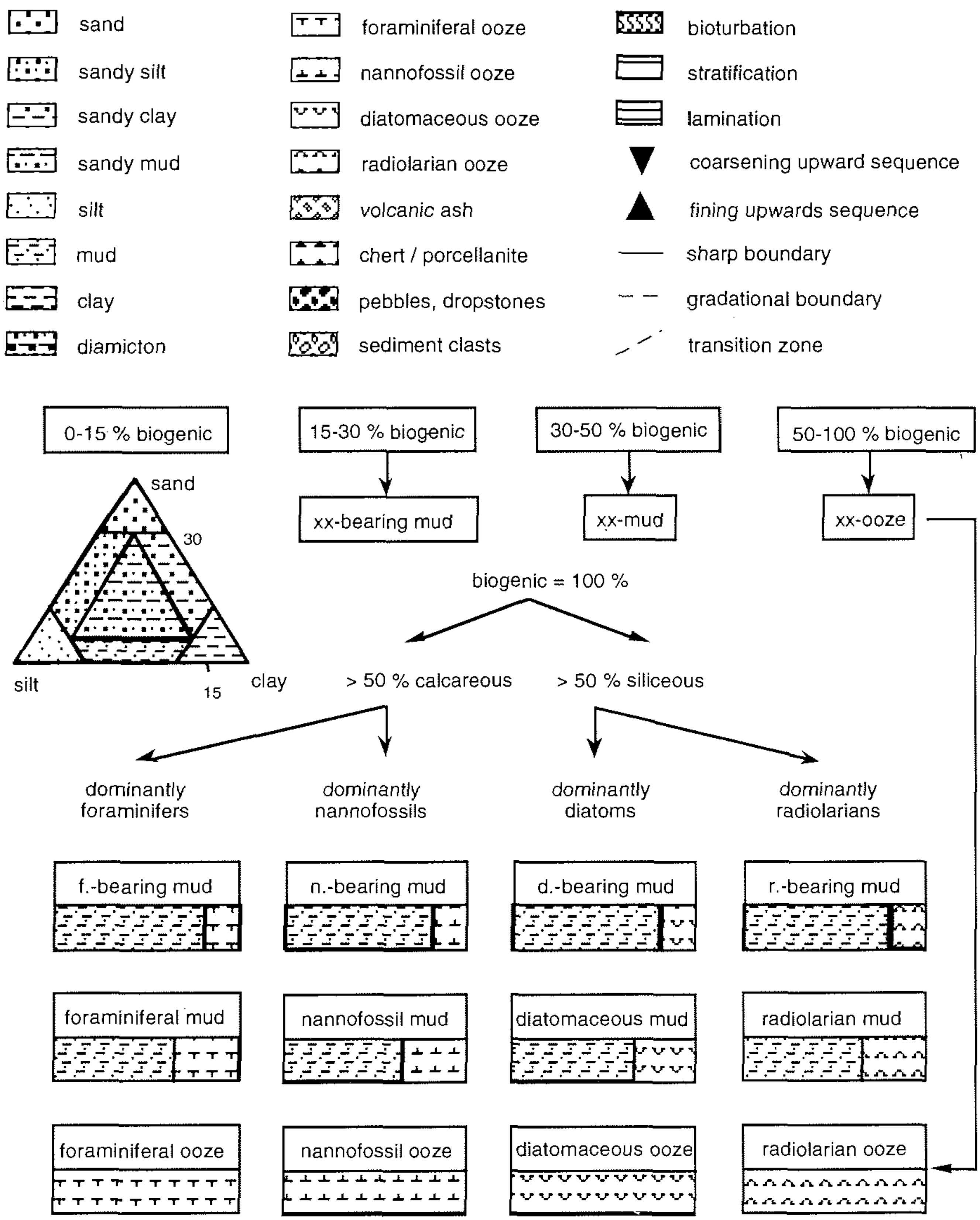


Figure 6.2.2: Lengths of gravity cores.

Table 6.2.1: Background information on cores taken during ARK XVI/2. Bold: stations of the geology working group; other cores listed include those where surface samples were taken.

Station	Gear	Latitude	Longitude	Water depth [m]	Recovery [m]
PS 57/153-1	GKG	79°09.6'N	05°20.2'E	1356	0.45
PS 57/153-2	SL	79°09.3'N	05°20.0'E	1337	8.84
PS 57/153-3	SL	79°09.5'N	05°19.9'E	1372	9.2
PS 57/157-1	CKG	80°04.9'N	04°54.6'E	1036	0.24
PS 57/158-1	CKG	80°08.9'N	03°53.6'E	1448	0.43
PS 57/158-2	SL	80°09.0'N	03°52.8'E	1445	7.02
PS 57/160-1	CKG	80°29.2'N	02°56.9'E	1482	0.49
PS 57/160-2	SL	80°29.2'N	02°57.0'E	1482	7.17
PS 57/161-1	SL	80°20.3'N	03°59.1'E	964	5.72
PS 57/161-2	SL	80°20.3'N	03°59.4'E	964	6.04
PS 57/161-3	CKG	80°20.3'N	03°58.8'E	964	0.49
PS 57/166-2	MUC	79°07.8'N	04°53.6'E	1495	
PS 57/168-2	MUC	79°06.5'N	04°36.2'N	1929	
PS 57/175-2	MUC	78°50.1'N	03°51.0'E	2239	
PS 57/176-2	MUC	79°03.86'N	03°43.4'E	2802	
PS 57/178	MUC	79°04.1'N	04°11.2'E	2385	
PS 57/181-1	MUC	79°04.5'N	03°36.0'E	3350	
PS 57/182-2	MUC	79°03.6'N	03°28.8'E	4020	
PS 57/188	CKG	79°08.8'N	04°14.9'N	1965	
PS 57/189	CKG	79°00.1'N	03°40.2'E	2874	
PS 57/197	MUC	78°59.6'N	04°59.6'W	1283	
PS 57/206-3	CKG	79°03.11'N	07°43.41'W	194	0.32
PS 57/227-3	MUC	79°20.00'N	13°35.15'W	178	
PS 57/252	MUC	79°04.50'N	03°21.30'E	5079	
PS 57/267	CKG	78°54.97'N	06°46.73'E	1490	
PS 57/271-1	SL	79°09.60'N	05°19.97'E	1345	8.6
PS 51/271-2	SL	79°09.66'N	05°20.23'E	1352	9.77
PS 57/272	MUC	79°08.28'N	06°06.19'E	1259	
PS 57/275	CKG	79°05.60'N	04°20.34'E	2259	
PS 57/276	CKG	79°05.47'N	04°09.66'E	2340	
PS 57/277	CKG	79°05.07'N	04°05.11'E	2418	



Figures 6.2.3 - 6.2.6: Legend and descriptions of box cores.

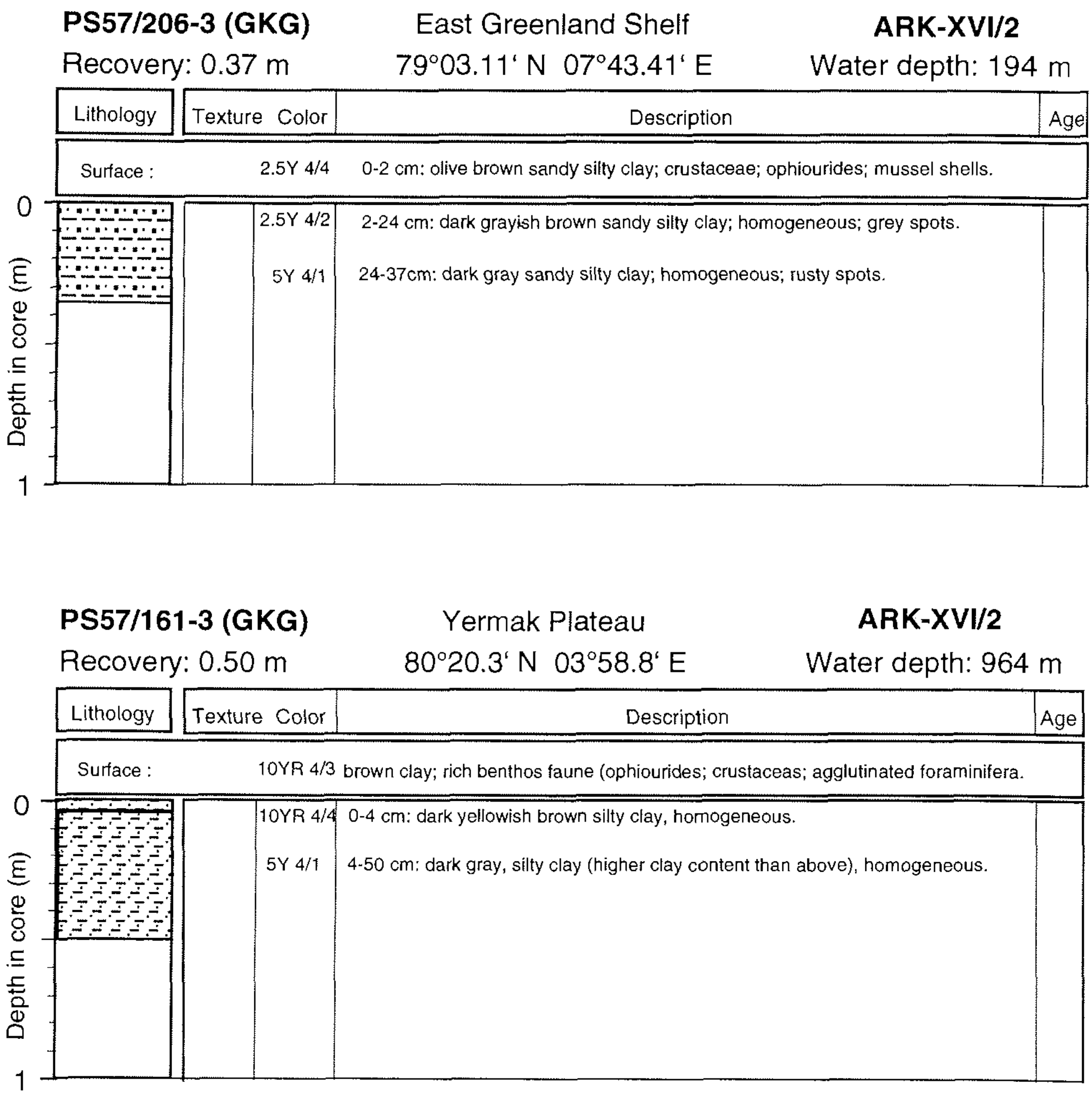
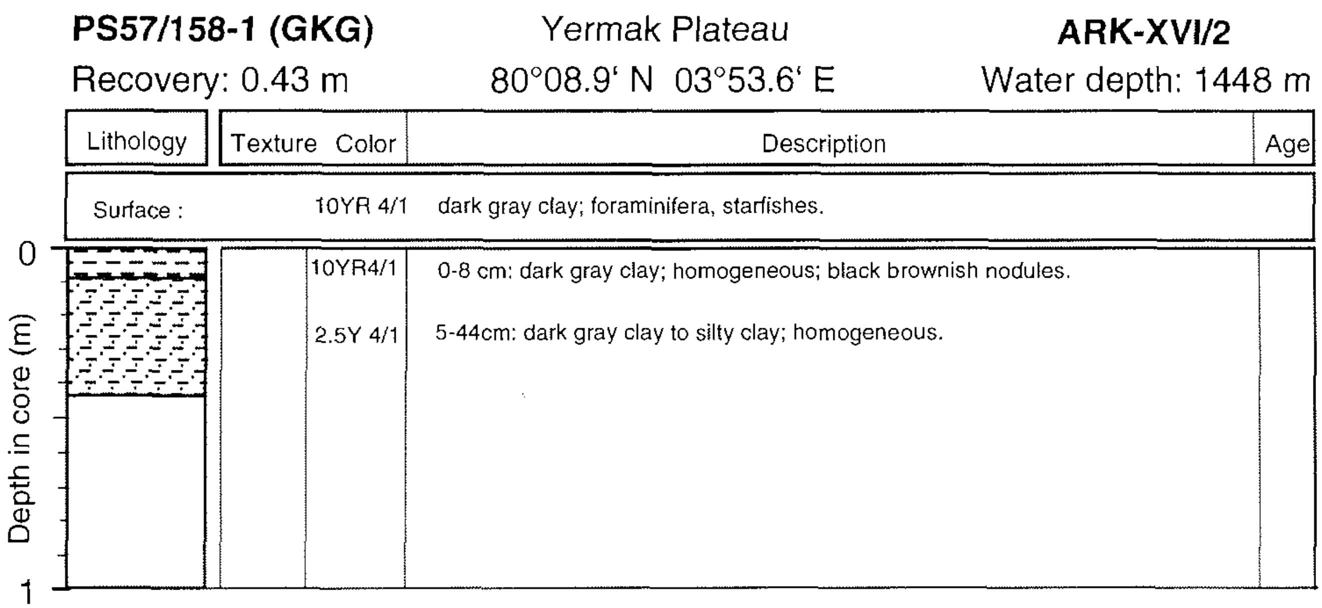
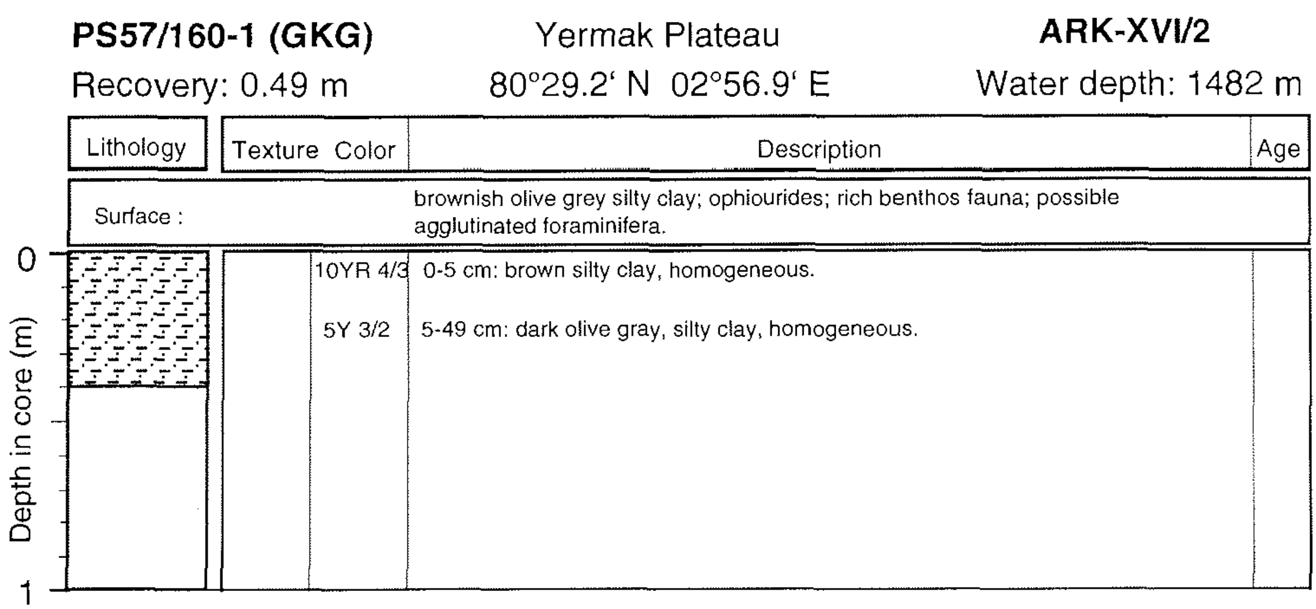

PS57/206-3 (GKG)
East Greenland Shelf
ARK-XVI/2
Recovery: 0.37 m
79°03.11' N 07°43.41' E
Water depth: 194 m
Lithology
Texture
Color
Description
Age
Surface :
2.5Y 4/4
0-2 cm: olive brown sandy silty clay; crustaceae; ophiourides; mussel shells.
0
1
Depth in core (m)
2.5Y 4/2
2-24 cm: dark grayish brown sandy silty clay; homogeneous; grey spots.
5Y 4/1
24-37cm: dark gray sandy silty clay; homogeneous; rusty spots.
PS57/161-3 (GKG)
Yermak Plateau
ARK-XVI/2
Recovery: 0.50 m
80°20.3' N 03°58.8' E
Water depth: 964 m
Lithology
Texture
Color
Description
Age
Surface :
10YR 4/3
brown clay; rich benthos faune (ophiourides; crustaceas; agglutinated foraminifera.
0
1
Depth in core (m)
10YR 4/4
0-4 cm: dark yellowish brown silty clay, homogeneous.
5Y 4/1
4-50 cm: dark gray, silty clay (higher clay content than above), homogeneous.

Figure 6.2.4

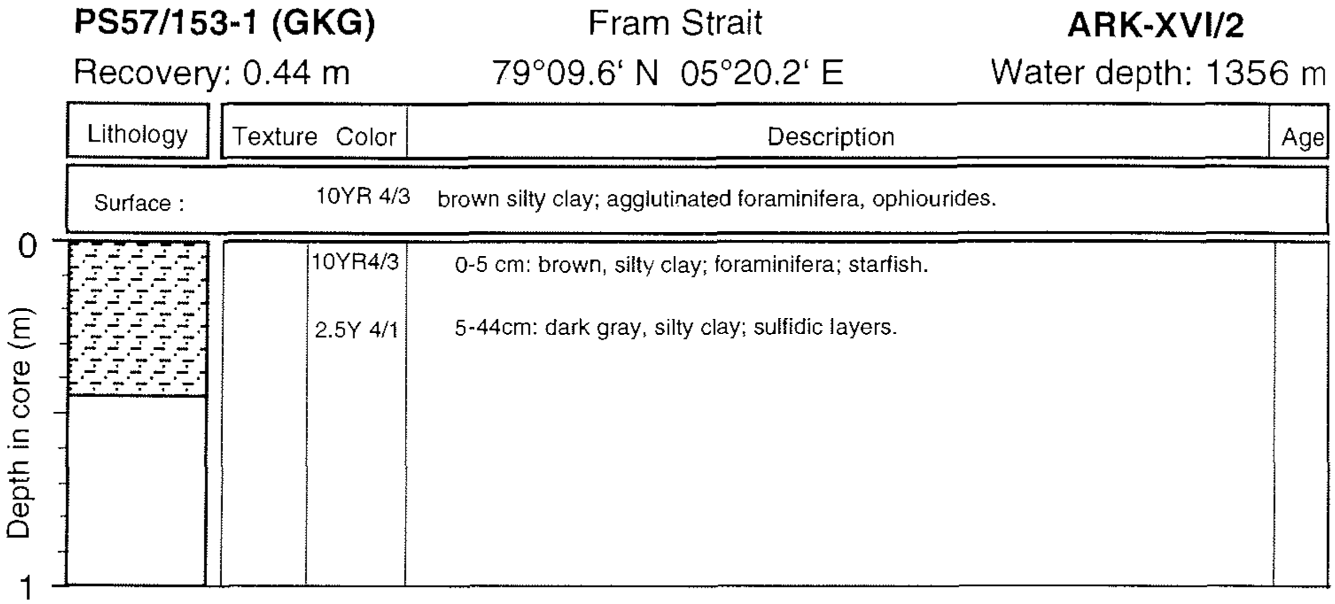


PS57/158-1 (GKG)
Yermak Plateau
ARK-XVI/2
Recovery: 0.43 m
80°08.9' N 03°53.6' E
Water depth: 1448 m
Lithology
Texture Color
Description
Age
Surface :
10YR 4/1
dark gray clay; foraminifera, starfishes.
0
1
Depth in core (m)
10YR4/1
0-8 cm: dark gray clay; homogeneous; black brownish nodules.
2.5Y 4/1
5-44cm: dark gray clay to silty clay; homogeneous.



PS57/160-1 (GKG)
Yermak Plateau
ARK-XVI/2
Recovery: 0.49 m
80°29.2' N 02°56.9' E
Water depth: 1482 m
Lithology
Texture Color
Description
Age
Surface :
brownish olive grey silty clay; ophiourides; rich benthos fauna; possible agglutinated foraminifera.
0
1
Depth in core (m)
10YR 4/3
0-5 cm: brown silty clay, homogeneous.
5Y 3/2
5-49 cm: dark olive gray, silty clay, homogeneous.

Figure 6.2.5


PS57/153-1 (GKG)
Fram Strait
ARK-XVI/2
Recovery: 0.44 m
79°09.6' N 05°20.2' E
Water depth: 1356 m
Lithology
Texture Color
Description
Age
Surface :
10YR 4/3
brown silty clay; agglutinated foraminifera, ophiourides.
0
1
Depth in core (m)
10YR4/3
0-5 cm: brown, silty clay; foraminifera; starfish.
2.5Y 4/1
5-44cm: dark gray, silty clay; sulfidic layers.

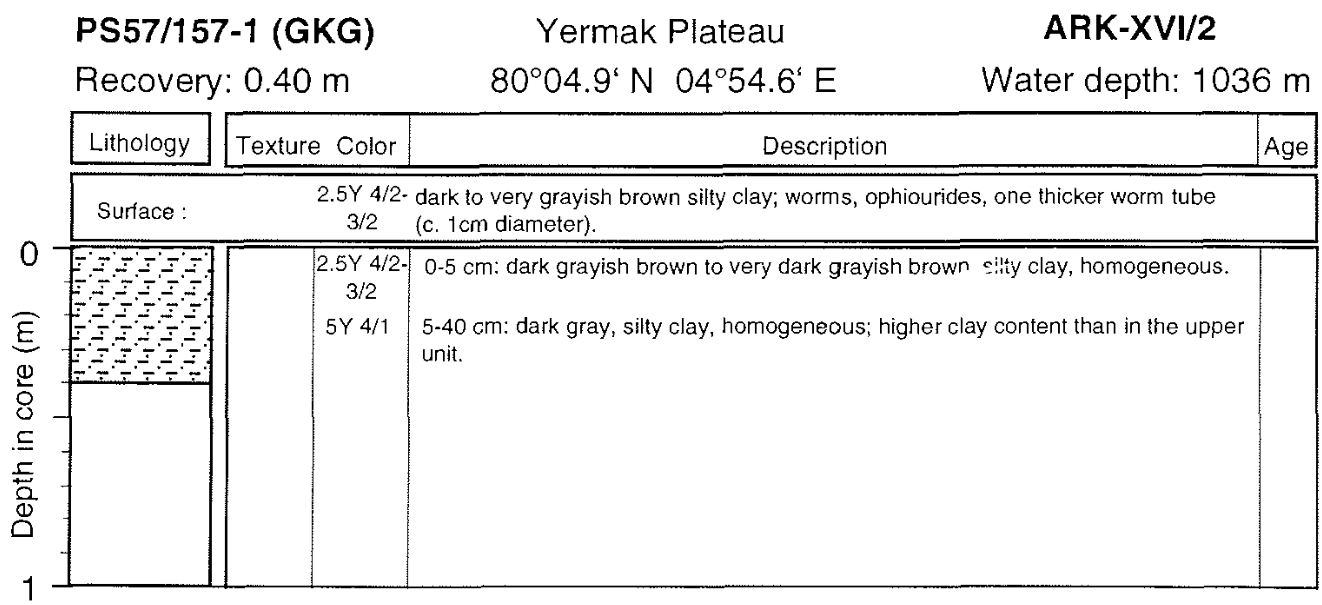

PS57/157-1 (GKG)
Yermak Plateau
ARK-XVI/2
Recovery: 0.40 m
80°04.9' N 04°54.6' E
Water depth: 1036 m
Lithology
Texture Color
Description
Age
Surface :
2.5Y 4/2-3/2
dark to very grayish brown silty clay; worms, ophiourides, one thicker worm tube (c. 1cm diameter).
0
1
Depth in core (m)
2.5Y 4/2-3/2
0-5 cm: dark grayish brown to very dark grayish brown silty clay, homogeneous.
5Y 4/1
5-40 cm: dark gray, silty clay, homogeneous; higher clay content than in the upper unit.

Figure 6.2.6

7. MULTI-DISCIPLINARY SEA-ICE INVESTIGATIONS

7.1. SEA ICE BIOLOGICAL STUDIES

(Fehling, Meiners, Schünemann, Werner)

General introduction

Sea ice is important in structuring polar marine ecosystems. Additionally, sea ice floes are a habitat for so-called sympagic communities which consist of bacteria, protists and metazoans. During this expedition we studied physical, chemical and biological properties of ice floes to characterize the summer situation in this habitat. Ice samples were obtained by means of ice coring at four ship-based stations and two helicopter-based stations. Additional under-ice studies were performed at the ship-based stations by sampling water from the uppermost 10m of the water column. Our studies focused on the quantitative and qualitative investigation of the sea-ice based food web and the food web structure in the underlying water. Three stations were conducted on sediment-laden sea ice floes (turbid sea ice).

Physical, chemical and biological properties of Arctic sea ice

At six stations we sampled several ice cores to measure vertical profiles of the following parameters:

- ice temperature
- ice bulk salinity
- chlorophyll-a and phaeopigment concentration
- nutrient concentrations (TN, NO_3, NO_2, SiO_4, PO_4 - measurements done in cooperation with the working groups of AWI and UH)
- seston (total matter), particulate organic carbon (POC) and nitrogen (PON)
- organism abundances (bacteria, protists, metazoans)
- concentration of transparent extracellular particles (TEP).

Most of the analyses will be conducted in the home laboratories, onboard RV POLARSTERN we could only determine the first 2 parameters mentioned above. A typical example of the available data set is given for the multi-year ice station 215 (Fig. 7.1.1).

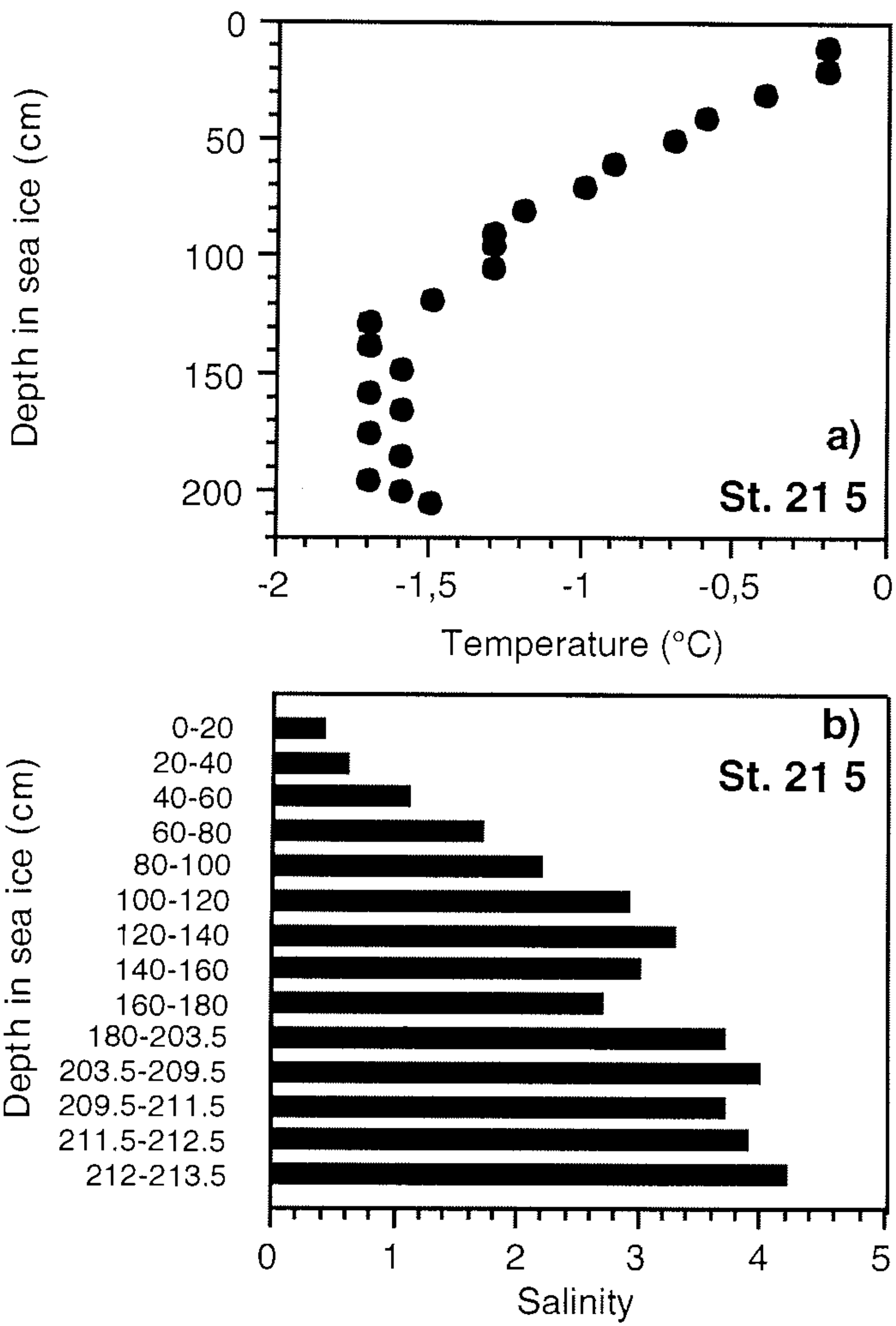


Fig. 7.1.1: Vertical distribution of temperature and bulk salinity in the ice floe at station 215.

Lowest temperatures were mostly observed in the bottom part of the ice cores, due to the surface heating by relatively high air temperatures. Ice bulk salinity mostly increased with depth and indicated brine drainage in the upper parts of the ice floes. Ice floes with salinities <1 were categorized as multi- year ice floes.

Investigation of the structure of the sea ice food web (experimental work)

A. Ingestion rates of sympagic protozoans and metazoans

Different approaches were used to investigate the trophic relations between sympagic bacteria, algae, proto- and metazoans. On three ice floes we collected larger amounts of brine and an integrated water sample (0-10m) and used it for uptake-experiments with fluorescently labelled bacteria (FLB) in order to determine ingestion rates of flagellates and ciliates on a low taxonomic level. These experiments will allow the determination of growth and grazing rates on bacteria and algae. Another aim of this experiments is the identification of mixotrophic species (especially ciliates) in the sea ice habitat. Additional grazing experiments with acoel turbellarians, which graze specifically on diatoms, will be performed in the home laboratories in Kiel.

B. Cell counts, grazing experiments and viability tests with Arctic sea ice organisms

In order to improve the general knowledge about sympagic organisms we took ice cores for the determination of abundances of bacteria, protists and meiofauna. Ice cores were cut into sections of 1- 20cm. These sections were melted in the dark by addition of seawater to avoid osmotic stress. Melted samples. were subsampled and fixed either with formalin (1% final concentration) or with Bouin's fluid (1% final concentration). Bouin fixed samples will be used for meiofauna investigation and taxonomy of ciliates. Formalin preserved samples were filtered onto 0.2µm and 0.8µm polycarbonate filters and stained with DAPI. These filters will be counted in the home laboratories using epifluorescence microscopical techniques to obtain vertical profiles of cell numbers and biomass of bacteria and protists. The estimated biomass of protists will be used to calculate the grazing impact by general allometric equations.

These indirect estimates will be compared with the results of direct grazing measurements which were conducted at the ship-based stations (see also above). Fluorescently labelled bacteria (FLBs) were added to brine and under-ice water samples. We measured the long-term disappearance of fluorescently labelled bacteria within the samples to provide data about the grazing impact of the total community. Experiments were run as time-course experiments for 24 h. Subsamples were taken after 0, 8, 16 and 24 hours and fixed with formalin (1% final concentration).

Viability tests were run over the entire ice-thickness. 1cm segments of ice cores from 4 stations were incubated with INT (0,02 % final concentration) in petri-dishes for 12h. INT is incorporated into living cells and is reduced to a red water-insoluble formazan-salt inside respiring cells. Using combined brightfield and epifluorescence microscopical techniques these experiments allow the quantification of total bacterial numbers and the number of actively (=respiring) cells. Cellspecific respiratory activity (formazan-grain-size) will be correlated to taxonomic groups (eukaryotes) and morphotypes (bacteria) after examination of the samples in our home laboratories.

In addition to this program we took bottom sections for the cultivation of different groups of sympagic biota (algae, protozoans and metazoans). Cultivated organisms will be used for further taxonomic work and additional grazing experiments in the home laboratories. Grazing studies will focus on the grazing impact to attached bacteria within artificial biofilms.

Measurement of transparent exopolymer particles (TEP)

Transparent exopolymer particles are a relatively new known class of particles produced from dissolved carbohydrate polymers exuded by phytoplankton and bacteria. While different studies indicate that TEP are important in the aggregation of diatom blooms, provide the matrix of marine snow, serve as a substrate and habitat for attached bacteria, the distribution, abundance and characteristics of this new class of particles within sea ice remain largely unknown. In order to improve our knowledge about TEP in sea ice we determined TEP both spectrophotometrically and microscopically at four stations for entire ice cores. Ice cores were cut into 1-20cm segments and were melted by addition of 0.2µm filtered seawater. Subsamples were filtered onto 0.4µm polycarbonate filters, stained with Alcian-Blue and will be analysed in our home laboratories.

Small-scale distribution and energy budgets of the under-ice fauna

Investigations on the environmental conditions (morphology, temperature, salinity, chlorophyll a, POC, PON) and the abundance and distribution of under-ice fauna (pelagic and sympagic metazoans suspended in the under-ice boundary layer, under-ice amphipods attached to the ice underside) were carried out at 4 ship-side ice stations. Under-ice videos showed that all stations were on level ice, characterized by an undulating lower surface with large holes and depressions, which is typical for the summer melt period. The meltwater influence is also expressed in the temperature and salinity at the ice-water interface (Table 1):

Ice station	**Ship station**	**Date**	**Temperature [°C]**	**Salinity**
215	159-3	2.8.2000	-0.3	31.0
221	196	8.8.2000	-0.6	30.7
224	227-1	11.8.2000	-0.6	29.7
228	247	15.8.2000	-1.8	33.3

Several species of under-ice amphipods (*Apherusa glacialis*, *Onisimus* spp., *Gammarus wilkitzkii*) were observed by the camera at the ice underside on all stations. They will be quantified by image analysis in the home laboratory. Furthermore, drifting calanoid copepods (*Calanus* spp.), hyperiid amphipods (*Themisto libellula*), pteropod gastropods (*Limacina helicina*) and - for the first time - a free-swimming under-ice polychaet were recorded in the under-ice water layer. A pumping system delivered stratified (0, 1, 2, 3, 4, 5 m below the ice) samples of the suspended under-ice fauna. It became already evident that there is a pronounced small-scale gradient in the distribution of organisms in this layer. In the first meters below the ice, sympagic harpacticoid (*Halectinosoma* spp., *Tisbe* spp.) and cyclopoid (*Oncaea* sp., *Cyclopina schneiderit*) copepods occurred in quite high concentrations. They are either flushed out of the ice by meltwater or perform active migrations between the two different realms. The typical pelagic species like the calanoid copepods (*Calanus* spp.) were concentrated in 3-5 m below the ice. They might avoid the meltwater at the ice-water interface.

Feeding experiments were carried out onboard with the most abundant species below the ice, the cyclopoid copepod Oithona similis. Size-fractionated food suspensions from the under-ice water were offered to the copepod for several days. Analysis of the chlorophyll decrease in these incubations will give some information on the grazing impact of the species on different autotrophic groups in the under-ice plankton. Experiments on the carnivorous feeding habit of the under-ice amphipod *Gammarus wilktzkii* carried out during the cruise yielded already some results. This predator consumed on average 0.8 (range: 0.3-1.6) large calanoid copepods (*Calanus hyperboreus*) or 11.6 (range: 1-18) small harpacticoid copepods (*Halectinosoma* spp.) per day in the experiments. With this feeding on both pelagic and sympagic organisms, the under-ice amphipod contributes to the cryo- pelagic coupling processes. The feeding experiments were supplemented by respiration measurements in order to assess the carbon and energy demand of this species and to compare these results with the simultaneously run experiments with the pelagic amphipod *Themisto libellula* (H. Auel).

7.2 GEOCHEMICAL AND STRUCTURAL PROPERTIES OF SEA ICE

(Granskog, Ehn)

During ARK XVI-2 sea ice samples were collected at a number of locations, both at ice stations nearby the ship and by helicopter. Helicopter stations focussed on dirty ice floes, with some sediment laden sea ice. In addition to ice cores also snow, meltpond water, and sediment was collected for trace metal analysis. The aim is to compare clean and dirty ice, and to detect a possible impact of sediments on the trace metal levels in sea ice, snow and meltponds. All geochemical analyses will be done later on in Helsinki.

Onboard the ship the crystal structure of sea ice was studied and salinity profiles were measured. The crystal structure revealed highly variable stratigraphic features, with large portions of granular ice. probably frazil ice. This might be due to sampling of dirty ice, which is known to be related to dynamic ice growth (i.e. frazil ice). Further information on the ice growth processes will be revealed by stable oxygen isotope analyses of the ice cores. Stable oxygen isotopic data and sediments collected on the ice floes will be used to depict the origin of the ice.

The observations made by the biological sea ice groups (IPOE, AWI), of e.g. chi-a, POC, seston, and nutrients, will also be used to reveal any relationships between different geochemical parameters in the ice.

7.3 ON THE ENERGETICS OF HIGHER TROPHIC LEVELS -THE KEY ROLE OF DOMINANT ZOOPLANKTON AND VERTEBRATES FOR THE ENERGY FLUX IN ICE-COVERED POLAR SEAS

(Auel)

Pelagic communities of ice-covered polar seas are characterised by the dominance of relatively few abundant key species. In the Arctic herbivorous copepods, mainly of the genus *Calanus*, utilise phytoplankton production and according to recent results also consume a substantial fraction of the particulate organic material produced by ice algae. Cryopelagic amphipods of the genera *Apherusa* and *Onisimus* feed on ice algae at the underside of the ice. In turn, copepods and herbivorous amphipods are preyed upon by the carnivorous amphipods *Themisto libellula* and *Gammarus wilkitzkii* as well as by cryopelagic fish species, such as *Boreogadus saida* and *Arctogadus glacialis* (polar and Arctic cod). Thus, a limited number of species form the major links and trophic pathways from primary production to the higher trophic levels of the food web.

In polar regions seabirds and seals play an important role as top-consumers. The European Arctic is considered one of the most important habitats for seabirds worldwide. The breeding population of seabirds in Norway, Iceland, East Greenland, Svalbard, and on the smaller northeast Atlantic and Arctic islands is estimated at app. 25 million individuals. More than 30 seabird species occur in the Barents Sea region. Among those little auks, kittiwakes, common and thick-billed guillemots are most abundant. Especially the auk species are known to find their food in the marginal ice zone.

A total of five seal species is associated with sea ice in the Atlantic sector of the Arctic. As typical inhabitants of the sea ice region ringed seals are distributed with 6 to 7 million individuals throughout the whole Arctic. They feed opportunistically on the cryopelagic fishes *Arctogadus glacialis* and *Boreogadus saida* in winter and on planktonic crustaceans, especially *Themisto libellula*, in summer.

Our current knowledge indicates a direct coupling of ice-associated pelagic organisms (zooplankton, fish, seabirds and seals) to the primary and secondary production of the sea ice community. However, a quantitative estimate of the significance of higher trophic levels for cryo-pelagic coupling processes in the Greenland Sea is still lacking. The studies conducted during the expedition ARK XVI/2 aim at quantifying the influence of dominant zooplankton organisms and marine vertebrates on the energy flow in the Greenland Sea ecosystem in order to better understand significant cryo-pelago-benthic coupling processes in ice-covered regions.

In order to reveal the effects of a varying ice cover on the pelagic community, sampling during ARK XVI/2 concentrated on transects from the open water, across the marginal ice zone, into areas completely covered by sea ice. The vertical distribution of mesozooplankton in the upper 100 m of the water column below the ice was investigated by stratified Multinet hauls (mesh 300 µm) covering depth intervals of 100-75-50-25-10-0 m in high resolution. A total of eleven Multinet samples was collected along two transects. The first transect extended from 80°14,54'N 4°8,14'E via four stations to 80°6,9'N 4°34,4'E across the marginal ice zone, while a second transect with seven stations started at 2°35'E and followed latitude 79°N westward until 13°35'W. The Multinet samples will be analysed in regard to zooplankton abundance, biomass and the distribution pattern of dominant species.

Additional material for experimental approaches and biochemical analyses was collected by Bongo net and two RMT 8 (Rectangular midwater trawl, net opening of 8 m^2) hauls. Individuals from these hauls were used for respiration measurements (Winkler method) and feeding experiments on board RV "Polarstern". Experimental studies concentrated on the pelagic hyperiid amphipod *Themisto libellula*, which occurred abundantly in surface waters below the sea ice and provides a major item in the diets of seabirds and ringed seals. Based on the results of the respiration measurements and feeding experiments, individual energy demands will be calculated and used to estimate the food consumption rate of the total population. Thus, the predation impact of *Themisto libellula* on the mesozooplankton community can be evaluated and discussed.

Attempts to catch polar cod by line and hook during three ice stations were not successful. However, some individuals were caught by Agassiz trawl on the East Greenland Shelf. These individuals will be used to assess their diet composition and trophic level. Therefore, a combination of classic and novel methods will be applied. Stomach and gut content analysis will provide information on the food composition in the latest past. Certain fatty acids as trophic biomarkers will reveal the long-term feeding behaviour. In order to assess the trophic levels of polar cod and the different zooplankton species, measurements of stable isotope ratios (C, N) are also planned.

A sighting survey from the bridge of RV „Polarstern" was conducted along the cruise track to provide estimates of seabird abundance in the investigation area. Standardized counting intervals of 10 to 15 minutes duration were recorded when weather conditions were favourable. Alcids contributed the major fraction of sightings. Little auks (*Alle alle*) were the most abundant seabird species in the marginal ice zone and occurred even in areas with more than 90% ice cover. In open water thick-billed guillemots (*Uria lomvia*) were encountered. The distribution of puffins (*Fratercula arctica*) usually considered as an Atlantic to sub-Arctic species extended further north than 80°N right into ice-covered areas. Besides the alcids, ivory gulls were observed regularly in ice-covered areas, whereas kittiwakes and fulmars were more abundant in ice-free waters. In the vicinity of Spitsbergen glaucous gulls (*Larus hyperboreus*) could be observed, too. Based on abundance data, the food demand of seabird populations in. the marginal ice zone will be estimated in order to assess their predation impact on zooplankton and fish.

Seal sightings were recorded both from the vessel as well as during four helicopter flights. In ice-covered areas ringed seals comprised the majority of sightings, whereas hooded seals regularly occurred along the East Greenland Shelf. Two of the airborne surveys covered eight transects of 30 nm each with a strip width of 400 m, whereas the other two flights had to be shortened and/or re-routed during flight due to bad visibility and foggy weather conditions.

Data obtained during ARK XVI/2 will improve our knowledge about the functioning of the pelagic ecosystem in the Greenland Sea as well as further our understanding of cryopelagic coupling processes in ice-covered Arctic seas. These results will provide a base for the evaluation of the potential consequences of global warming and a retreat of the sea ice cover on zooplankton and marine vertebrates in Arctic marine ecosystems.

8. ATMOSPHERIC TURBIDITY AT SEA

(Behr)

Information about the spatial and temporal distribution of the net total radiation and its components at the sea surface as well as atmospheric turbidity are one of the most important parameters in resolving numerous meteorological and oceanographic questions.

Therefore during the cruise the following radiation components were recorded: global and direct solar radiation as well and sunshine duration. The other components necessary to close the radiation balance: reflected solar radiation, long-wave thermal radiation of the atmosphere, and ocean surface radiation are computed using numerical models successfully tested on former research cruises in the Atlantic, Behr (1990).

As the income of solar radiation at the sea surface is controlled by the content of absorbing constituents, the knowledge of their amount is essential. The term "aerosol" comprises all material within the atmosphere with the capacity of extinction (sum of absorption and scattering) solar radiation. As direct recording the amount of atmospheric aerosol is very difficult at sea, this quantity has to be determined by indirect methods. The most common way is to measure direct solar radiation and compare these data with computed solar radiation penetrating a Rayleigh atmosphere. The loss of solar energy is expressed by the turbidity-factors. Foitzik and Hinzpeter (1958) have introduced those factors describing how many Rayleigh atmospheres are equivalent to an actual atmosphere.

The following turbidity-factors are in use:

TL: Linke-turbidity-factor, describing all radiation processes in the whole solar spectrum,
Ts: turbidity-factor, describing all radiation processes in the short-range part of the solar spectrum ($0\ \mu m < 1\ \lambda < 0.63\ \mu m$). It gives information about the amount of dust in the atmosphere,
Tr: turbidity-factor, describing all radiation processes in the red part of the solar spectrum ($0.62\ \mu m <1\ \lambda < 2.8\ \mu m$). It gives information about the amount of water-vapour in the atmosphere.

The factors T_L, T_S, and $T_r = T_x$ can be computed by:

$I_x = I_{Ox} \exp(-T_x \cdot m\ \delta)$ (1)

with:

I_{Ox}: extraterrestrial solar radiation received from a surface normal to the beam of the sun. Its quantity depends on the distance sun - earth only,
I_x: direct solar radiation received from a surface normal to the beam of the sun, e.g. measured with a Linke-Feussner-Actinometer,

m: optical air mass, dependent on the solar elevation angle.
δ: optical depth of the atmosphere.

The data set of measurements of direct solar radiation I obtained with a Linke-Feussner-Actinometer reveals the spatial and temporal variation of the atmospheric turbidity during the cruise. As a first result the daily courses of direct solar radiation I as well as T_L, T_S, and T_r at 3 August 2000 will be shown in Fig. 1.

R/V POLARSTERN worked the whole day in cold air originating directly from the North-Pole. Between 04 and 13 UTC there were some scattered clouds in the sky only, reducing the solar income. The flux of the air-masses reaching our working area is illustrated in Fig. 2, comprising 108-hours-backward trajectories within 8 layers between surface and -50 hPa.

Direct solar radiation (dotted line) is roughly 900 W/m2, that is about 80% of the extraterrestrial radiation reaching the top of the atmosphere. The Linke-turbidity-factor TL (bold line) is throughout the day about 2. This value is representative for a clean unloaded atmosphere.

The spectral turbidity-factors Ts and Tr show a similar behaviour throughout the day:

T_S is about 1. This stands for an atmosphere that is absolutely free of any dust.

T_r is about 8, expressing a water-vapour content of a about 8 to 10 kg/m2. In the tropical Atlantic we obtained in the vicinity of the ITCZ values for Tr of 40 to 50. This stands for a water-vapour content of 40 to 50 kg/m2.

These findings are a good completion to the former results of the tropics found by Behr (1990, 1992).

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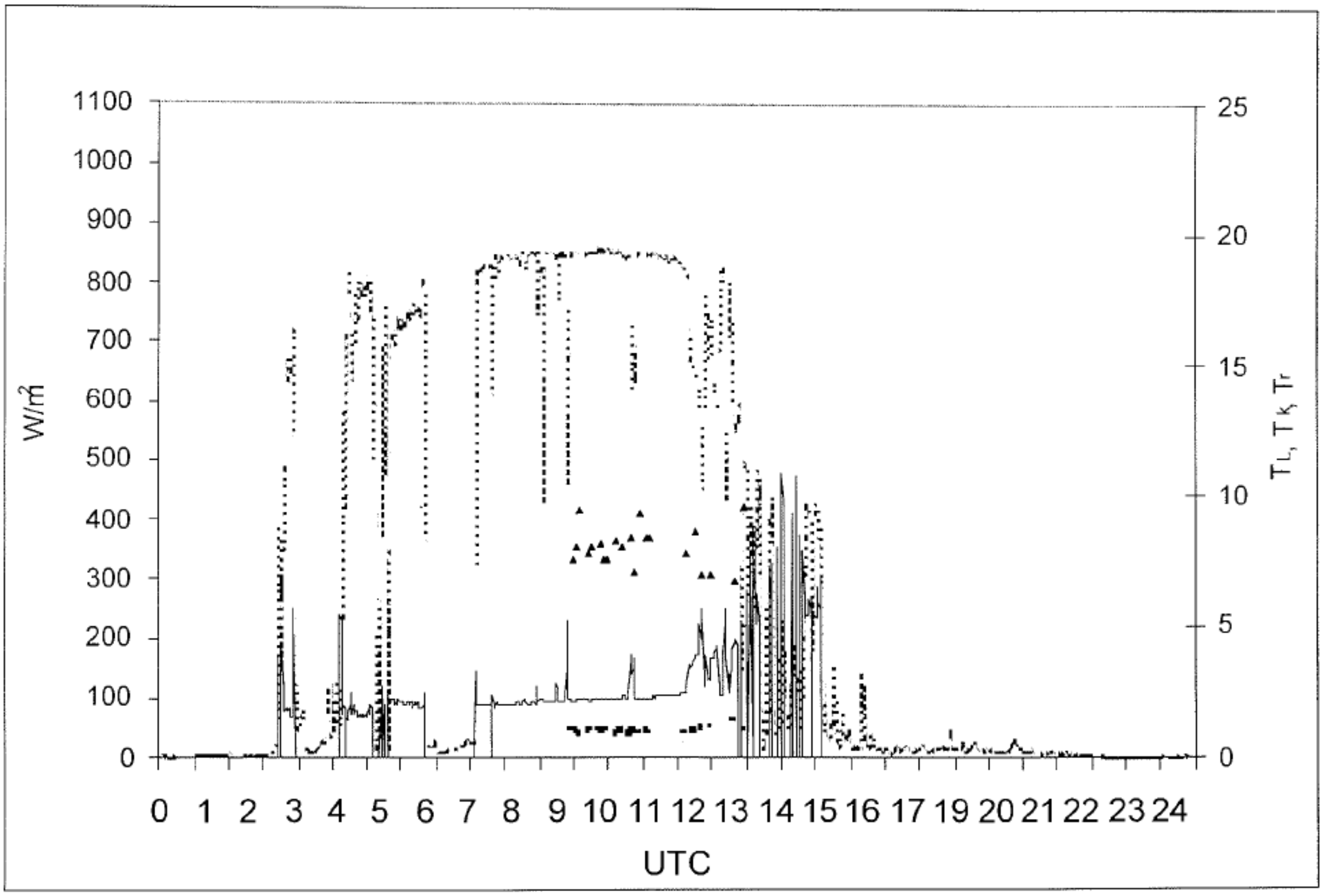

Fig. 1: Daily cycles of the turbidity factors TL, (bold line), Tk (•), and Tr (Δ) and of direct solar radiation (dotted line) on 3 Aug 2000. R/V Polarstern's position was at 79° 59' N / 4° 36'E.

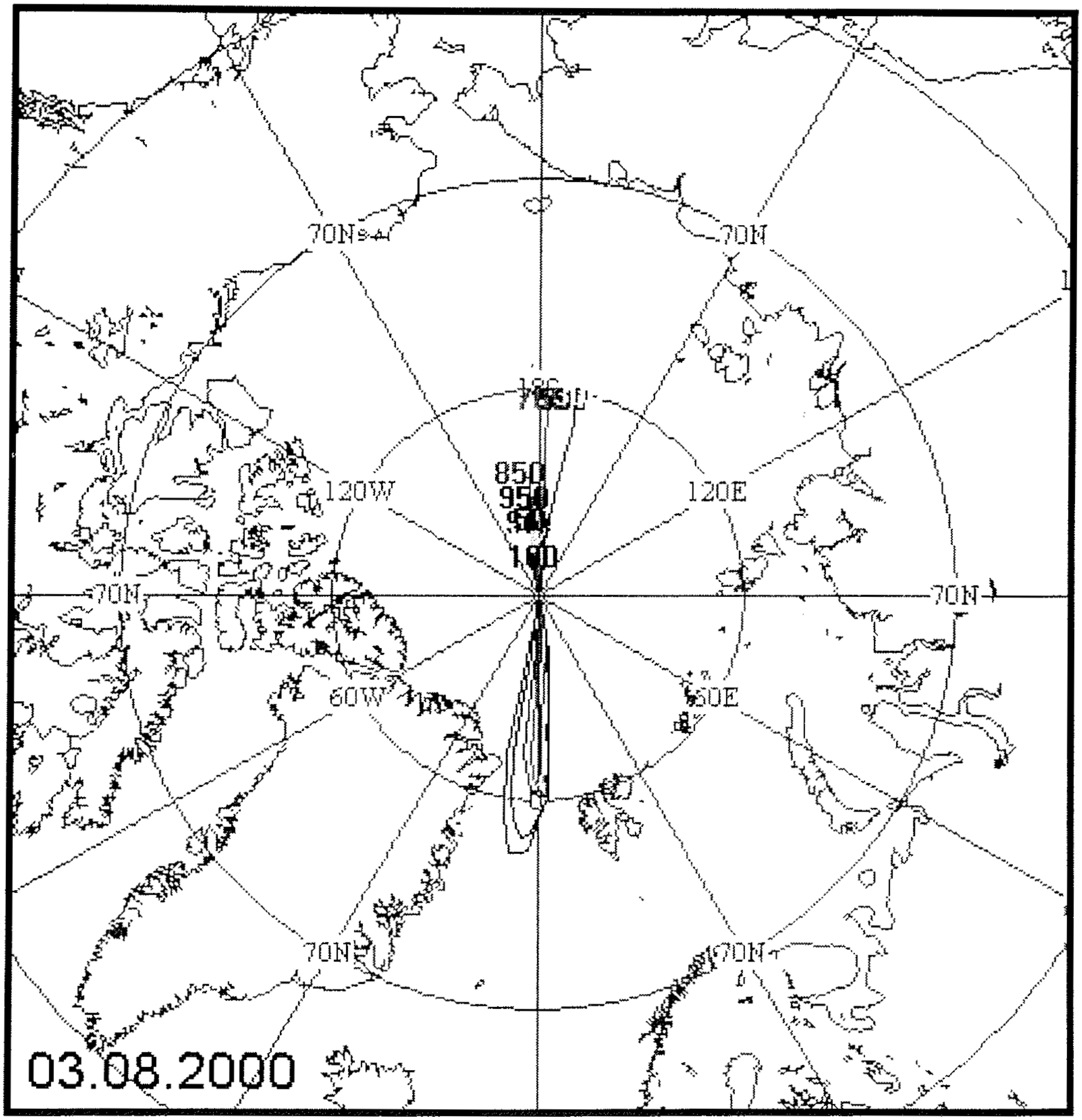

Fig. 2: Backward trajectories in different levels started 108 hours ago reaching the position of RIV Polarstem on 3 Aug 2000, 00 UTC. The pressure levels used are: surface, 950 hPa, 850 hPa, 700, 500 hPa, 300 hPa, 140 hPa, 100 hPa, and 50 hPa.

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ANNEX 3

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40.	2. Stwdess	Silinski, Carmen
41.	2. Stwdess	Neves, Alexandre
42.	2. Steward	Huang, Wu-Mei
43.	Laundrym.	Yu, Kwok, Yuen
44.	Apprentice	Kruse, Lars
45.	Apprentice	Wanke, Steffen

Annex 4

Station list ARKXVI/2

(see data files)

ANNEX 5

Recovered moorings

VEINS FRAM STRAIT

mooring	Latitude Longitude	Date/Time (UTC) of first record	Water Depth	Type	SN	Instru-ment Depth	Record length Days
V 1-3	78 50.27 N 8 38.50 E	14 Sep 99 9:27	266 m	Argos	# 144 ID	52 m	
				FSI	# 1565	63 m	321 d
				Microcat	# 218	65 m	321 d
				BB-ADCP UP	# 1561	105 m	321 d
				RCM7	# 9403	211 m	321 d
				RT 661	# 301		
				AR 261	# 25		
V 2-3	78 51.26 N 08 18.60 E	14 Sep 99 11:20	784 m	Argos	# 117 ID	35 m	
				FSI	# 1447	46 m	321 d
				Microcat	# 216	47 m	321 d
				RCM7	# 8401	277 m	no data
				Seacat	# 1167	773 m	321 d
				FSI	# 1442	775 m	321 d
				AR 261	# 24		
				AR 661	# 450		
V 3-3	78 50.29 N 07 57.41 E	13 Sep 99 2024	1023 m	Argos	# 166 ID	60 m	
				FSI	# 1450	71 m	322 d
				BB-ADCP UP	# 1563	143 m	322 d
				RCM7	# 8400	249 m	322 d
				BB-ADCP DOWN	# 1626	806 m	322 d
				FSI	# 1474	1013 m	322 d
				RT 661	# 238		
				RT 661	# 199		
V 4-3	78 50.10 N 06 55.39 E	16 Sep 99 15:55	1497 m	Argos	# 158 ID	48 m	
				FSI	# 1451	59 m	319 d
				RCM7	# 10929	240 m	319 d
				FSI	# 1324F	241 m	319 d
				FSI	# 1473	1486 m	319 d
				Seacat	# 1978	1487 m	319 d
				RT 161	# 886		
				RT 161	# 839		

V 5-3	78 49.14 N	16 Sep 99	1970 m	Argos	# 110	46 m	
	06 27.84 E	14:10			ID		
				FSI	# 1456	57 m	319 d
				RCM 8	# 12326	238 m	319 d
				FSI	# 1325F	239 m	319 d
				RCM 8	# 12333	1494 m	319 d
				FSI	# 1472	1960 m	319 d
				Benthos	# 774		
				Benthos	# 775		
V 6-3	78 49.96 N	16 Sep 99	2630 m	Argos	# 162	40 m	
	05 02.52 E	8:06			ID 10352		
				FSI	# 1553	47 m	323 d
				Microcat	# 227	48 m	323 d
				RCM 8	# 12329	238 m	323 d
				RCM 8	# 12328	1484 m	323 d
				FSI	# 1470		
				AR 261	# 27	2620 m	323 d
				AR 661	# 544		
V 10-3	78 59.74 N	20 Sep 99	2578 m	APL-ULS	# 25	55 m	322 d
	02 03.28 W	12:01		Argos	# 106	61 m	
					ID 24313		
				FSI	# 1567	68 m	322 d
				Microcat	# 225	69 m	322 d
				RCM 7	# 8050	249 m	322 d
				LR-ADCP UP	# 825	506 m	322 d
				RCM 8	# 12332	1512 m	322 d
				RCM 8	# 12330	2568 m	322 d
				AR 661	# 452		
				AR 261	# 17		
V 11-3	79 00.10 N	20 Sep 99	2376 m	Argos	# 041	40 m	
	03 05.45 W	15:27			ID 23050		
				DCM12	# 17	40 m	322 d
				CMR-ES 300	# 32	40 m	322 d
				Seacat	# 2414	57 m	322 d
				RCM 7	# 4040	58 m	322 d
				RCM 7	# 12643*	254 m	322 d
				RCM 7	# 12644*	1460 m	322 d
				RCM 8	# 12587	2366 m	322 d
				AR 661	# 577		

V 12-3	78 59.39 N	19 Sep 99	1832 m	Argos	# 048	49 m	
	04 10.95W	16:56			ID 29859		
				DCM 12	# 134	49 m	324 d
				CMR-ES 300	# 48	49 m	324 d
				Seacat RCM 7	# 2415	58 m	324 d
				RCM 7	# 9465*	59 m	324 d
				RCM 7	# 6798	305 m	324 d
				RCM 7	# 9708*	1511 m	324 d
				Microcat	# 224	1817 m	324 d
				RCM 8	# 10069	1822 m	324 d
				AR 661	# 30		
V 13-3	78 57.00 N	21 Sep 99	967 m	DCM 12	# 47	33 m	323 d
	05 21.09 W	13:27		CMR-ES 300	# 44	33 m	323 d
				RCM 7	# 8402	45 m	323 d
				Microcat	# 229	46 m	323 d
				RCM 7	# 12646*	221 m	323 d
				RCM 7	# 10909*	957 m	323 d
				AR 661	# 110		
V 14-3	79 00.64 N	21 Sep 99	286 m	CMR-ES 300	# 17	48 m	323 d
	06 49.23 W	20:53		Seacat	# 2416	59 m	323 d
				RCM 7	# 8396	60 m	323 d
				RCM 7	# 10907*	276 m	323 d
				AR 661	# 84		

Remarks: 2:water inside instrument
3: battery problems
*: Paddelrotor (RCM-instruments without index: Savoniusrotor)

Deployed Moorings

FRAM STRAIT

mooring	Latitude Longitude	Date/Time (UTC) of first record	Water Depth	Type	SN	Instru-ment Depth
F 1-4	78 50.33 N	18 Aug 00	258 m	Argos	# 108	34 m
	08 38.55 E	14:58			ID 5426	
				FSI	# 1551	45 m
				Microcat	# 211	46 m
				BB-ADCP UP	# 1561	95 m
				RCM 7	# 9401	202 m
				AR 361	# 18	
				AR 361	# 19	
F 2-4	78 50.37 N	18 Aug 00	794 m	Argos	# 105	45 m
	08 18.35 E	12:48			ID 24577	
				FSI	# 1557	56 m
				Microcat	# 212	57 m
				RCM 7	# 9402	256 m
				RCM 8	# 9767	782 m
				Seacat	# 1253	783 m
				EG& G	# 14104	
				EG& G	# 14105	
F 3-4	78 50.33 N	18 Aug 00	1031 m	Argos	# 169	43 m
	07 56.16 E	9:50			ID 10579	
				FSI	# 1559	54 m
				Microcat	# 213	55 m
				RCM 7	# 8370	264 m
				RCM 8	# 9561	1020 m
				RT 461	# 199	
				AR 261	# 22	
F 4-4	78 49.95 N	20 Aug 00	1481 m	Argos	# 167	32 m
	06 56.60 E	18:09			ID 10574	
				FSI	# 1560	43 m
				Microcat	# 214	44 m
				RCM 7	# 8367	233 m
				Seacat	# 2420	1469 m
				RCM 8	# 9770	1470 m
				Benthos	# 774	
				Benthos	# 775	

F 5-4	78 50.38 N	20 Aug 00	2470 m	Argos	# 164	46 m
	05 50.86 E	14:47			ID 10354	
				FSI	# 1561	57 m
				Microcat	# 215	58 m
				RCM 8	# 10004	247 m
				RCM 8	# 10503	1503 m
				RCM 8	# 10498	2459 m
				RT 161	# 840	
				RT 161	# 817	
F 6-4	78 50.01 N	04 Aug 00	2637 m	Argos	# 168	53 m
	05 02.53 E	15:21			ID 10575	
				FSI	# 1562	59 m
				Microcat	# 217	60 m
				RCM 8	# 1087	259 m
				RCM 8	# 9187	1515 m
				RCM 8	# 9185	2631 m
				RT661	# 373	
				RT 461	# 26	
				Pegel SB 26	# 258	2636 m
F 7-3	78 50.00 N	04 Aug 00	2319 m	Argos	# 147	70 m
	04 03.07 E					
				FSI	# 1563	76 m
				Microcat	# 220	77 m
				RCM 8	# 11887	266 m
				RCM 8	# 9783	1512 m
				RCM 8	# 9390	2308 m
				RT 661	# 374	
				RT 461	# 29	
F 8-3	78 50.00 N	06 Aug 00	2470 m	Argos	# 111	54 m
	02 33.70 E	821			ID 24314	
				FSI	# 15464	60 m
				Microcat	# 221	61 m
				RCM 7	# 8417	140 m
				RCM 8	# 11888	246 m
				RCM 8	# 116613	747 m
				RCM 8	# 9786	1503 m
				RCM 8	# 9782	2459 m
				AR661	# 544	
				RT 261	# 28	

F 9-3	78 56.60 N	07 Aug 00	2439 m	APL-ULS	#49	47 m
	00 22.50 W	10:40		Argos	# 112	53 m
				ID 8347		
				FSI	# 1566	59 m
				Microcat	#222	60 m
				RCM 8	# 9201	184 m
				RCM 8	# 11890	270 m
				RCM 8	# 10491	771 m
				RCM 8	# 9995	1527 m
				RCM 8	# 9184	2433 m
				RT661	# 238	
				Benthos	# 780	
				PeQel SB 26	# 257	2438 m
F 10-4	79 01.48 N	13 Aug 00	2554 m	APL-ULS	# 48	61 m
	02 01.57 W	18:38		Argos	# 119	67 m
						ID 7868
				FSI	# 1568	74 m
				Microcat	# 223	75 m
				NB-ADCP UP	# 378	254 m
				RCM 8	# 11892	511 m
				RCM 8	# 12324	1517 m
				RCM 8	# 9188	2543 m
				AR 261	# 25	
				Benthos	# 777	
F 11-4	78 59.93 N	13 Aug 00	2349 m	Argos	# 048	50 m
	03 04.32 W	14:46			ID 29859	
				DCM 12	# 134	50 m
				CMR-ES 300	# 45	50 m
				Seacat	# 1973	59 m
				RCM 7	# 11854	60 m
				RCM 7	# 11059	226 m
				RCM 7	# 9464	1432 m
				RCM 8	# 10071	2338 m
				AR 661	# 29	
F 12-4	78 59.84 N	13 Aug 00	1889 m	Argos	# 041	65 m
	04 05.74 W	11:17			ID 29050	
				DCM 12	# 47	65 m
				CMR-ES 300	# 37	65 m
				Seacat	# 1975	74 m
				RCM 7	# 11845	75 m
				RCM 7	# 10349	321 m
				RCM 7	# 7718	1567 m
				Microcat	# 226	1874 m
				RCM 8	# 11625	1878 m
				AR661	# 291	

F 13-4	78 59.59 N	09 Aug 00	982 m	CMR-ES 300	# 34	36 m
	05 24.63 W	15:30		RCM 7	# 10303	48 m
				Seacat	# 1254	49 m
				RCM 8	# 9765	235 m
				RCM 7	# 9706	971 m
				AR 661	# 292	
F 14-4	79 00.61 N	09 Aug 00	274 m	CMR-ES 300	# 19	45 m
	06 49.12 W	9:11		Seacat	# 1976	56 m
				RCM 8	# 9763	57 m
				RCM 7	# 11475	263 m
				AR 661	# 77	
FEvi-1	79 01.70 N	19 Aug 00	2456 m	Benthos 204-SRT # 196	171 m	
	04 20.86 E	22:05		sedimenttrap # 860018 (S/MT 240)	231 m	
				sedimenttrap # 890001 (S/MT 241 02)	2283 m	
				RCM 8	# 10873	2440 m
				RT 661	# 243	

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Data Type: Cruise Report
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