The Expedition ARKTIS XV/1 of RV „Polarstern" in 1999

Edited by Gunther Krause
with contributions of participants

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Cruise leg ARK XV/1 Bremerhaven - Tromsø
23.06.99 - 19.07.99
(G. Krause, Chief Scientist)

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1 Introduction

1.1 Summary

The most prominent event of this expedition was the first deployment of the French ROV "VICTOR 6000" from board of RV "Polarstern". It was carried out on the basis of a French-German cooperation between IFREMER and AWI. The mission was regarded as a feasibility study. The ROV was employed to explore regions suitable for a long-term study of benthic organisms in the Arctic Deep Sea, whereas the French party focussed on technical aspects such as handling procedures on board of a foreign vessel and performance under polar environmental conditions including ice coverage of the surface waters.

The extensive system (a total of 105 tonnes of material) was installed during "Polarstern's" stay in the shipyard whereby numerous modifications on board of the ship accrued. Favoured by calm weather conditions and little ice coverage all dives of "VICTOR 6000" were undisturbed and successful beyond expectations. The dives lasted between 15 and 26 hours. In the Molloy Deep the record depth of 5552 m was reached. Besides test dives "VICTOR" was employed 111 hours for scientific purposes.

In an area at 79°N west of Spitsbergen - now called the "house garden" - a frame with artificial substrates was deployed by the ROV for colonisation studies. Also cages covering small areas of the sea floor were left there for exclusion experiments. It is planned to revisit this site in 2001 to examine the changes which have occured in the meantime. The work aims at testing recent hypotheses on the patterns of life of the deep-sea faunal communities and their surprising biodiversity.

The observations on the various structures of the sea-floor, e.g. ripples, accumulation of stones, traces of bottom slides, which are stored on video tapes, will also be of interest to geological disciplines. The capability of the ROV "VICTOR 6000" to perform selective sampling and experiments has greatly increased the possibilities to perform novel process studies on the sea floor.

In view of the spectacular operations with the large ROV it should not be forgotten that "Polarstern" was used as a multi-disciplinary research ship as it is usual practice. During the total cruise the distribution of planktonic foraminifers was studied, and DNA-analyses were performed for their genetic characterisation. For research into the activities of the bacterial benthic and sea-ice flora numerous samples were collected and partly analysed on board. As in previous years the hydrographic section at 75°N was occupied with 62 CTD-stations. The data are required for a study on the ventilation and bottom-water renewal in the Greenland Sea.

1.2 Narrative of the cruise

For most members of the French team who were in charge to operate the ROV "VICTOR 6000", the cruise virtually began more than two weeks before "Polarstern" left her home port on June 23, 1999. Extensive installations of the ROV system on board and first tests of the deployment and recovery procedures under the quiet conditions in the harbour required a considerable time of preparation before "Polarstern" cast the lines.

Before the invaluable ROV was employed for its first dive, the handling of it was exercised several times at sea using a dummy with the same dimensions and mass as the real ROV. After only the first test it was – fortunately – discovered that the winch, used to launch the "VICTOR", was not functioning properly. The repair could not be made on board the ship. It

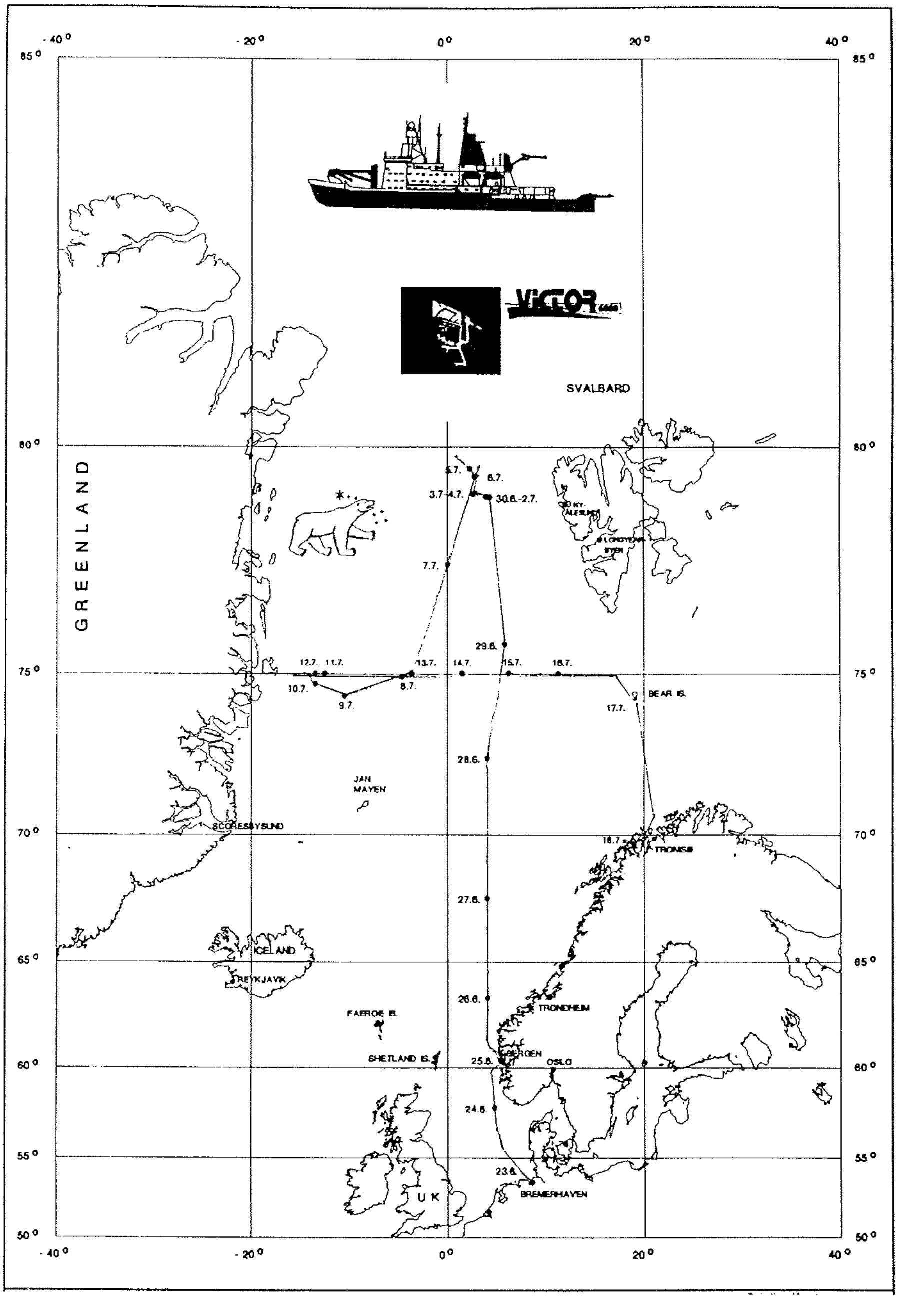

Fig. 1: Cruise track of the expedition

was necessary to stop over in Bergen for a replacement of the hydraulic motor that operates the winch. The weather was favourable, and only ten hours were needed for the replacement. On June 29, the first technical test dive down to the sea floor (2800 m) was successfully completed before the scientific dives in the Fram Strait began.

The deepest and longest dive of "VICTOR 6000" was performed into the Molloy Deep. It lasted for almost 27 hours, the maximum depth was 5552 m, and the temperature of the bottom water was - 0.7°C.
All of the dives were favoured by ice-free conditions or only little ice coverage. There so was much open water that even a small detour was required to take ice cores from a sufficiently large and thick ice floe at 79°50´N, 2°57´E.

From the northernmost position we moved south to the area around 75°N, 3°W to service two moorings. After a dive of the ROV into a canyon at the foot of Greenland´s continental shelf (74°22´N, 10°18´W) a second ice sampling station was done after some search for a suitable floe. At the beginning of the hydrographic section at 75°N, 16´W there was also little ice coverage. Only on the track towards the east along 75°N "Polarstern" steamed through a band of heavy ice which was about 20 miles wide.

During the CTD-work on 75°N the ROV-system was completely dismantled for unloading in Tromsø, where "Polarstern" arrived in the evening of July 18.

1.3 Weather conditions

In the beginning (June 23 and 24, 1999) RV "Polarstern" sailed through the North Sea along the east side of a high located over the British Isles with north-westerly winds of Bft 5. The high moved to Scandinavia so that the wind decreased and changed to easterly direction during the next days.

In the meantime an Atlantic gale center arrived over Iceland. Because the high blocked, the low swerved to the south-east. But on its frontal side secondary lows moved from eastern Europe to the southern Norwegian Sea. The increasing gradient caused an increasing wind up to Bft 6 for a short time.

While the high shifted eastward a new high was formed over the Greenland Sea on June 29, 1999. On its north-eastern side polar lows moved from the North Pole via Spitsbergen to the east. The combined fall of pressure resulted in a north-westerly airstream with Bft 6 for a short time, and the visibility changed from poor to good rapidly when the cold air entered.

On June 30 RV "Polarstern" arrived in the research area of Fram Strait. Up to July 4 a nearly stable weather situation prevailed. A high over Greenland was opposite to a low near the North Pole which was surrounded by troughs. Some of these pressure systems came off and moved south-eastward to the Barents Sea via Spitsbergen. In this connection the wind direction always changed from north-west to north-east. The windforce did not increase to more than Bft 4 because whenever a trough passed Spitsbergen the high over Greenland reduced its pressure on the same scale.

On July 5 RV "Polarstern" arrived at its northernmost position near 80° north. On her way to there it passed a field of small and medium ice floes.

The Greenland high drifted to Iceland, and on the next day it joined to the subtropical high that had moved to the Bay of Biscay some time before. A wedge extending to northern Greenland was almost stationary. Accordingly, the north-westerly airstream continued.

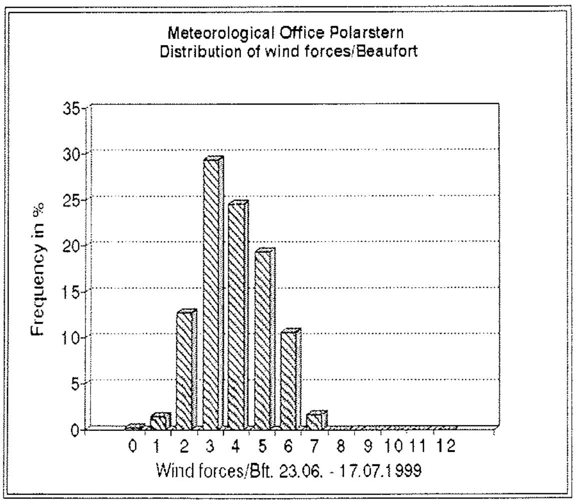

Fig. 1.1. Frequency distribution of wind strengths

Between Newfoundland and South Greenland the formation of a gale center began. It culminated on July 7 with a core pressure lower than 975 hPa south-east of Kap Farvel. At light reduction the eddy moved north-eastward slowly and pushed the offshore wedge to the north-east on July 8.

On the next day the occlusion crossed the research area with drizzle, rain and poor visibility. The easterly wind increasing up to Bft 6. After passing the front the wind veered south to south-west and decreased down to Bft 4 rapidly. The sea state decreased and only a 2 m swell was left.

The center of the low followed the next day. Drizzle and rain began once more. Light winds, from south-east first but north-east later, dominated. On the way to the start position of the hydrographic zonal transect on 75°N RV "Polarstern" passed a large field of several years old ice floes.

Over the Kara Sea a strong eddy developed, included the low mentioned above and moved to the North Pole slowly. Weak secondary lows followed from Denmark Strait via Jan Mayen to Barents Sea on July 11 and 12 with the result of northerly winds about Bft 4, a compact layer of low stratus clouds and moderate to poor visibility.

A change of weather conditions took place on July 13. West of the Hebrides a gale center formed with a weak high pressure wedge over the Norwegian Sea. In this connection the wind died down and changed to westerly direction slowly.

The low became stationary near Iceland but the warmfront moved northwards and crossed the northern Norwegian Sea at the night to July 16. On its front the wind changed to east and increased up to Bft 7. After its passing the wind decreased a little. Advection of warm air from south-east and sinking of air from higher tropospheric levels to lower levels resulted in a strong warming in the near surface atmosphere, but it did not reach the surface of the sea. An extremely strong inversion developed. The low tropospheric vertical minimum temperature was 5.5°C at 110 m whereas a maximum of 20.8°C occured at 556 m.

Meanwhile a wave had developed at the cold front over Norway. It moved north-westward and in cooperation with rising pressure over northern Siberia a strong gradient survived. After the wave had passed west of RV "Polarstern" the wind veered to south and decreased to Bft 3 to 4 in the morning of July 17 when the research programme ended.

2 Marine Biology

2.1 The Deployment of the French Remotely Operated Vehicle (ROV) "VICTOR 6000"

Within the frame of a Franco-German co-operation between AWI and IFREMER the French Remotely Operated Vehicle (ROV) "VICTOR 6000" (Fig. 1) was successfully deployed from board RV "Polarstern" during the polar expedition ARK XV/1 from 23.06. - 18.07.1999 to Fram Strait and the Greenland Sea. The use of a deep-diving ROV represents a remarkable step in German benthic deep-sea research (see also Chapter 2.1.6). In contrast to traditional observation/sampling methods (e.g. moored time-lapse cameras, towed photo/video systems, box and multiple corers), the ROV allows controlled optical surveys, a targeted sampling of water probes, sediments, and organisms as well as direct manipulation at the seafloor (installation of experiments), and thus opened new perspectives for innovative research projects in the deep sea.

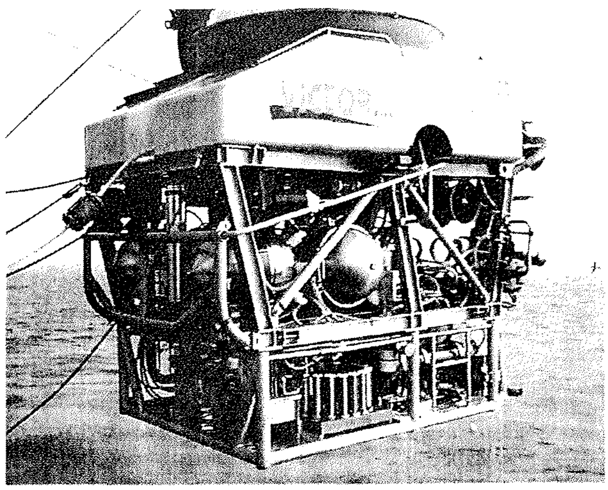

Fig. 2.1: The Remotely Operated Vehicle "VICTOR 6000"
For more pictures and information see: http://www.ifremer.fr/victor/polarstern/ARKXV1/

2.1.1 Preparation of the ROV system

(M. Nokin, IFREMER, B. Sablotny, AWI)

Due to the particularities of the expedition, a step by step program was carried out before starting the scientific dives. One of the first onboard activities were calibrations and tests of the recently installed underwater navigation system "POSIDONIA" on RV "Polarstern" to ensure safe operation of the "VICTOR" system. A dummy, similar to the vehicle in form and weight, was utilised during transit to Fram Strait for training and validation of the launching and recovery procedures from board RV "Polarstern".

A technical dive was carried out to test the system, to tune up the necessary co-ordination between the control container of the ROV and the bridge, and to verify the adequate performances of the ship in station keeping and trajectory control.

No technical or operational critical problems were to be faced on "VICTOR" during dives. In particular, the heading sensor of the vehicle (magnetic sensor) ran properly up to 79°N, and no difficulties with low temperature were encountered, knowing that on land trials a limit at –5°C was observed. Final qualification of "VICTOR" to its maximum depth (19h at 5500 m) was demonstrated during the scientific dives.

With a few exceptions, installation of the ROV onboard RV "Polarstern" can be considered as very satisfactory. This includes launching and recovery equipment, location of the different sub-systems and operational links between working areas (video and graphical displays, communication means). Some modifications or new arrangements discussed on board between AWI scientist and the IFREMER/ GENAVIR team could be envisaged for future expeditions.

In the same way, a specific procedure was tested to launch and to recover safely the system in ice-covered areas. This procedure will probably need some additional sensor (on the ship or on the vehicle) to determine the exact position of the vehicle related to the ship near surface, just before recovery. The experience gained during this expedition is fruitful and will allow to define appropriate equipment and procedures for deployment of "VICTOR" in marginal ice zone.

The excellent co-operation between the German and the French team made this first step a success which opens the way for future expeditions.

2.1.2 Scientific dives with the ROV system

(T. Soltwedel, AWI)

Favoured by optimum weather conditions (low sea states, almost no sea-ice in the diving areas), a total of five scientific dives were carried out at four different locations (Fig. 2.2): Dives 1 and 2 were conducted at about 2500 m water depth at the continental slope west of Svålbard (Site I; 79°04'N, 4°10'E). An area of approx. 5 km^2 was chosen to become a long-term station ("AWI Hausgarten") for multidisciplinary deep-sea research for the next 10 years; the ROV was used to perform a pre-site survey. Dive 3 was carried out in the nearby Molloy Deep (Site IIa; 79°08'N, 2°50'E), the deepest depression in the Arctic Ocean with a max. water depth of about 5600 m. The forth scientific dive led to the Hayes Deep (Site IIb; 79°28'N, 3°00'E), another deep basin in the same region, however smaller and shallower (3600-3700 m) than the Molloy Deep. The Molloy and the Hayes Deep are located in the vicinity of the Molloy Ridge, connecting the Spitzbergen and Molloy Fracture Zone. Finally, dive 5 was conducted in a deep canyon system at about 3150 m water depth on the Eastern Greenland continental rise (Site III; 74°24'N, 10°17'W).

Total diving time of "VICTOR 6000" for scientific purposes was about 111h; the ROV remained at the seafloor for more than 86h (Tab. 1). Individual diving times ranged between 15h and 26h (between 11h and 22h at the bottom). Maximum water depth during the dives was 5552 m (Molloy Deep). The ROV deployment in the Molloy Deep was the longest dive (more than 19h at the bottom) ever done by the system at such a great depth.

The dives were used to carry out large scale optical surveys to assess seafloor topography (including biogenic sediment structures) and abundances of large epibenthic organisms (megafauna). During dives 1, 2 and 5 the ROV followed a pre-planned zig-zag course (Fig. 2.2) allowing extrapolations on areal distribution patterns. Each ROV deployment was extensively used to conduct a targeted sampling of organisms and sediments with the help of coring devices, the "slurp gun" and the "pac-man" claw, all handled by the ROVs manipulator. In addition, water was sampled at different heights above the seafloor.

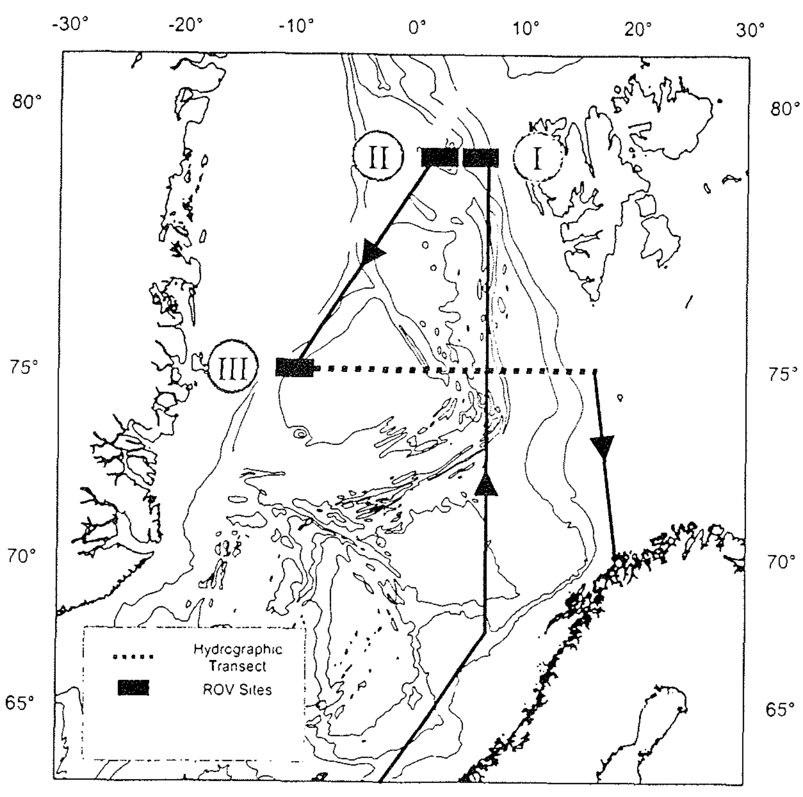

Fig. 2.2 Ship's track and ROV sites during ARK XV/1

During dive 2 the ROV was used to work in the surroundings of a metal frame, which was lowered to the seafloor with the ships winch. The frame carried various hard substrates (i.e. wooden, plastic and stone plates) for colonisation experiments, cages for exclusion experiments and packages of fish simulating large food-falls. The cages and the fish baits were distributed in the vicinity of the metal frame with the help of the ROV. It is intended to revisit this station in 1-2 years to control and/or terminate and evaluate the experiments.

Tab. 2.1: ROV deployments during expedition ARK XV/1

Dive	Location	Date	Remark	Latitude	Longitude	max. Depth	Dive Time [h:min] total	(at bottom)
1	Site I	30/06/99	Start	79°04.0 N	4°10.0 E			
	"Hausgarten"		Bottom	79°03.9 N	4°11.2 E	2517 m		
		01/07/99	Departure	79°03.9 N	4°11.1 E			
			Surface	79°04.2 N	4°13.4 E		25:20	(21:31)
2	Site I	01/07/99	Start	79°03.8 N	4°11.1 E			
	"Hausgarten"		Bottom	79°04.4 N	4°04.1 E	2458 m		
		02/07/99	Departure	79°03.9 N	4°05.9 E			
			Surface	79°04.5 N	4°06.0 E		14:48	(11:19)
3	Site IIa	03/07/99	Start	79°07.0 N	2°50.5 E			
	Molloy Deep		Bottom	79°08.3 N	2°33.7 E	5552 m		
		04/07/99	Departure	79°06.7 N	2°40.5 E			
			Surface	79°07.3 N	2°33.0 E		26:20	(19:10)
4	Site IIb	04/07/99	Start	79°28.0 N	3°00.0 E			
	Hayes Deep		Bottom	79°29.3 N	3°07.9 E	3612 m		
		05/07/99	Departure	79°27.8 N	2°42.0 E			
			Surface	79°27.8 N	2°44.0 E		22:57	(18:12)
5	Site III	09/07/99	Start	74°23.0 N	10°16.0 W			
	75°-Canyon		Bottom	74°22.8 N	10°18.7 W	3167 m		
		10/07/99	Departure	74°24.4 N	10°15.9 W			
			Surface	74°24.1 N	10°15.9 W		21:20	(16:18)

2.1.3 Large-scale assessment of megafauna

(H. Bluhm, AWI)

Megafauna investigations in the deep Fram Strait, started during ARK XIII/2 at the Yermak Plateau and the Molloy Deep, were continued during the expedition ARK XV/1. The objectives of these studies are to compare taxa compositions of the abyssal Fram Strait with those of other deep-sea regions and to achieve knowledge on the large-scale variability of species diversity and distribution of the megabenthos in polar waters and the world oceans.

The seafloor and its larger epifauna, animal trails and burrows as well as geological surface structures were mapped. "VICTOR 6000" was equipped with six video cameras: a main high-resolution pan and tilt CCD camera, starboard and port side cameras, cameras directed to the tool-sled, to the sample "carrousel" of the "slurp gun", and to the manipulator arm. An additional camera, oriented vertically to the seafloor, was attached to the metal frame at the starboard side close to the tool-sled. Four video channels were recorded by S-VHS video recorders resulting in 160 video tapes and image information from the seafloor and the pelagic domain of approx. 480 hours.

- *Large-scale video surveys*

The bottom was observed primarily with the main pan and tilt camera following zig-zag courses in a distance of approx. 1m above the seafloor. Its zoom capability allowed the observer to study single objects in detail. The changing oblique angles of the camera were helpful to identify the three-dimensional shapes of the fauna, so that at least at higher taxonomic levels, a determination of most of the specimens were achieved. A vertically orientated camera was used for continuous registration of the seafloor and its large epifauna. The video signals of the side- and downwards looking cameras were recorded to study the motion of swimming or drifting animals and to prolong the observation time for those animals passing the ROV.

- *Observation of the megabenthos and its behaviour*

Live observations of megafauna are needed to estimate the speeds of creation and life-spans of "lebensspuren" (feeding traces, trails and burrows), which determine the small-scale heterogeneity and biodiversity of the seafloor (ref. Chapter 2.1.4). The time periods the ROV was stopped to carry out animal and sediment sampling, were used to study the behaviour of the megafauna, such as isopods feeding on the seafloor and walking sea cucumbers. Due to the large zoom capability of the main CCD camera, animals of only 3mm body size could be observed

- *Sampling the megafauna*

The manipulator and the "pac-man" claw were used to pick up larger animals like sponges and crinoids. The organisms were stored in the large sample box integrated in the ROVs tool-sled. Small-sized specimens were sucked in with the "slurp gun".

- *First Results*

The first two dives were carried out in the "AWI-Hausgarten" (Site I). Differences in the species composition of the megafauna community of the northern, shallower (2300 m) and the southern, deeper part of this site (2500 m) were detected. The abundances of stalked ten-armed crinoids and sea cucumbers of the genus ?*Peniagone* (fam. Elpidiidae) increased with depth. At least three types of fish, cerianths, isopods, and octopods were found at this site. Sponges of different morphological types attached to hard substrates were observed frequently. During the second dive we met an accumulation of stones, densely covered by large plate-like sponges. "VICTOR 6000" followed this "reef"-like structure to obtain data of its extent and colonisation.

The overall dominance of sea cucumbers (probably *Elpidia glacialis*; fam. Elpidiidae) and small sized amphipods at the deepest part of the Molloy Deep (5552 m) was comparable to the findings of the ARK XIII/2 expedition, when a location at the eastern border of this deep was investigated. Human waste, mainly plastic sheets and bags, tree branches and wood logs were discovered at this study site. This material may have been transported with the Arctic ice drift and sunken after ice melting. In most cases the artificial hard substrates were colonised by anemones. Solitary Actiniaria with long trunks were found attached to the sediment, and a second type of sea cucumbers (fam. ?*Synallactidae*) occurred. During the whole dive no fish was observed.

In the Hayes Deep polychaete tubes occurred in high densities, however it is not clear how many were still inhabited by living organisms. Additionally, actiniarians, cerianths, amphipods, and shrimps were detected. Sometimes we observed octopods, sitting on the seafloor or drifting in a short distance above the sea floor, head and arms orientated to the sea floor.

At the eastern part of the video transect a rough bottom topography of dune-like waves, and rocks cracked into pieces were found. We hypothesised, that tectonic activity in the past should have occurred at this site, however those video recordings need to be analysed by geologists. After passing the deepest part of the Hayes Deep (3600 m) "VICTOR 6000" followed the transect to the West, up to a depth of approx. 2800 m, where a taxa composition comparable to the deep Site I ("AWI Hausgarten") was observed.

Site III is located between the East Greenland Current flowing in south-westerly direction, and the West-Spitsbergen current, which heads to the north-west. Influenced by the irregular topography the current regimes at the Hayes and the Molloy Deeps should be dominated by strong flows and local turbulences. Several fields of vertically orientated ripple marks found at a depth of approx. 3000 m at the western rise of the Hayes Deep supported this notion.

The last dive was carried out within a canyon system at approx. 75°N. Small sponges and cerianths occurred in small densities at the shallow parts of the video transect. In certain cases ophiuroids, anemones, crinoids, isopods, holothurians (*Elpidia glacialis*), fishes and trails of echinoids were encountered. Within the canyon high abundances of small ball-like sponges were detected frequently on the seafloor, associated to hard-substrates together with snail and bivalve shells.

2.1.4 Small-scale heterogeneity and diversity of meiofauna at the deep seafloor

(K. Vopel, T. Soltwedel, AWI)

Our investigation will provide basic data for a future project, giving information about the criteria for selection of samples, and extent and type of replication. We will test various assumptions embodied in modern hypotheses about the maintenance of high species diversity among the smallest metazoans at the arctic deep seafloor. Non-equilibrium theories are based on the idea that competition always leads to a reduction in diversity due to competitive exclusion. This is commonly mediated in practice because random disturbance effects prevent competitive exclusion from taking place, and hence raise diversity. High levels of disturbance will decrease diversity by knocking species out of the community. According to this theory, disturbance is the primary controlling agent of diversity and the relationship is complicated by maximum diversity being achieved by intermediate levels of disturbance. The disturbance agent can be biological as well as physico-chemical.

The best description we currently have of how high diversity in the deep-sea is maintained is the spatial temporal mosaic theory. This theory has been developed from research into deep-sea benthic macrofaunal diversity. It postulates the role of non-equilibrium patch effects. Small scale discrete disturbance operating within this low resource ecosystem can maintain high diversity by causing patches, each of which run through unique non-equilibrium cycles over different time scales. In this system, high species richness results because for every species somewhere reasonably nearby is a patch offering satisfactory conditions. Diversity apparently reflects the interaction of at least three different scales: interaction between patches, dispersal between patches and disturbance. Patch dynamics give a theoretical framework for testing how the small scale effects that influence individual specimens control diversity.

Organisms alter the seafloor of the deep sea in a variety of ways. They make burrows, sediment mounds, leave feeding traces and fecal castings, and build robust structures in which to live. Tubes and tests are produced by a variety of taxa, including arenaceous foraminifers, xenophyophores, and polychaetes. They vary from millimetres to several centimetres in length. Photographs show that these structures are common and are often the most conspicuous small-scale topographic features on the sea floor. In deep-sea sediments biologically produced structures can persist long enough to be viewed as habitat heterogeneity by other species in the community, and this source of patchiness was supposed to be important for structuring meiobenthic deep-sea communities. Sessile projecting structures and sediment depressions (agglutinating foraminifers, sponges, anemones, polychaete tubes, crinoids) might also effect communities through their interactions with near-bottom flow. These structures disrupt local patterns of flow, thereby altering particle deposition (patchy input of organic material) and erosion rates, as well as abundances of sedimentary microbes.

Since heterogeneity appears at the scale of the biological influence ("ambits") of individual organisms (on the order of centimetres in dimension) and structures are often relatively delicate mud aggregations which cannot be sampled with classical tools, the deployment of a Remotely Operating Vehicle became inevitable. A first survey revealed Sites I, II (a and b) and III as contrasting sites with respect to biologically produced habitat heterogeneity and the abundance of large mobile epifauna (LME). If, as in the theory, heterogeneity contributes to the maintenance of diversity, then a location that has more biologically produced habitat heterogeneity (Site III) should have the highest diversity. However, a decrease in diversity resulting from low biologically habitat heterogeneity at the Molloy and Hayes Deep (Sites IIa, b) is possibly counterbalanced by an increase in the diversifying effect of predation by holothurians.

During five dives of "VICTOR 6000" a total of 41 sediment samples were taken by means of small plastic tubes (length 40 cm, diameter 5.5 cm). Two conspicuous topographic features of the sediment and two sessile epifaunal species were repeatedly sampled using the ROVs manipulator arm and a 3CCD pan and tilt camera: (1) Isopod burrow-openings at 2517 m depth (Site I; continental slope west of Svålbard), (2) feeding traces at 5552 m depth (Site IIa, Molloy-Deep), (3) sea-anemones at 3612 m depth (1 cm diameter, Site IIb, Hayes-Deep), and (4) 1-3 cm diameter sponges at 3167 m depth (Site III; Eastern Greenland continental rise). Samples taken from the adjacent sediment served as control in each case. Additionally, one multiple corer was employed at every station. The cores were sub-sampled by means of syringes with cut off anterior ends, the top 5 cm being subdivided into slices with a thickness of 1 cm each. Samples will be analysed for chloroplastic pigments, proteins, phospholipids, water content, granulometric parameters and identity and abundance of meiobenthic metazoans. The data will be subjected to multivariate statistical analyses, which discriminate between sites based on the faunistic attributes. The community structure of meiobenthic metazoans can be displayed through clustering and ordination of samples. Species principally responsible for determining sample groupings will be identified and the community differences linked to patterns in the physical and chemical environment. Beside comparing meiobenthic communities at contrasting sites and analysing small sediment patches (topographic features, biogenic structures) for differences in community structure processes that control diversity can be investigated by carrying out "exclusion experiments". Therefore, we used the ROV to place six cages and five tubes (35 and 12 cm diameter) on the seafloor to prevent the enclosed meiobenthic communities from being preyed upon by LME. A new deployment of the ROV planned for 2001 will allow for precise sampling of these patches.

2.1.5 Dynamics and succession in colonisation of artificial hard-substrates and utilisation of large food-falls by benthic organisms in the Arctic deep sea

(M. Klages, AWI)

In the area of the benthic long-term station an experimental set-up was deployed at a depth of 2480 m. An aluminium-frame, 1.6m high and of hexagonal shape, each side 90 cm wide, carries 40 artificial hard-substrates to study the colonisation of uncovered areas by sessile species depending on hard bottom. Each of the 20 plates with dimensions of 25 x 25 cm and 24 x 11.5 cm are made out of perspex and bricks, respectively. Additionally, six pieces of wood (50 x 15 x 7 cm) were attached to the frame in order to follow the utilisation of this kind of carbon input into the deep sea. The colonisation experiment is part of a larger project where similar experiments were either initiated last year at some hundred metres of water depth on the deeper shelf of the Antarctic Weddell Sea or will start this year at King George Island in shallow water. Contrary to the assumed lack of pelagic larvae (Thorsons's rule) or demersal drifting stages of juvenile benthic species at high latitudes recent results indicate that considerable high numbers of larvae can be found during the Arctic summer season in the benthic boundary layer and at the surface of the Barents Sea. The aim of this bipolar project is to investigate whether there are similarities or dissimilarities in the dynamic and succession of the colonisation of such free areas in the two polar regions with different evolutionary history. Icebergs often carry numerous boulders and drop-stones, frozen into the ice while in contact to landmasses, which melt out over the open ocean and fall down to the seafloor. The lower number of icebergs in the Arctic as compared to the Antarctic supports one of our hypothesis for the Nordic experiment: hard substrates are rare in the Arctic deep sea and competition for this limited resource should be high. This will be checked by revisiting the deployment and sampling plates at regular intervals in the future.

The energy flow into the benthic ecosystem of the deep sea is partly driven by sinking carcasses of dead or dying vertebrates and invertebrates. The frequency of occurrence and the relevance of food-falls for the deep sea ecosystem is rather unknown. There are some theoretical calculations about the significance and the long-term effects of such events both for the highly motile scavengers such as amphipods and the less motile benthic community living at or in the sediment. Some yet unproven estimates argue that some kilograms of fish may me utilised within decades by the sediment community of the deep sea. The establishment of a long-term benthic deep sea station and the access to "VICTOR 6000" during the expedition was a good opportunity to start proving the above mentioned calculations and estimates. Four bundles of fishes, each weighing about ten kilograms were deployed at different spots around the steel-frame, and marked with a plastic marker dropped close to the bait by the ROV. These markers will enable us to localise the spots of food-falls even after years. It is planned for the future to collect sediment cores at these sites to analyse the species composition, their abundance and activity. Sediment cores were already taken during this cruise in the vicinity of the steel-frame and the same parameters will also been measured on them.

The high precision ultra short baseline navigation of "VICTOR" was used to deploy and recover some dead fishes simulating a food fall at about 2300 m water depth. The position of the dead fishes at the seafloor was marked and revisited after 12.5 hours, while in the meantime the ROV carried out video survey and sediment coring. Before recovery, the vehicle was directed to the marked position, the fishes were collected and transferred into the scientific tool-sled. The preliminary result is that some hundreds of amphipods belonging to two species of lysianassoid gammarids were collected in very good condition. Secondly, obvious differences in attack efficiency are visible. Whereas flatfish (*Limandes limandes*) was only partly utilised (roughly 15 percent of the ventral side was fed by the amphipods, nearly no success on the dorsal side) the deployed mackerel and cod were fed totally, so that only their skeletons remained.

2.1.6 Advantages of a deep-diving ROV over traditional sampling methods for deep-sea research and recommendations for future work

(H. Bluhm, M. Klages, T. Soltwedel, K. Vopel, AWI)

Operations of the French ROV "VICTOR 6000" during the expedition ARK XV/1 exhibited the great potential of a remotely operated system in deep-sea research. Comparing operational capabilities of traditional deep-sea observation and sampling systems with those of a deep-diving ROV, the advantages of the latter became evident:

- The operation time at depth of a ROV surpasses that of a manned vehicle by quite a considerable amount. A remotely operated device may uninterruptedly work at the sea floor for several days by the crew working alternating shifts on the ship. In this way the available ship time is used most efficiently.

- In contrast to towed photo/video systems, a ROV can be stopped during deployment in case an interesting object occurs, which then can be studied in detail. Animal trails can be followed by the ROV to its producers, providing insights in the creation processes of such structures.

- With the help of an accurate underwater navigation, a ROV is able to find back specific locations at the seafloor (which have been mapped during earlier deployments) and also to repeat transects at the bottom precisely (monitoring). Thus, ROVs allow to deploy e.g. small autonomous benthic stations (with cameras, sensors and/or short-term experiments), to carry out some other work at the seafloor (observations, sampling), and to recover the stations at the end of the ROV deployment.

- In contrast to the sampling with box corers or multiple corers, the ROV is able to carry out a targeted sampling of sediments and organisms on centimetre-scale (!) by means of coring devices, the "slurp gun", the "pac-man" claw (all handled by the ROVs manipulator) or directly with the manipulator arm.

- Probably the greatest advantage of the ROV is its capability to carry out manipulations in the water column or at the seafloor. Even complex experiments can be installed, maintained or terminated in a controlled manner.

A Remotely Operated Vehicle will not replace traditional observation sampling gears, however, the use of a ROV offered scientists the unique possibility to start innovative research projects in the deep sea.

For future deployments of "VICTOR 6000" within the frame of the Franco-German co-operation with IFREMER the AWI scientists and technicians would like to give the following recommendations for modifications and adjustments according to their specific requirements:

- *still camera or high resolution digital camera in vertical view:*

It appears that by now the use of digital cameras currently available doesn't fit the requirements of scientists working with underwater photographs (insufficient resolution). The vertical camera should be replaced by a still camera or at least by a digital camera with the highest resolution possible.

- *laser beams/grid for distance/size measurements:*

By now it is difficult to estimate distances to or sizes of objects (especially if there is no information about the zoom factor of the 'pan and tilt' main camera). We recommend to add laser beams or even a (pulsed?) laser grid for better spatial informations.

- *forward looking lights at the ROVs bottom:*

To make small bottom surface structures clearly visible to the main camera, forward looking lights at the ROVs bottom (low angle to the seafloor) should be installed to enhance optical contrasts.

- *'slurp gun' with larger opening:*

The 'slurp gun' appeared to be a useful tool for the collection of organisms. We recommend to optionally widen the inlet of this tool by a funnel to increase sampling efficiency.

- *automatic opening/closing of sampling box:*

The (on-command) automatic opening and closing of the large sampling box within the tool sled could probably save time (no time-consuming handling with the ROVs manipulator).

- *recovery of the ROV in the ice-upward-looking camera, distance sensors:*

For the recovery in heavy ice conditions the ROV has to be kept at depth till immediately before picking up the system. An upward looking camera and/or sonar could help to determine the exact position of the ROV in relation to the support vessel.

- *training of AWI scientist/technicians to use the ROVs manipulator:*

A training of scientist/technicians in the use of the ROVs manipulator might help not to disturb the ROV pilots.

- *checklist for scientist before deployment:*

To ensure that all scientific requirements to the ROV system are taken into consideration before deployment and to allow scientist to be aware of camera settings (i.e. field of view), we recommend to design a "checklist" for scientists working with the ROV.

2.2 Genetic characterisation of Arctic subpolar and polar planktonic foraminifers

(K. Darling, D. Kroon, UE/GI)

Objectives

Molecular genetic analysis of planktonic foraminiferal DNA has shown that many morphologically defined species found in the tropical, subtropical and transitional provinces represent complexes of different and often highly divergent types (genotypes). Some of these are now considered cryptic species.

An investigation of the morphologically-defined species *Globigerina bulloides*, *Turborotalita quinqueloba* and *Neogloboquadrina pachyderma*, found within the subpolar and polar provinces, shows that they also individually represent several different genotypes. The spatial distribution patterns of their genotypes in the surface waters of the Denmark Straits and Drake Passage indicate that the genotypes are not ubiquitous throughout the cool water provinces. In some cases, they exhibit distribution patterns suggestive of species with different ecological requirements. The objective of this project is to determine the full extent of genetic diversity within the Arctic planktonic foraminiferal assemblages and to determine whether their spatial distribution can be correlated with specific hydrographic and/or nutrient environments.

We have investigated the spatial distribution of planktonic foraminiferal genotypes at 6 m depth along the cruise track from ~63°N to the first station at ~79°N. The 15 multinet stations provide the opportunity to determine the vertical distribution of foraminiferal genotypes to a depth of 500 m. Results will be matched against CTD profiles and chlorophyll, silicate and phosphate data to provide a record of their ecological environment. Morphological data will be obtained from the digital video images taken prior to DNA extraction and also from Scanning Electron Micrographs.

Work at Sea

Pumped sample collection from 63°N to ~79°N.

Planktonic foraminifers were obtained by pumping uncontaminated sea water from 6m depth through a plankton net suspended over a sink inside the ship. Seven separate plankton samples were taken and specimens were identified individually by stereomicroscopy. The specimens were filmed using digital video imaging and then crushed and processed for DNA analysis. Bulk plankton samples were also taken for later scanning microscopy.

Multinet sampling.

Foraminifers from 13 of the 15 multinet stations were sampled for DNA analysis from 5 depth intervals (500-300 m, 300-200 m, 200-100 m, 100-50 m and 50-0 m). CTD profiles were taken in association with each multinet collection and water from the rosette-sampler used for chlorophyll, silicate and phosphate analysis.

Shipboard results

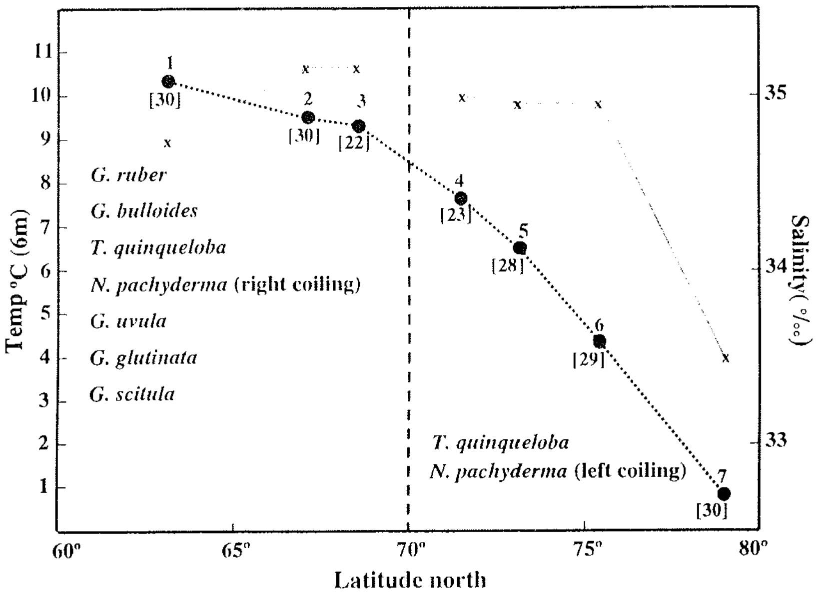

Fig. 2.3: Foraminiferal assemblages collected at 7 stations along the cruise track to ~79°N

Pumped samples

Fig. 2.3 shows the relationship between the foraminiferal assemblages collected at the 7 pumped stations along the cruise track to ~79°N. Temperature (closed circles) and salinity (crosses) of the North Atlantic surface water at each station and the number of individual specimens taken for DNA analysis are shown. At sampling stations 1-3, 7 morphospecies were identified and 82 specimens individually processed for DNA analysis. Between stations 3 and 4, the water temperature fell below 8°C and the foraminiferal assemblage changed from a diverse subarctic assemblage to an arctic assemblage represented only by the two morphospecies *N. pachyderma* and *T. quinqueloba*. The decrease in foraminiferal diversity coincides with a change in the coiling direction of the test of *N. pachyderma* from a right coiling population to a left coiling population.

The sample set obtained during this cruise uniquely provides the opportunity to determine the genotype diversity of planktonic foraminifers within the Arctic realm. The Arctic genotype distribution patterns will be compared to the Antarctic equivalents. Already, the DNA analysis of Antarctic *N. pachyderma, G. bulloides* and *T. quinqueloba* specimens indicates that an 8°C threshold temperature represents a change in foraminiferal genotype province. A similar transition temperature of 8°C has now been found in the Arctic waters. We anticipate that DNA analysis will also show a change in genotype within the morphospecies. Such distribution patterns are suggestive of cryptic species adaptation to different temperature conditions.

Within the Arctic foraminiferal province (stations 4-7), 83 individual specimens were identified and processed for DNA analysis. This data set will help to determine whether genotype provinces exist within the Arctic waters. The fall in salinity from an average of 35 ‰ at stations 1-6 to 33.5 ‰ at station 7 indicates that the assemblage at station 7 was collected in waters mixing with the cold arctic polar water of the East Greenland Current. Foraminifers collected in this region may indicate a further foraminiferal genotype province.

Multinet samples

Following the pumped stations (1-7), multinet samples were taken at four stations in close proximity within the cold, low salinity water. At least 4 specimens of *N. pachyderma* and 2 specimens of *T. quinqueloba* were picked from each depth interval. In total, 130 individual foraminifers were selected for DNA analysis. Before crushing, the morphology of the test of each specimen was recorded by digital video imaging.

A west to east transect was then sampled with 8 multinet stations at 75°N (Fig. 1). A total of 245 individual specimens of *N. pachyderma* and *T. quinqueloba* were selected for DNA analysis over five depth intervals. Before crushing, the morphology of the test of each specimen was also recorded by digital video imaging. This data set will show the pattern of distribution of genotypes within the water column which can then be related to the hydrographic and nutritional environment.

Conclusions

The data collected during this cruise will be invaluable for the determination of the true genetic diversity of planktonic foraminifers in the subarctic/arctic provinces. Without doubt, cryptic species will be discovered, enhancing the fact that protist diversity in the ocean is greater than morphological analysis indicates. This data set will also help to determine gene flow patterns in the ocean on a global scale, ultimately providing evidence for the mode of evolution within the marine environment. Further, increased knowledge of the adaptation of planktonic foraminiferal cryptic species should improve the resolution of palaeoceanographic studies.

2.3 Investigations of polar planktonic foraminifers in the water column

(E. Stangeew, J. Netzer, GEOMAR)

The goal of this project is to obtain a better understanding of the oxygen and carbon isotopic composition of living planktonic foraminifers in relation to the respective composition of the surrounding water. Sampling of the foraminifers and water was carried out as planned. Since the project was continued during the next leg, a coherent account will be published in the cruise report of the expedition ARK XV/2.

2.4 Sea ice and deep sea microbiology

(K. Berlitz, R. Brinkmeyer, E. Helmke, J. Jokiel, M. Wanger, AWI)

Our bipolar studies on bacterial sea ice as well as deep-sea communities were continued during this leg. The sea ice studies focused on two multiyear sea ice floes with sediment intrusions and fresh water pools on top of the ice floes. Brine salinity, bulk salinity of melted sea ice and pH were determined every 10 cm along the 3.5 m long ice cores. The other general ecological parameters as POC, PON, chlorophyll *a* and total bacterial counts were analyzed only on selected ice horizonts. Comprehensive studies on the structure and function of the bacterial communities were conducted on three of four ice core sections respectively, as well as 2 melt ponds and sea water adjacent to the ice. To obtain information about the taxonomic diversity of the different bacterial communities and the phylogeny of the different community members, DNA extractions as well as in situ hybridizations by rRNA-targeted fluorescent oligonucleotide probes (FISH) were prepared. Cultural approaches (MPNs) with different substrate qualitities and quantities, varying salinities and temperatures were performed to gain insights into the physiological potentials of the communities. The in situ function of individuell cells or taxonomic groups was analyzed by means of FISH combined with autoradiography and enzymatic determinations respectively. Bulk activities were estimated by means of thymidine and glucose incorporation under simulated in situ conditions. Part of the sea ice studies had an applied research aspect with the aim to detect protective and defensive reactions of the bacteria based on the production of new bioactive substances applicable in the agriculture and pharmaceutical industries. Specific enrichment cultures were prepared to isolate such bacteria.

Due to relatively slow growth of the cold adapted bacteria all the culture approaches could not be evaluated on board and the genetic analyses must be completed in the home laboratory. Preliminary results are only available from the bulk activity measurements. They indicate that even the poorly colonized upper sea ice sections and melt pools had reasonable bacterial activities.

The deep sea studies focused on water samples taken with the CTD-rosette sampler on 4 stations at six different water depths as well as on sediment and overlaying water samples collected with the multicorer. With these decompressed samples secondary production, glucose turnover, and cultural approaches were conducted at different temperature and pressure conditions. By means of these experiments and cultures, we will broaden our knowledge about structure of the deep sea communities and about the potential function as well as origin of the different community members. The overlaying water samples collected with the MUC were compared with the overlaying water samples taken by the ROV "Victor 6000". Some of the "Victor 6000" water samples were collected directly in the surrounding of biological turbation, which is a supposition for studying "deep sea gradients". A piece of wood with strong indications of microbial degradation was collected with the ROV in the Molloy Deep. Different culture approaches and molecular biological preparations were performed with the wood to find out if deep sea adapted bacteria accumulate on substrate which is untypical for the deep sea, and if lignin degradation occurs.

The question of whether decompression sensitive bacteria exist was followed up by means of water samples taken with the reconstructed pressure retaining water sampler. The water sampler was used at two deep sea stations. However, clear evidence for the existence of a decompression sensitve bacterial flora was not obtained. A sediment corer for the determination of microbial activity in situ was deployed for the first time in the deep sea. Unfortunately, technical problems were encountered at a depth of 5200 m. Subsequent deployments at shallower depths were successful.

3 Physical Oceanography

(G. Budéus, R. Plugge, S. Ronski, S. Schmidt, AWI,
E.R. Rodriguez, I. Tutivén, UDEC)

General

The work of the Physical Oceanography group concentrated on the study 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 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 XV/1 the time series was continued by an east west transect across the Greenland Sea at 75°N (Fig. 1). Two moored deep sea profilers were recovered and two were deployed.

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 12 bottles of 2.5 L content. The equipment worked faultlessly.

For temperature calibration an SBE35 Ultra Precision Deep-Sea Thermometer was applied. The thermometer is triggered by the SBE32 rosette each time a bottle is fired and it stores measured temperatures internally.

Comparisons between SBE35 and CTD measurements have been restricted to depth levels below 2000 dbar 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 guarentee temperature fluctuations to be 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 is 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 they 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.

Moorings

Two JoJo-moorings deployed in 1998 have been replaced successfully (74°55'N, 04°20'W and 75°05'N, 03°20'W). The recovered moorings were principally intact, however failed to profile regularly due to minor mechanical problems, which could be identified already during the cruise. Parking positions of the vertically profiling CTDs were one at the top, the other at the bottom, where the instruments sampled their respective time series. The downward and upward speeds of the vehicles were with 0.75 and 0.25 m/s excellently adjusted.

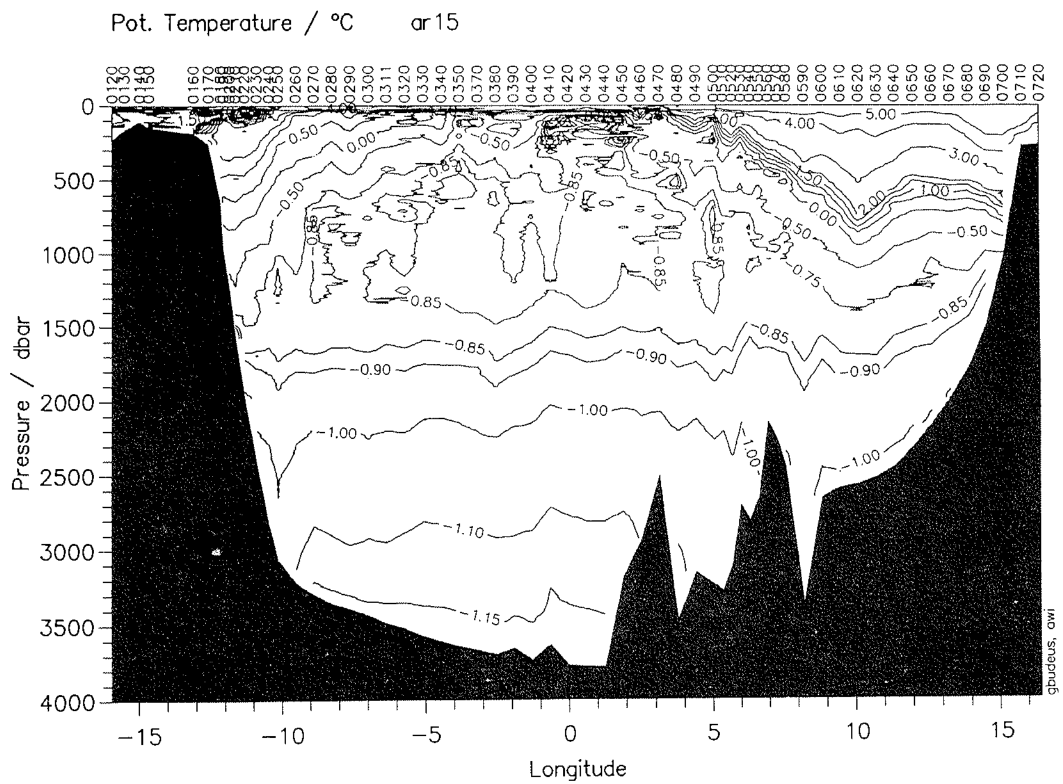

Fig. 3.1 Potential temperature for the transect at 75°N (preliminary data, not finally calibrated)

CTD station work

The transect on 75°N extends from the East Greenland to the Norwegian shelf and comprises 61 stations. 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 nevertheless.

The upper waters show little modifications with respect to salinity, indicating that winter convection did not suffice to introduce lower salinity waters into depths exceeding some hundred meters. Consequently, the underlying temperature minimum layer, which had been ventilated partly in winter 1996/1997, is getting slowly warmer, showing now temperatures of about -0.85 °C in contrast to values below -0.9°C during 1998. The intermediate temperature maximum at roughly 1500 m depth stands out less prominently therefore, but still persists.

From 1998 to 1999, modifications of the deepest parts of the water column are small but significant. While the isotherms of the deep waters were level over the central gyre, a slight depression is now observed (e.g. the -1.15°C isotherm in Fig. 3.1). The cause of the temperature increase has to be carefully identified after the final calibrations will have been applied.

A small number of CTD measurements has also been taken at stations where dives of the ROV "VICTOR 6000" have been performed. A surprising increase in deep water temperatures has been observed there in comparison to previous years, most probably indicating an advance of warmer arctic deep waters towards the south.

4 Station list

Date	Station	Time	Latitude	Longitude	Depth	Equipment employed
30.06.	001	08.50	79° 03,8' N	004° 25,2' E	2314	MN 500, CTD 500
		10.50				VICTOR deployed
01.07.		13.07				VICTOR on deck
		13.30	79° 04,5' N	004° 14,5' E	2383	MUC
		18.47				VICTOR deployed
02.07.		10.15				VICTOR on deck
	002	13.46	79° 07,9' N	002° 30,7' E	5263	MN 500
		14.56				CTD
		17.45				MUC
		21.15				ISIS
03.07.		05.16				PWS
		10.23				VICTOR deployed
04.07.		13.14				VICTOR on deck
		14.00				MN 500
	003	18.09	79° 28,0' N	002° 59,4' E	3668	CTD, MN 500, MUC
05.07.	004	06.30	79° 50,0' N	002° 57,0' E	2375	ICE-station begin
		10.00				end
	005	14.24	79° 29,9' N	003° 10,2' E	3352	VICTOR deployed
06.07.		13.43				VICTOR on deck
	006	17.00	79° 40,2' N	003° 17,0' E		CTD 500, MN 500,
		21.00				CTD,PWS
07.07.		00.45	79° 40,9' N	003° 11,5' E		PWS on deck
08.07.	007	06.00	75° 04,5' N	003° 27,1' W	3684	JoJo-mooring
		07.07				recovered
	008	08.15	75° 04,6' N	003° 26,7' W	3684	JoJo-mooring deployed
		09.50	75° 04,63' N	003° 26,7' W	3686	Mooring released
	009	12.32	74° 54,8' N	004° 37,4' W	3627	JoJo-mooring
		14.10				recovered
09.07.	010	00.38	74° 24,4' N	010° 18,7' W	3224	MUC
		08.55	74° 21,8' N	010° 18,2' W	3145	VICTOR deployed
10.7.		06.34				VICTOR on deck
	011	15.47	75° 02,3' N	014° 23,4' W	169	ICE-station begin
		17.43				end
	012	20.05	75° 00,0' N	015° 56,0' W	244	CTD
		20.15				
	013	21.15	75° 00,1' N	015° 32,8' W	181	CTD, ISIS
		21.55				
	014	23.15	75° 00,1' N	015° 02,0' W	123	CTD
		23.22				

11.7.	015	00.45 00.54	75° 00,1' N	014° 19,8' W	161	CTD
	016	03.10 03.20	75° 00,0' N	013° 40,6' W	191	CTD
	017	05.27 05.40	74° 59,9' N	013° 07,0' W	259	CTD
	018	06.31 07.01	74° 59,9' N	012° 43,0' W	645	CTD
		07.08 07.54	74° 59,7' N	012° 43,9' W	635	MN
	019	08.30 09.15	75° 00,0' N	012° 31,9' W	985	CTD
		09.55 10.45	75° 00,0' N	012° 32,0' W	971	MN
	020	11.25 12.11	75° 00,1' N	012° 20,8' W	1250	CTD
	021	12.51 13.41	75° 00,1' N	012° 06,0' W	1617	CTD
	022	14.21 15.29	75° 00,1' N	011° 46,9' W	2017	CTD
	023	16.28 17.37	75° 00,0' N	011° 20,4' W	2438	CTD
	024	18.35 19.52	75° 00,0' N	010° 54,8' W	2844	CTD
	025	20.40 22.10	74° 59,9' N	010° 34,7' W	3084	CTD
		22.20 23.10	74° 59,7' N	010° 38,3' W	3079	CTD
12.07.	026	00.42 02.11	75° 00,0' N	009° 57,1' W	3228	CTD
	027	03.20 04.47	75° 00,1' N	009° 18,0' W	3311	CTD
	028	05.54 07.23	75° 00,0' N	008° 39,8' W	3372	CTD
	029	08.35 10.10	75° 00,0' N	008° 03,6' W	3408	CTD
	030	11.30 13.07	75° 00,2' N	007° 24,2' W	3510	CTD
		13.23 14.15	75° 00,1' N	007° 23,8' W	3449	MN
	031	15.34 17.16	74° 59,9' N	006° 43,9' W	3500	CTD
	032	18.26 20.05	75° 00,0' N	006° 05,3' W	3535	CTD
	033	21.15 22.50	75° 00,0' N	005° 27,9' W	3583	CTD
13.07.	034	00.00 01.34	57° 00,3' N	004° 50,6' W	3622	CTD
	025	02.48 04.29	75° 00,2' N	004° 09,3' W	3652	CTD

13.07.	036	06.09	74° 55,0' N	004° 37,2' W	3623	JoJo-mooring deployed
		09.00	74° 55,0' N	004° 37,0' W	3624	Mooring released
	037	11.05	75° 00,0' N	003° 33,4' W	3678	CTD
		12.50				
		12.58	75° 00,4' N	003° 33,1' W	3677	MN
		13.47				
	038	15.05	75° 00,1' N	002° 51,9' W	3702	CTD
		16.48				
	039	18.03	74° 59,9' N	002° 13,0' W	3659	CTD
		19.43				
	040	20.50	75° 00,1' N	001° 36,0' W	3746	CTD
		22.25				
	041	23.40	75° 00,0' N	000° 57,3' W	3655	CTD
14.07		01.15				
	042	02.25	74° 59,9' N	000° 16,9' W	3783	CTD
		04.00				
	043	05.04	75° 00,0' N	000° 21,3' E	3800	MN
		05.50				
		06.00	75° 00,1' N	000° 21,7' E	3789	CTD
		07.47				
		07.55	75° 00,2' N	000° 22,2' E	3785	MN
		08.05				
	044	09.25	75° 00,2' N	000° 58,9' E	3792	CTD
		11.04				
	045	12.16	75° 00,0' N	001° 38,1' E	3178	CTD
		13.49				
	046	15.01	75° 59,9' N	002° 16,8' E	2969	CTD
		16.21				
	047	17.32	75° 00,0' N	002° 56,5' E	2526	CTD
		18.40				
	048	19.47	74° 59,9' N	003° 34,2' E	3483	CTD
		21.20				
	049	22.20	75° 00,1' N	004° 10,3' E	3169	CTD
		23.41				
15.07	050	00.53	75° 00,1' N	004° 52,3' E	3248	CTD
		02.17				
	051	02.58	75° 00,1' N	005° 11,0' E	3298	CTD
		04.31				
		04.39	75° 00,7' N	005° 09,0' E	3170	MN
		05.29				
	052	06.26	74° 59,8' N	005° 29,6' E	3124	CTD
		07.49				
	053	08.38	75° 00,4' N	005° 48,4' E	2599	CTD
		09.48				
	054	10.37	74° 59,9' N	006° 07,6' E	2873	CTD
		11.55				
	055	12.37	75° 00,2' N	006° 29,1' E	2658	CTD
		13.58				
	056	14.38	75° 00,1' N	006° 47,8' E	2228	CTD
		15.40				

15.07.	057	16.24	75° 00,0' N	007° 08,3' E	2269	CTD
		17.32				
	058	18.11	75° 00,1' N	007° 26,0' E	2483	CTD
		19.20				
	059	20.22	75° 00,0' N	008° 02,5' E	3396	CTD
		21.51				
	060	23.16	74° 59,5' N	008° 43,0' E	2679	CTD
16.07		00.27				
	061	01.47	75° 00,1' N	009° 22,0' E	2605	CTD
		02.58				
	062	04.20	75° 00,1' N	010° 00,7' E	2586	CTD
		05.34				
	063	06.44	75° 00,0' N	010° 39,0' E	2542	CTD
		08.00				
		08.15	74° 59,9' N	010° 37,8' E	2546	MN
		09.00				
	064	10.22	75° 00,5' N	011° 17,7' E	2458	CTD
		11.30				
	065	12.45	74° 59,9' N	011° 56,4' E	2343	CTD
		13.49				
	066	14.58	75° 00,1' N	012° 34,6' E	2189	CTD
		16.03				
		16.12	75° 00,4' N	012° 33,6' E	2190	MN
		17.00				
	067	18.15	74° 05,6' N	013° 14,0' E	2018	CTD
		19.15				
	068	20.27	75° 00,1' N	013° 49,8' E	1815	CTD
		21.15				
	069	22.35	74° 59,6' N	014° 29,0' E	1840	CTD
		23.20				
17.07	070	00.33	75° 00,1' N	015° 09,7' E	1032	CTD
		01.05				
	071	02.10	75° 00,2' N	015° 48,8' E	285	CTD
		02.25				
	072	03.36	74° 59,9' N	016° 27,6' E	277	CTD
		03.50				
		03.59	75° 00,0' N	016° 27,8' E	276	ISIS
		04.58				
	073	06.04	75° 00,0' N	017° 06,1' E	165	CTD
		06.14				

Abbreviations

CTD Instrument system to measure vertical profiles of temperature and conductivity and to collect water samples, Seabird 911 plus, calibration thermometer SBE 35, Seabird Mini-Rosette with 12 bottles, 2.5 l each.
ISIS In-Situ-Incubation-Sampler
MN Multi-Net
MUC Multi-Corer
PWS Presssure Water Sampler
The number following MN and CTD indicate the maximum depth to which the devices were used

5 Participants

Name		Institution
1.	Artzner, Laurent	GENAVIR
2.	Becker, Tobias	RB
3.	Beraud, Severine	GENAVIR
4.	Berlitz, Katrin	AWI
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6.	Brinkmeyer, Robin	AWI
7.	Budéus, Gereon	AWI
8.	Cadiou, Jean François	IFREMER
9.	Chopin, Jean Pierre	GENAVIR
10.	Christophe, Alain Jacques	GENAVIR
11.	Coail, Jean Yves	IFREMER
12.	Compagnot, Norbert	GENAVIR
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14.	Crozon, Jaques	IFREMER
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16.	Gilliotte, Jean Pierre	IFREMER
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27.	Luccioni, Marc	IFREMER
28.	Martossini, Henri	IFREMER
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31.	Nokin, Marc	IFREMER
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39.	Sonnabend, Hartmut	DWD
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44.	Tutiven, Isabel	AWI/UDEC
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47.	Wodtke, Wolfgang	RB

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UE/GI	University of Edinburgh Grant Institute Dept. of Geology and Geophysics West Meins Road Edinburgh EH9 3JW Scotland	2

7 Ship's crew

Rank	
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1. Offc.	Grundmann, Uwe
1. Offc.	Rodewald, Martin
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2. Offc.	Peine, Lutz
2. Offc.	Thieme, Wolfgang
Doctor	Mecklenburg, Gerd
R. Offc.	Hecht, Andreas
2. Eng.	Delff, Wolfgang
2. Eng.	Folta, Henryk
2. Eng.	Simon, Wolfgang
Electron.	Baier, Ulrich
Electron.	Dimmler, Werner
Electron.	Fröb, Martin
Electron.	Holtz, Hartmut
Electron.	Muhle, Helmut
Electron.	Piskorzynski, Andreas
Boatsw.	Loidl, Reiner
Carpenter	Neisner, Winfried
A.B.	Bäcker, Andreas
A.B.	Bastigkeit, Kai
A.B.	Bohne, Jens
A.B.	Hagemann, Manfred
A.B.	Hartwig, Andreas
A.B.	Moser, Siegfried
A.B.	Schmidt, Uwe
A.B.	Winkler, Michael
Storek.	Beth, Detlef
Mot-man	Arias Iglesias, Enr.
Mot-man	Dinse, Horst
Mot-man	Fritz, Günter
Mot-man	Giermann, Frank
Mot-man	Krösche, Eckard
Cook	Fischer, Matthias
Cooksmate	Möller, Wolfgang
Cooksmate	Müller-Homburg, Ralf
Cooksmate	Tupy, Mario
1. Stwdess	Dinse, Petra
Stwdess/Kr	Brendel, Christina
2. Stwdess	Huang, Wu-Mei
2. Stwdess	Schmidt, Maria
2. Stwdess	Silinski, Carmen
2. Stwdess	Streit, Christina
Laundrym.	Yu, Kwok Yuen

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