Scientific Cruise Report of the 1991 Arctic Expedition ARK VIII/2 of RV „Polarstern“

(EPOS II: Study of the European Arctic Shelf, “SEAS”, of the European Science Foundation)

Wissenschaftlicher Fahrtbericht über die Arktis-Expedition ARK VIII/2 von 1991 mit FS „Polarstern“

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with contributions of the participants

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F - 67 000 France

Contents Page

1. Introduction

The northern Barents Sea and and the ice-covered area at its continental slope down to the Nansen Basin are important transition zones between the eastern high Arctic and the seas strongly influenced by the North Atlantic Current system. Although there has been much effort especially by Norwegian and Russian researchers, but also of other countries, to describe and understand the ecology of the Barents Sea and the waters around Svalbard, our knowledge about the northernmost part of this area is still poor and mostly restricted to single or a few compartments of the whole ecosystem.

The second leg of the 1991 cruise of the German RV "Polarstern" gave an opportunity to a multi- and interdisciplinary endeavour to enlarge our ecological knowledge of the northern Barents Sea and adjacent waters, including physical and chemical oceanography as well as marine geology.

Such an enterprise is regarded an international challenge and should help to bring together scientists from eastern and western countries as well. The European Science Foundation (Strasbourg), based on the experience from the first European "Polarstern" Study (EPOS I, 1988/89) of the Weddell Sea, acknowledged this new initiative, included it into its Scientific Programmes and offered substantial support.

In addition, due to agreements between the Alfred-Wegener-Institute, the Murmansk Marine Biological Institute of the Academy of Sciences of the USSR and the Arctic Ecology Group of the Institute of Oceanology of the Polish Academy of Sciences, there was some cooperation in oceanography and biology between the research vessels "Polarstern", "Dalnie Zelentsy" and "Oceania" in the central, western and eastern Barents Sea.

2. Summary and Itinerary (E. Rachor)

2.1 Research Area and Targets

The eighth Arctic expedition of the German RV "Polarstern" in the summer of 1991 in total covered a wide range of the Arctic Ocean:
The first leg (ARK VIII/1) brought "Polarstern" to the Fram Strait in the Greenland Sea, an area, where the main outflow of Arctic waters from the Arctic Ocean occurs.
The second leg (ARK VIII/2), going to the central and northern Barents Sea including its continental slope, met the areas, where the largest amounts of Atlantic water enter the Arctic Ocean.
Thereafter, ARK VIII/3 covered a substantial, hitherto poorly investigated portion of the deep Arctic Mediterranean even beyond the North Pole, thus connecting the research areas of the first two legs (see Ber. Polarforsch. 107).

This report deals with the second leg, the second European "Polarstern" Study (EPOS II), patronized by the European Science Foundation as an ecological Study of the European Arctic Shelf (SEAS).

Research started in the frontal zone and near the ice edge in the central Barents Sea, where Atlantic and Arctic water masses meet. It included extensive hydrographic, chemical, planktological, benthological and sedimentological work; ice research was initiated.
The biological phenomena studied comprised phyto- and zooplankton distribution, composition and productivity; vertical particle flux; microbial and animal activity patterns influencing nutrient fluxes at the sea floor; zoobenthos community structures, and interrelationships of invertebrate benthos and fishes and biogeographical aspects of distribution. All this biological work focussed on production, consumption, transformation, and especially the vertical flux of organic matter (pelago-benthic coupling) as well as advective processes related to the interference of different water masses in the area. Benthic studies were intended to relate structural features and processes at the bottom with the vertical and advective particle fluxes.

In the Storfjord and thereafter in the area north of Spitsbergen, in addition to these biological objectives, the formation and circulation of cold, dense bottom water was one main objective of the oceanographers and, in addition, the description of the circulation of Atlantic water along the northern shelf slope. The advective processes related to these water motions are regarded as essential for the renewal of the bottom water of the deep Arctic Ocean as well as for the transport of organisms, food and inorganic particles and for the structuring of communities.

Accordingly, the ecological work about the pelago-benthic coupling had to consider these different water masses, their chemical properties (like nutrients, oxygen) and their "fate" along the overall west - eastern gradients and the very specific transitions in frontal, ice edge and continental slope areas.
The water circulation and the related biological phenomena were studied mainly along transects from the shelf down its slope, and along a profile from the Nansen Basin in the north back to the frontal zone in the central Barents Sea.
Geological work concentrated on core sampling down the continental slope, to obtain information about the Pleisto- and Holocene sedimentation regimes, dependent on the changes in ice coverage of the Eurasian shelves. In addition, surface sediments taken in the whole area of investigation, will not only be analysed for these geological purposes, but also to provide background data for the ecological work and to identify possible sources and sinks of advected mineral and organic matter.
Ice research and observations of birds, whales and seals completed the effort of the Study of the European Arctic Shelf.

2.2 Short Cruise Itinerary

ARK VIII/2, from June 20 to July 30, started and terminated in Tromsø; research covered areas from the central Barents Sea to the continental slopes west, north and northeast of Svalbard (Fig. 2.2-1). Altogether 54 scientists from 15 countries were on board for multidisciplinary ecological research.

On the 21st of June, "Polarstern" met with the Polish RV "Oceania" from Gdynia and the USSR RV "Dalnie Zelentsy" from Murmansk at about 72° N and 25° E. We discussed further cooperation on board "Polarstern" and transferred equipment and the three scientists Dr. Ingrid Kröncke and Katrin Latarius, AWI, and Dr. Jaques Tahon, VU Brussels, to "Dalnie Zelentsy" to perform oceanographic measurements and biological sampling/observations in the eastern Barents Sea up to Novaya Zemlya. The first CTD station provided a common measuring profile with "Oceania".

On the 22nd of June, extensive work started at a central Barents Sea station (no. 40), in the area of the Polar Front, where a sediment trap together with a CTD current meter were moored. The majority of the main gear for biological sampling and measurements was put into action:
Rosette water bottles for chemical and phytoplankton work, combined with a vertically profiling oceanographic CTD, an Apstein phytoplankton net, Secchi disk and light penetration measurements, Bongo, "Fransz" and multi-nets for zooplankton, in addition a large "Passelaigue" zooplankton net;

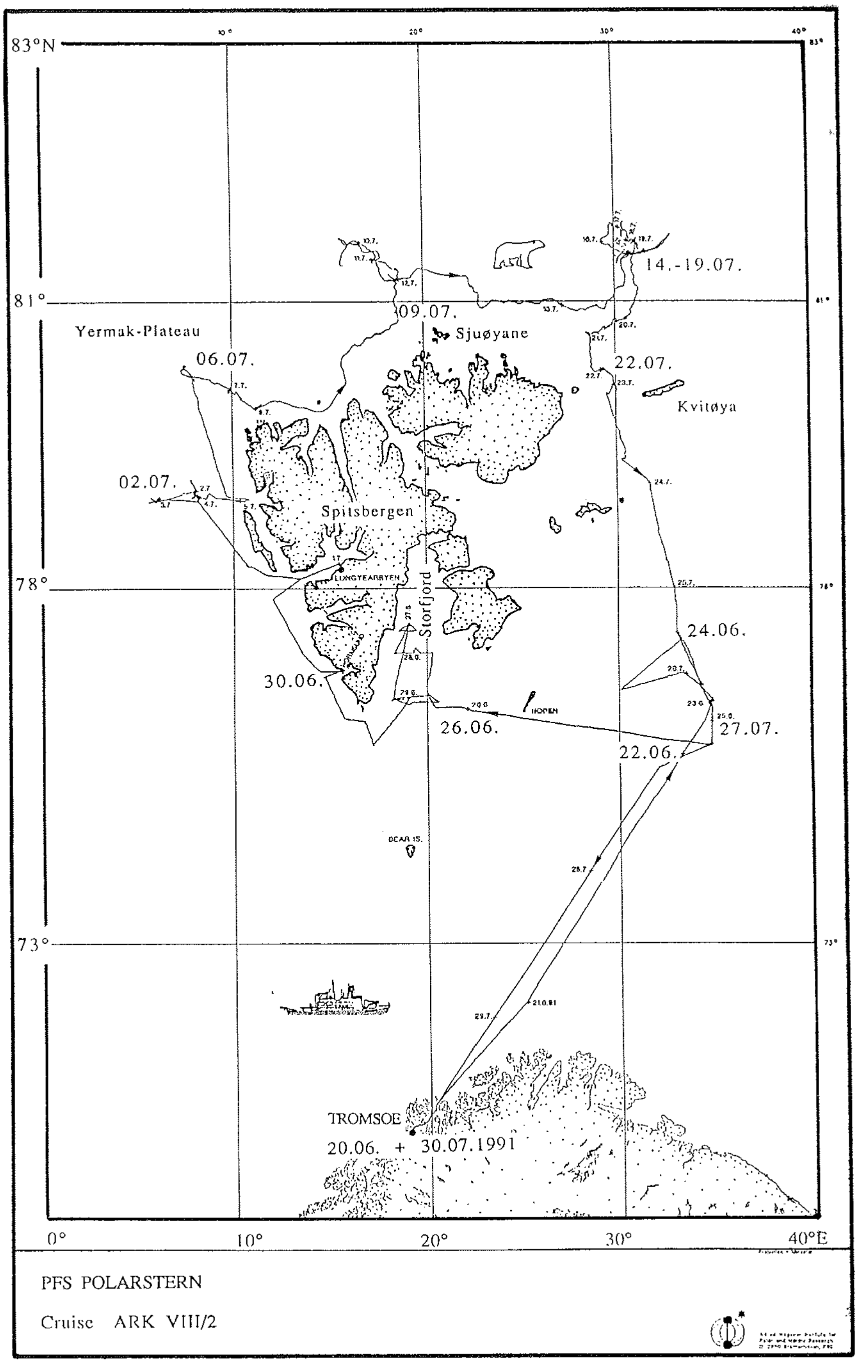


Fig. 2.2-1: Map of the cruise track
ARK VIII/2 ("EPOS II" = "SEAS"), RV "Polarstern"

an ocean floor observation system (OFOS), allowing direct video observations and foto camera snapshots, otter and Agassiz trawls for catching large invertebrate benthos as well as fishes, a large box sampler and a multicorer for studies of endofauna, micro-organisms, sediment properties and processes as well as for geological purposes.
Our sampling allowed quite a good examination of the conditions across the frontal zone (stations 38 to 45); and station no. 41 (June 24) initiated ice research.

After sampling in the central Barents Sea, "Polarstern" moved to the Storfjord area, where a second extensive sampling programme was performed, including two oceanographic long-time moorings to investigate bottom water circulation. (One of the moorings had to be recovered at station no. 68 and was re-deployed at station no. 69). For the laboratory studies with live animals, baited fish traps (weirs) were deployed at the fjord bottom for several hours. - On July 29, we took over Mrs. Irina Petrovna Serova (MMBI) from the Polish RV "Oceania", as she was suffering from sickness. Our physician could help her efficiently, and we disembarged her at Longyearbyen, from were she came well back to Murmansk. - The work in the Storfjord regime was finished with measurements and sampling in the Storfjord-Renna on June 30 (station no. 75).

In the afternoon of the same day, we visited the Polish Research Station in Hornsund (southern Spitsbergen); and in the evening the staff of the Station and of RV "Oceania" were invited for a party on board "Polarstern". We then sailed to Longyearbyen, where the chief scientist, G. Hempel, and Profs. H.F. Kern and H. Jannasch as well as Mrs. Petrovna left us on the first of July. E. Rachor took over as chief scientist. Mr. C.-J. Hug-Fleck, a scientific journalist, came on board, not only to do his journalistic work, but also to help in geological sampling.

Station work then continued in the Isfjord-Renna (no. 76); and, on the 2nd of July, we started an extensive programme along the first slope transect in the open Atlantic water west of Spitsbergen (Kongsfjordrenna). This transect was finished on July 5 (station no. 82).

The next transect, between the northwestern point of Spitsbergen and the Yermak Plateau, covered areas with drifting ice, allowing some ice coring work and sampling across the eastern branch of the diverging West Spitsbergen Current, from which the Nansen Basin of the Arctic Ocean is supplied with Atlantic water.
After station no. 90 our work continued north of Svalbard, where we passed Moffen Island in the late evening of July 8 (station no. 92).

We then came into areas with heavy pack ice conditions, and luckily started the next transect down the slope to the Hinlopen Trough northwest of Seven Islands (Sjuøyane) on July 10. Due to the occurrence of leads and polynya-like open waters we could work down to depths of about 2700 m (station no. 99), allowing for CTD profiles as well as plankton, benthos and geological sampling. Even the Agassiz trawl could be used. Two days of bad weather (July 12 and 13), with wind of Beaufort force 7 to 8, some snowfall and about the lowest temperatures of the cruise (-4° C), could not prevent us from continuing our meanwhile routine-like work.

After station no. 101 we proceeded to the east through again sometimes heavy pack ice and found a way to station no. 104 in the south of our intended northeastern-most transect (July 14).
Until the 16th of July a giant ice floe prevented us going farther north, to work down the slope into the Nansen Basin. On the other hand, this handicap allowed for extensive sampling and ice research. An oceanographic mooring together with a sediment trap was deployed at station no. 105, and a meteorological (Argos) buoy was disposed on the large floe. As before, we suffered from the absence of a helicopter, which would have allowed us to investigate the possibilities of going farther north.

We used the polynya-like open water south of the floe for an otter trawl at station 107, which again enlarged the list of fish species, hitherto unknown in the waters north of Svalbard. Then, after all, we found a way to the north allowing sampling down the most important eastern transect into the Nansen Basin (northernmost station: no. 109 at 81°41.9'N and 30°30.1'E with a water depth of 2942 m). This work was finished on the 19th of July.

"Polarstern" then went southward through the pack ice and performed another (shallow) transect, running from east to west across the Renna northwest of Kvitøya. In spite of the short distance, but due to the ice conditions, this transect work took quite a long time and terminated with station no. 122 on the 21st of July.

Thereafter we worked along a long profile back to the central Barents Sea, allowing for sampling on the shelf proper. The last station with ice research was no. 124 (July 23). There a sediment trap was deployed at the ice for about 24 h in an area with a pronounced chlorophyll maximum, while during the days before phytoplankton was not very abundant.
In the central Barents Sea, near the Polar front, chlorophyll measurements also showed high values, but in greater depths than before. The sediment trap mooring there (at station no. 40) was recovered successfully on the 26th of July (station no. 143) and re-deployed for about another year the next morning.

A meeting with RV "Dalnie Zelentsy" allowed for the transfer of equipment, samples and information about the cruises, which was discussed on board "Polarstern" in the evening of the 26th.
Before finishing our work, we took two gravity corer samples west of our route for Norwegian geologists. Station no. 147 on the 27th of July was thus the last of the whole cruise leg.
Then we steamed back to Tromsø, where we arrived at 7.00 h LT on the 30th of July. Altogether, 3676 nautical miles were covered by the cruise.

I want to express our thanks to the whole ship's crew, as our success was assisted substantially by their cooperation and efforts. I myself was strongly supported by our Captain, L. Suhrmeyer, our nautical officers and engineers.
- Eike Rachor -

2.3 Outline of some Preliminary Results

The Study of the European Arctic Shelf allowed for synoptic sampling and cooperation in a wide field of ecology. Although the initial plan, to work in north-eastern Barents Sea waters, could not be realized, all the final plannings for the work in offshore Svalbard and the central Barents Sea waters were successfully covered.

Physical and Chemical Oceanography:

Physical and chemical oceanographers provided information about the hydrographic regime in the whole investigation area by vertical profiling with CTD, combined with a Rosette water sampler, at every station. Accordingly, plankton samples could be taken in well defined water bodies all over the shelf and its slope. The conditions across the Polar front up to the ice edges in the central and northern Barents Sea could be compared at the beginning and by the end of the cruise. The characteristics and significance of the nutrient rich Atlantic waters were elaborated in the Barents Sea proper as well as along its northern margin, where the northern branch of the Atlantic water influx into the investigation area was traced.
Several long-term moorings were successfully deployed to study the circulation in the Storfjord with special emphasis to the outflow of dense, cold bottom water as well as the boundary currents at the continental slope northeast of Svalbard. In the inner Storfjord we found a reservoir of such cold bottom water originating from brine release during ice formation. Northeast of

Spitsbergen, in and above the Atlantic water core, upwelling-like structures were found, which may be regarded interesting when fertilizing the euphotic layers near the marginal ice zone after a first nutrient depletion. Compared with the situation in 1987 (ARK IV/3 of RV "Polarstern"), the Atlantic water core was found to be more than 1°C warmer, which is an indication of a substantial interannual variability of the Atlantic influence. Along the continental margin, some patches of advected shelf water were identified between 700 and 1000 m depth.

Phytoplankton and Sedimentation:

The results of the phytoplankton studies together with the chlorophyll measurements well agreed with the findings of the oceanographers. The main algal developments were found in the Barents Sea proper, with surface maxima always close to the marginal ice zones ("spring" situation). South of the ice and across the Polar Front in the Barents Sea, deep chlorophyll maxima occurred in water layers beneath 40 m, while the surface waters were depleted in biomass and nutrients.
West and north of Spitsbergen, chlorophyll and phytoplankton abundances were generally low. However, exuberant *Melosira* belts were seen along the margins of ice floes and cakes, especially in melting first-year ice. The contribution of such ice-related algae to the overall production near the ice edge may be significant. According to the different water masses met, several phytoplankton communities could be identified already during the cruise.
Seven short-term deployments of sediments traps near the ice allowed some insights into actual processes of downward particle transport. The sediment trap moored at the Polar Front in the central Barents Sea was recovered after 35 days of deployment and then again moored for at least one year. Another long-term trap was deployed at the upper edge of the continental margin northeast of Svalbard.
The short and medium term studies of sedimentation during the cruise seemed mostly to indicate "summer" situations with only weak sedimentation signals, mainly effected via zooplankton fecal pellets.

Zooplankton:

As in phytoplankton and benthos, typical regional patterns in the distribution of zooplankton were obvious from the different studies of the zooplanktologists. But, due to the greater mobility of the animals, distribution was in some cases less confined to water masses than to the food regime. For example, in the copepod *Oithona similis* highest abundances and reproduction were more often found in the Arctic top 50 m of the water column above the warmer and

poorer masses of Atlantic or Barents Sea waters. From preliminary laboratory results with the euphausid*Thysanoessa inermis* it is indicated that such mobile species may still be triggered in their vertical migration behaviour by the diurnal light cycle, although this is weakened in the high latitudes.
Accordingly, and as assumed by the lack of high chlorophyll concentrations in large areas of even open waters as well as by the predominance of fecal pellets in the sediment traps, grazing of zooplankton was found to dominate and control the whole (direct) vertical particle flux regime in most of the investigation area during summer. The early presence of high numbers of grazers (e.g. advected by Atlantic water) seemed sufficient to control phytoplankton (especially in the areas northwest and north of Svalbard).

Benthos and Fish:

There were no (quick) indications of a strong sedimentation event at any of the investigated stations during the cruise; the distribution of bottom animals rather indicated the overall, long-term hydrographic and sedimentological regimes. This finding was consistent with the results of the sediment biochemistry measurements.
Several different bottom assemblages were met during the cruise. In the area north of Svalbard, especially at the deep, northeastern-most stations (108, 112) typical Atlantic (boreal) elements became rare; instead, invertebrate and fish species not detected in the Barents Sea proper and west of Spitsbergen, were found in the trawls. Two presumably new fish species were caught. Nevertheless, species like *Pandalus borealis*, *Sebastes marinus* and others were also caught northeast of Svalbard, indicating that this study area is not isolated from sub-Arctic regions and that food input into the shelf slope habitats is still sufficient for such species. Typical Boreo-Arctic species like *Sclerocrangon ferox* and *Pontaster tenuispinus* were well distributed over the whole investigation area.

Seabirds and Mammals:

The numbers of regularly counted seabirds were generally low during the cruise. But, in frontal zones and close to the ice edge high densities were observed, indicating a better availability of food. Altogether, only 7 whales were recorded. Polar bears were seen more than 20 times; and the recorded seal number was above 600 (harp seals moving north to their summer feeding grounds and hooded seals being scattered on the ice).

Benthic Biogeochemistry and Microbiology:

An extraordinarily diverse combination of methods to study benthic biogeochemical and early diagenetic processes, such as organic matter oxydation, nutrient regeneration and fluxes, benthic respiration, linked with bacteriological studies, have been applied during the cruise to provide information on benthic-pelagic coupling.

Geology / Sedimentology:

As in biogeochemistry, communicable results of the geological sampling programme have not been available at the end of the cruise. A total of more than 70 m gravity corer samples were taken, and at 38 locations large surface sediment samples were obtained with a vented box sampler. Surface sediments were taken from the boxes for micro-paleontological studies (benthic foraminifera) and for measurements of chemical properties as a contribution to the research on pelago-benthic coupling and to study sources and transportation routes of Barents Sea sediments.

Ice Research:

Along track observations north of Svalbard recorded ice coverages mainly above 90 per cent, but, sometimes as low as 10 to 20 per cent. At 11 stations work on ice allowed measurements of ice thickness, temperature and chemical profiles, albedo, and, in a few cases, under ice CTD. Mean multiyear ice thickness varied between 140 and 291 cm.

3. Station Maps and Transect Profiles

Captions:

Fig. 3 - 1: Research area in the Barents Sea
(Polar Front zone and Barents Sea transect)
1a: Ship´s route and location of stations
1b: Depths profile of the transect back to the Polar Front

Fig. 3 - 2: Storfjord area: Ship´s route and location of stations, depths contours are indicated

Fig. 3 - 3: Transect Kongsfjordrenna

3a: Ship´s route and location of stations
3b: Depths profile of the transect

Fig. 3 - 4: Yermak Plateau transect

4a: Ship´s route and location of stations
4b: Depths profile

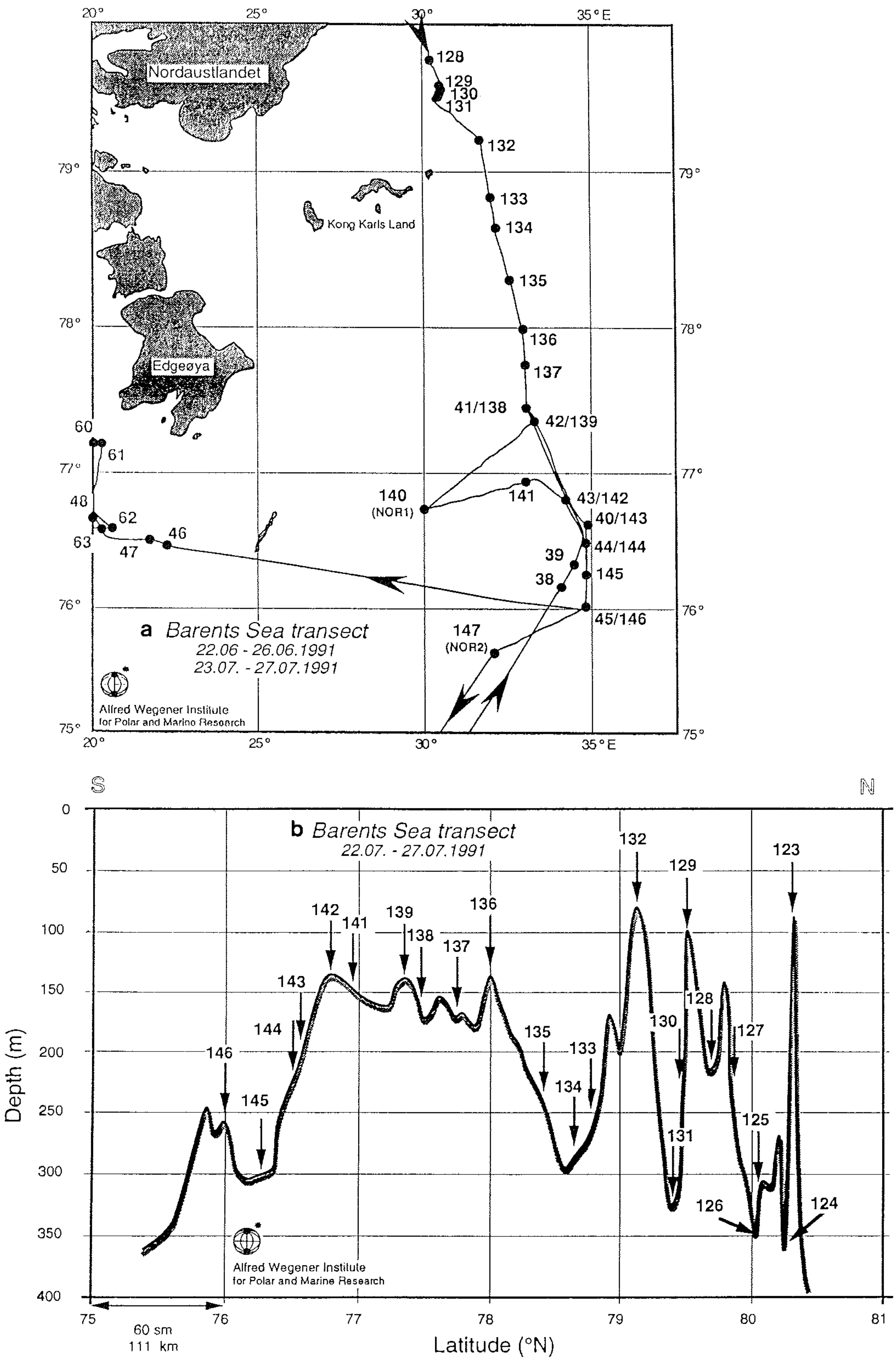
Fig. 3 - 5: Transect northwest of Seven Islands (Sjuøane)

5a: Ship´s route and location of stations
5b: Depths profile

Fig. 3 - 6: Research area ("transect") on the continental slope northeast of Svalbard
6a: Ship´s route and location of stations
6b: Depths profile (simplified)

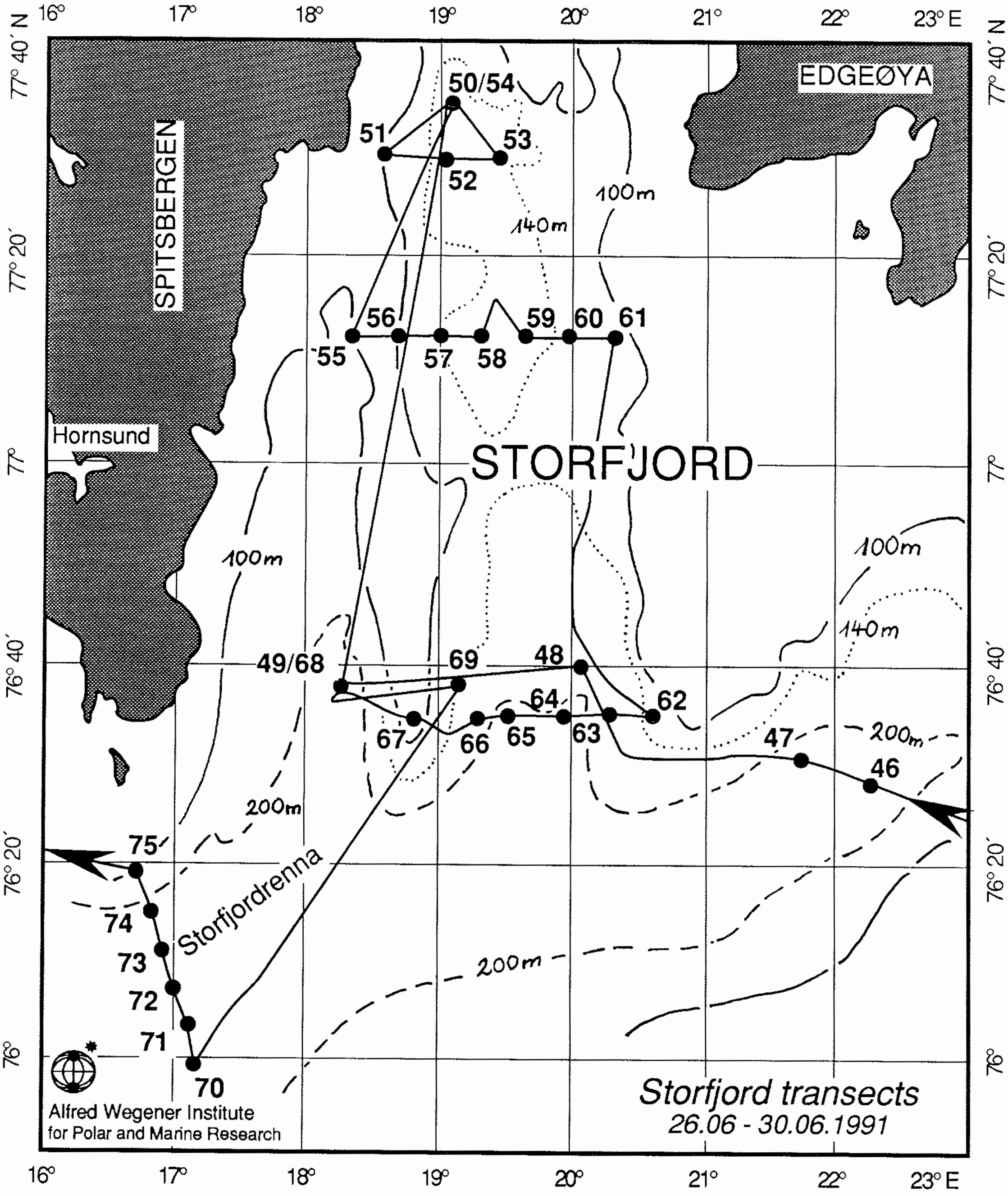
Fig. 3 - 7: Research area north and west of Kvitøya

7a: Ship´s route and location of stations
7b: Depths profile across trench northwest of Kvitøya



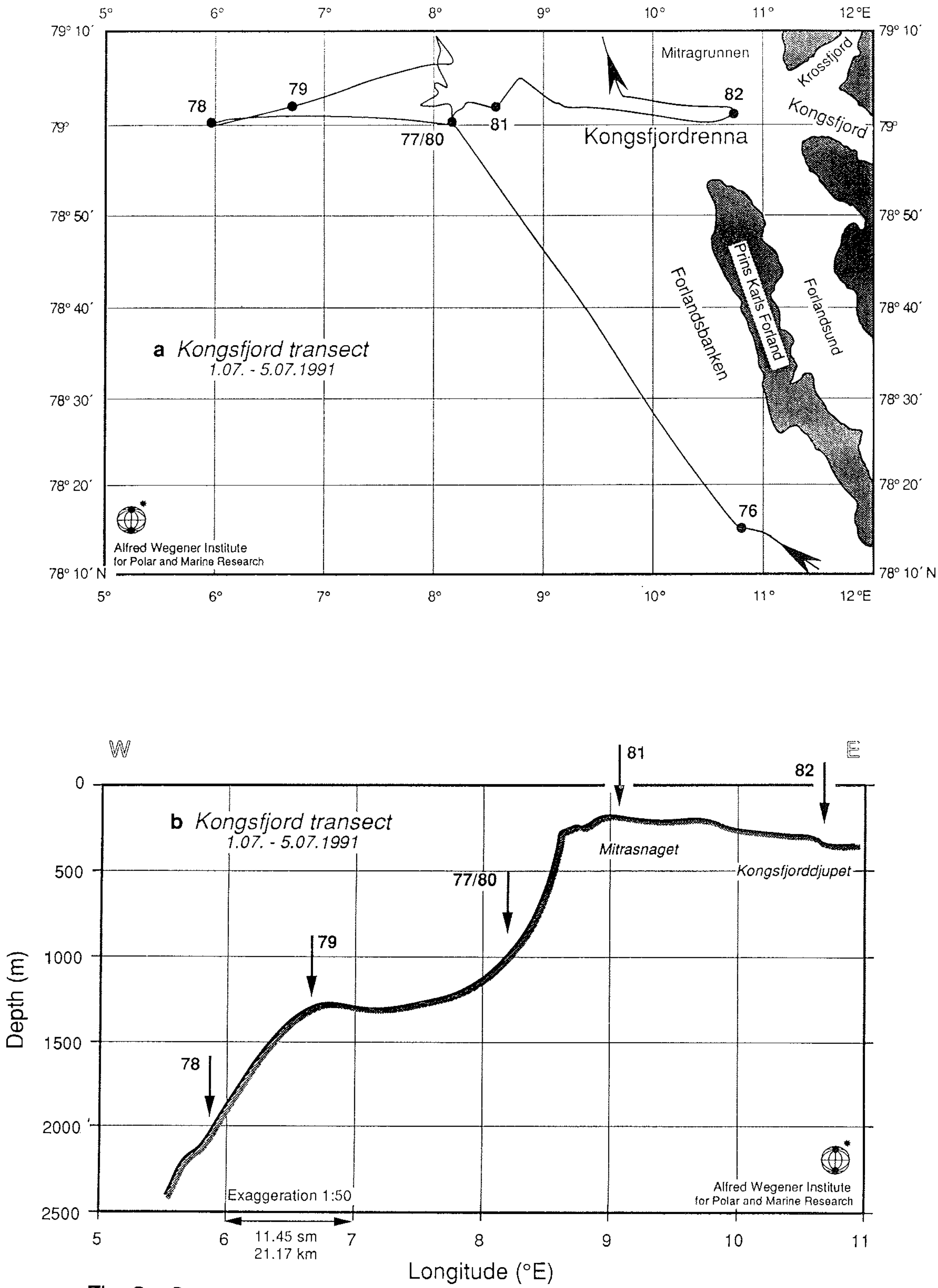
Nordaustlandet
Kong Karls Land
Edgeøya
a Barents Sea transect
22.06 - 26.06.1991
23.07. - 27.07.1991
Alfred Wegener Institute for Polar and Marine Research
140 (NOR1)
147 (NOR2)
20° 25° 30° 35°E
75° 76° 77° 78° 79°
b Barents Sea transect
22.07. - 27.07.1991
S
N
Depth (m)
Latitude (°N)
60 sm
111 km
Alfred Wegener Institute for Polar and Marine Research

Fig. 3 - 1



16° 17° 18° 19° 20° 21° 22° 23° E
77° 40´ N
77° 20´
77°
76° 40´
76° 20´
76°
SPITSBERGEN
EDGEØYA
Hornsund
STORFJORD
Storfjordrenna
50/54
51
52
53
55
56
57
58
59
60
61
49/68
69
48
64
62
67
66
65
63
47
46
75
74
73
72
71
70
100m
140m
200m
Alfred Wegener Institute
for Polar and Marine Research
Storfjord transects
26.06 - 30.06.1991

Fig. 3 - 2



a Kongsfjord transect
1.07. - 5.07.1991
Mitragrunnen
Krossfjord
Kongsfjord
Kongsfjordrenna
Prins Karls Forland
Forlandsbanken
Forlandsund
78
79
77/80
81
82
76
Alfred Wegener Institute
for Polar and Marine Research
b Kongsfjord transect
1.07. - 5.07.1991
W
E
Mitrasnaget
Kongsfjorddjupet
Depth (m)
Longitude (°E)
Exaggeration 1:50
11.45 sm
21.17 km

Fig. 3 - 3

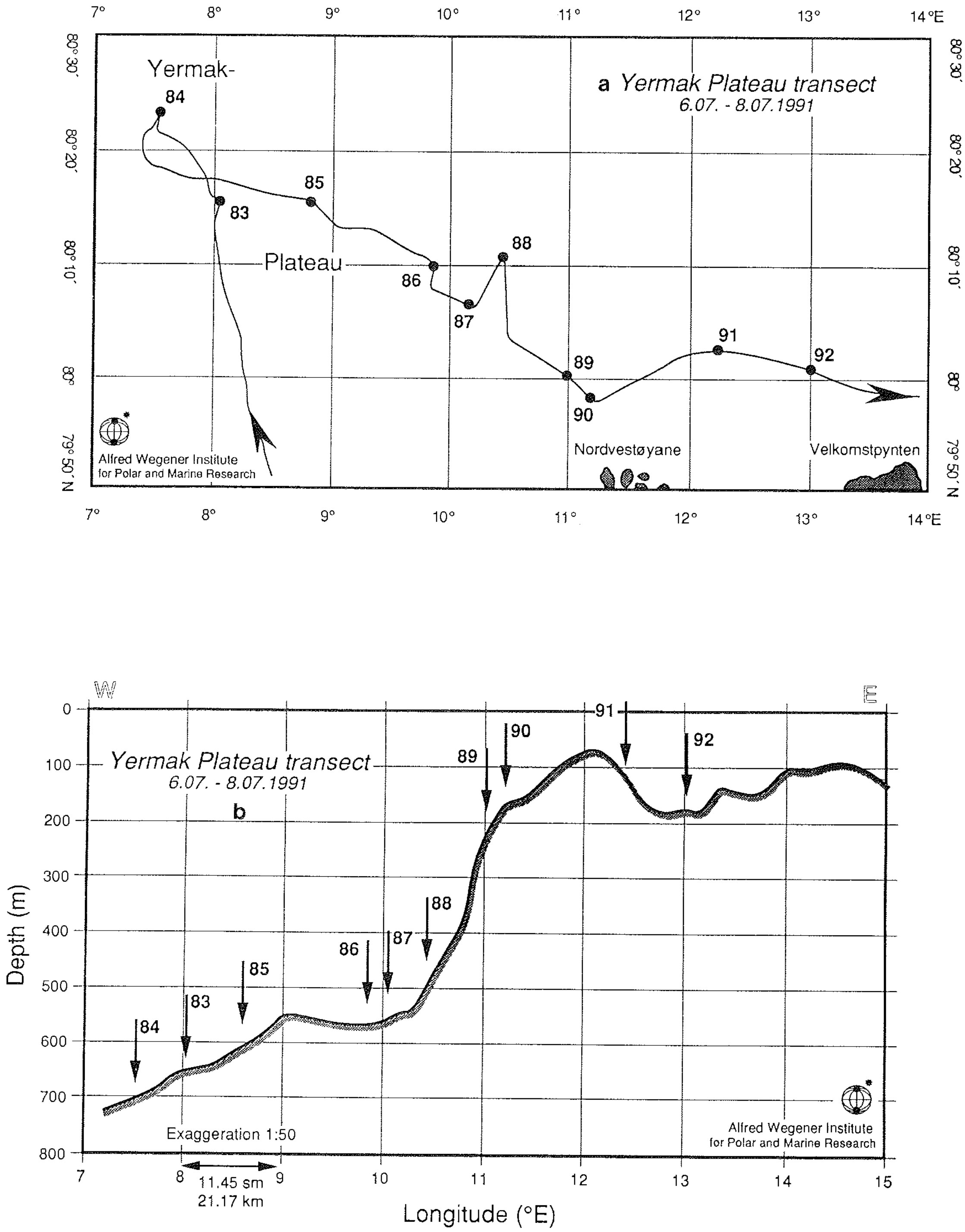

a Yermak Plateau transect
6.07. - 8.07.1991
Yermak-
Plateau
84
83
85
86
87
88
89
90
91
92
Nordvestøyane
Velkomstpynten
Alfred Wegener Institute for Polar and Marine Research
7° 8° 9° 10° 11° 12° 13° 14°E
80°30' 80°20' 80°10' 80° 79°50' N
Yermak Plateau transect
6.07. - 8.07.1991
b
W
E
Depth (m)
Longitude (°E)
Exaggeration 1:50
11.45 sm
21.17 km
Alfred Wegener Institute for Polar and Marine Research

Fig. 3 - 4

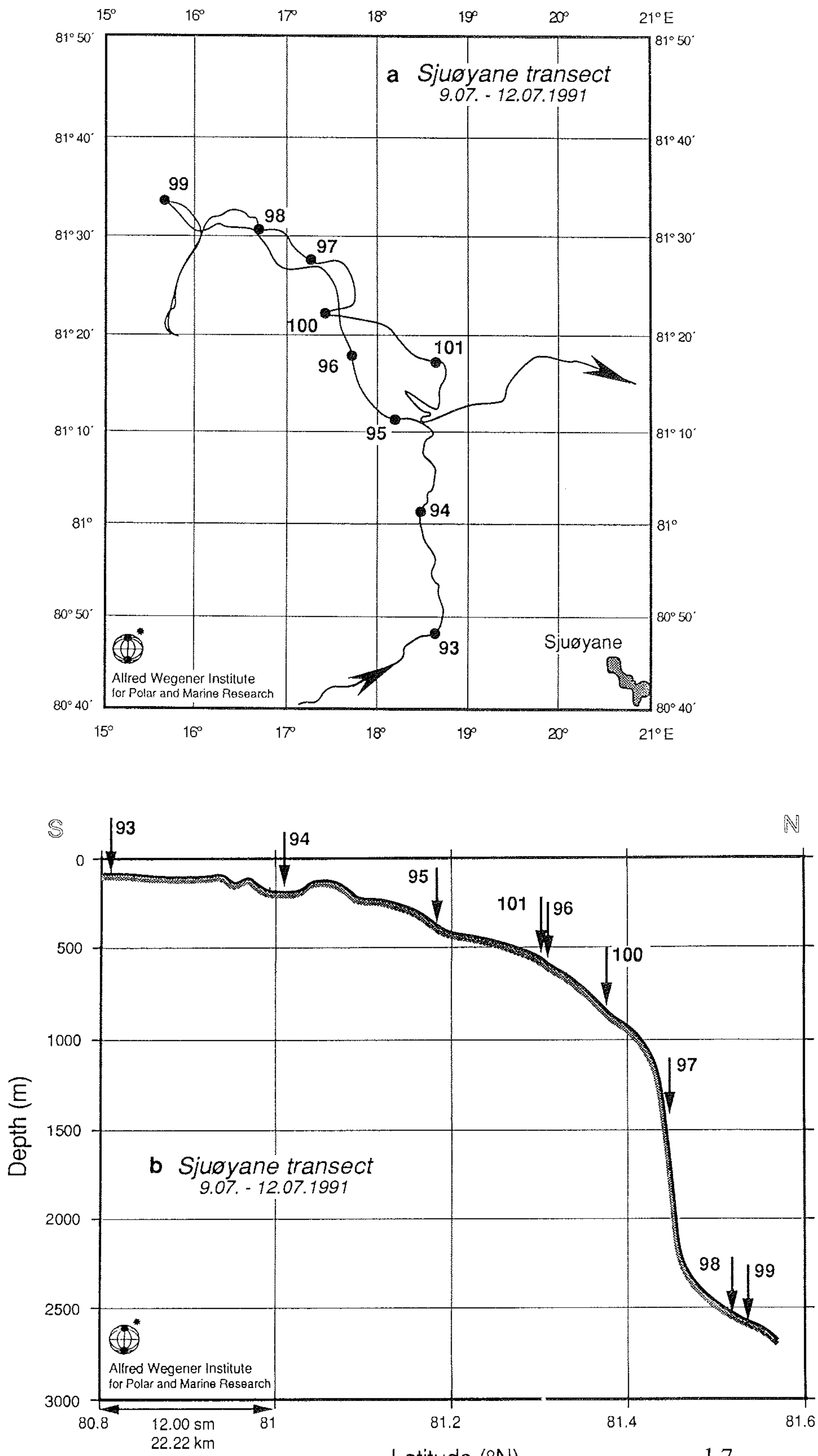
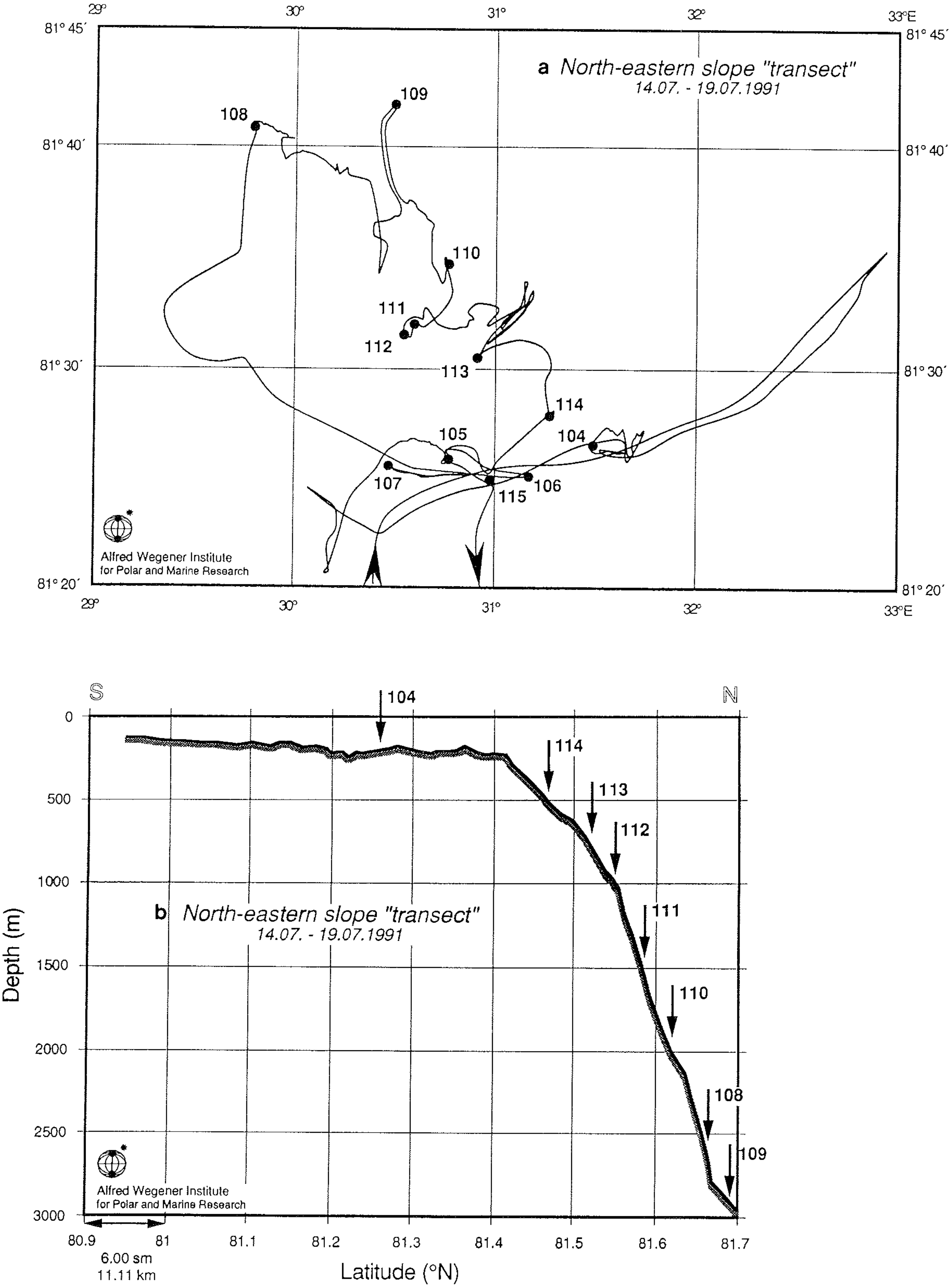
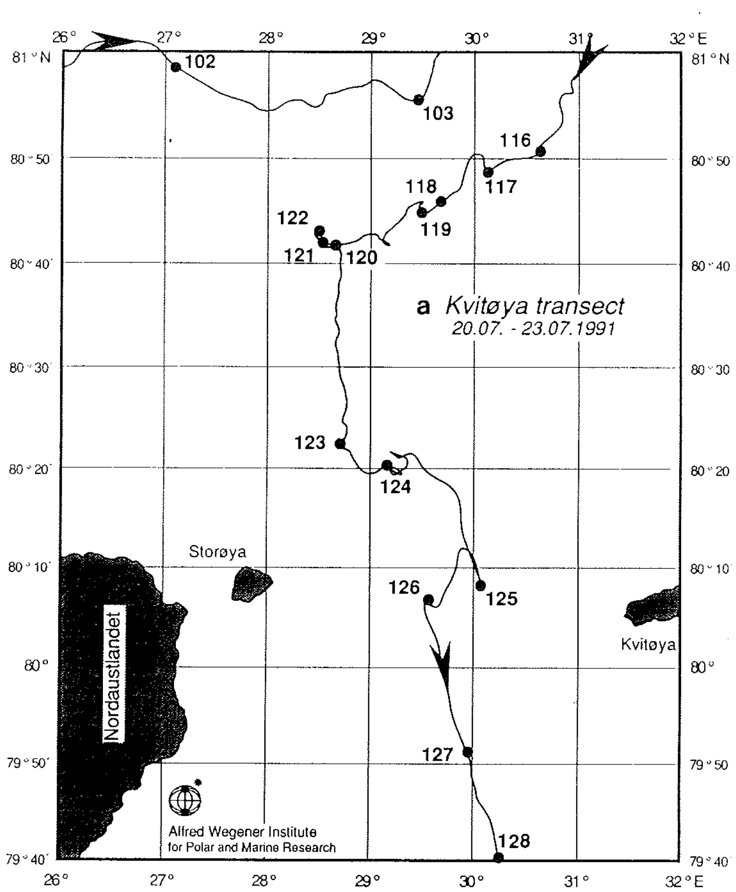

a Sjuøyane transect
9.07. - 12.07.1991
15°
16°
17°
18°
19°
20°
21° E
81° 50'
81° 40'
81° 30'
81° 20'
81° 10'
81°
80° 50'
80° 40'
99
98
97
100
101
96
95
94
93
Sjuøyane
Alfred Wegener Institute
for Polar and Marine Research
S
N
93
94
95
101
96
100
97
98
99
0
500
1000
1500
2000
2500
3000
Depth (m)
b Sjuøyane transect
9.07. - 12.07.1991
Alfred Wegener Institute
for Polar and Marine Research
80.8
12.00 sm
22.22 km
81
81.2
81.4
81.6
Latitude (°N)

Fig. 3 - 5



a North-eastern slope "transect"
14.07. - 19.07.1991
29°
30°
31°
32°
33°E
81° 45´
81° 40´
81° 30´
81° 20´
108
109
110
111
112
113
114
104
105
107
106
115
Alfred Wegener Institute
for Polar and Marine Research
S
N
b North-eastern slope "transect"
14.07. - 19.07.1991
Depth (m)
0
500
1000
1500
2000
2500
3000
80.9
81
81.1
81.2
81.3
81.4
81.5
81.6
81.7
Latitude (°N)
6.00 sm
11.11 km

Fig. 3 - 6



26° 27° 28° 29° 30° 31° 32°E
81°N
80°50'
80°40'
80°30'
80°20'
80°10'
80°
79°50'
79°40'
102
103
116
117
118
119
122
121
120
a Kvitøya transect
20.07. - 23.07.1991
123
124
Storøya
126
125
Kvitøya
Nordaustlandet
127
128
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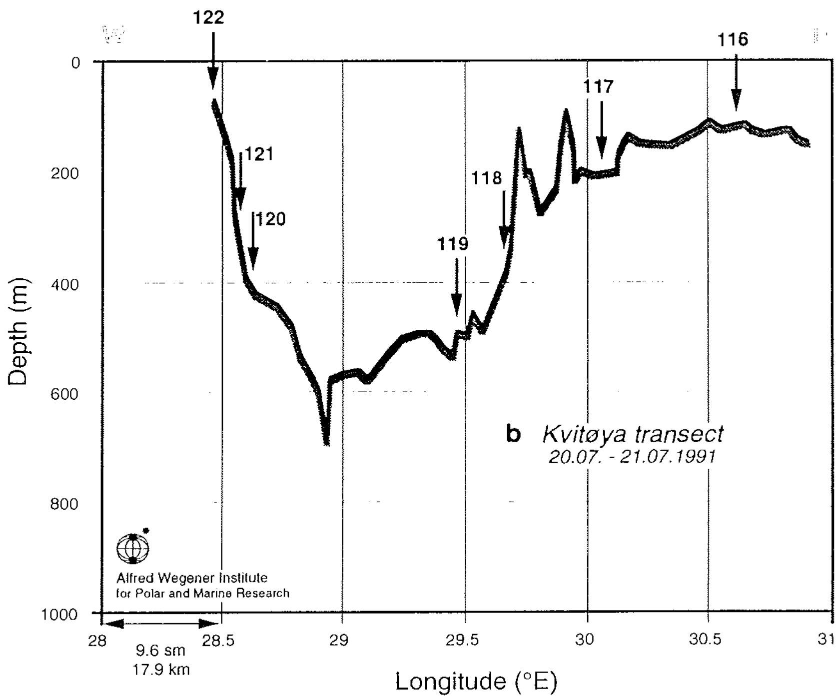
for Polar and Marine Research



122
116
117
121
120
118
119
0
200
400
600
800
1000
Depth (m)
b Kvitøya transect
20.07. - 21.07.1991
Alfred Wegener Institute
for Polar and Marine Research
28
28.5
29
29.5
30
30.5
31
9.6 sm
17.9 km
Longitude (°E)

Fig. 3 - 7

4. Oceanography

(U. Schauer, G. Civitarese, M. Duman, I. Harms, A. Luchetta, D. Matishov, G. Owrid, V. Petrov, A. Shaban, V. H. Strass)

Introduction

The renewal of the central Arctic Ocean water masses is probably to a large extent controlled by processes on the shelves and on the continental slopes. Hence, the Barents Sea is one of the key areas for the hydrographic system of the Arctic Ocean. The main heat and salt inflow to the whole Arctic Ocean occurs either through the Barents Sea itself or along its continental slope. Transporting warm and saline Atlantic water, the Norwegian Current branches at several locations on its way north. Following the coastline of northern Norway, one branch turns towards east and enters the Barents Sea. The western branch continues as West Spitsbergen Current along the continental slope of the Norwegian and the Greenland Seas. In the Fram Strait, the West Spitsbergen Current branches again, and only the eastern part enters the Nansen Basin.

The development of the Atlantic water distributed in the various areas differs considerably. The Atlantic water, which enters the shelf, is remarkably exposed to modification by direct heat loss to the atmosphere and by mixing with Barents Sea water due to tides and processes at the Polar Front. On the other hand, the Atlantic water moving along the continental slope subducts more and more below the Arctic surface water and hence becomes inhibited from direct interaction with the atmosphere.

On the shelf, cold and saline shelf bottom water is formed due to ice production and brine release during winter. In areas with appropriate conditions large amounts of the dense water can accumulate and flow through depressions to the shelf edge and then enter the deep basins. It is assumed that this water contributes to the bottom water of the deep basins and to the Arctic halocline. One of the probable production areas for considerable amounts of dense shelf bottom water, which flows to the deeper levels of the Norwegian Sea, is the Storfjord of Spitsbergen.

The oceanographic program was designed with three different main aims:

1. to describe the hydrography of the Polar Front in the central Barents Sea in relation to biological processes,
2. to study the flow and development of Atlantic water along the continental slope west and north of Spitsbergen, and its interaction with Arctic and shelf water,
3. to study the development and outflow of cold saline bottom water formed in the Storfjord.

4.1 Physical Oceanography

(U. Schauer, I. Harms, G. Owrid, V. Petrov, A. Shaban, V. H. Strass)

Methods

A total of 111 profiles were taken with a *Neil Brown* Mark III CTD system in combination with a *General Oceanics* Rosette Sampler with 24 water bottles of 10 l. At stations shallower than 1000 m a *Backscat* fluorometer was attached to the CTD. The temperature and the pressure probes of the CTD were calibrated before and after the cruise. The salinity was calibrated by measuring the salinity of water samples with a *Guildline* Autosal 8400 B. The *in situ* salinity calibration and the *in situ* comparison of the CTD temperature with reversing thermometers were severely affected by the strong temperature and salinity gradients all over the Barents shelf. A mean correction for salinity will be applied here. For the few deep-water stations a profile by profile calibration will be used.

Four moorings equipped with *Anderaa* current meters and thermistor chains, *Seabird* CTDs (Seacat 16 SBE) and one with a sediment trap (type S/MT 230) were deployed for one, respectively two years.

The sediment trap (type Mark 6), deployed in the central Barents Sea (see "Phytoplankton"), was equipped with an *Anderaa* current meter.

The Barents Sea Transects (V.H. Strass et al.)

At the beginning and at the end of the cruise leg, "Polarstern" carried out two almost meridional transects across the Barents Sea between the longitudes of 30° and 35° E. The first, south-north running transect extended from 75°59' to 77°27' N, the second, south-heading transect from 76° to 80°42' N.

The first transect was sampled in the period 22 to 26 June, the second about one month later, from 21 to 27 July. The repetition of the southern stations along the same transect allows for the study of temporal developments during the transition from early to high summer.

The most pronounced seasonal changes occurred in the top 30 m of the water column, where the melting of sea ice led to a decrease in salinity of more than 1 in places, and where the subsequent warming of the freshened layer locally caused a temperature increase of up to 2°C (compare Figs. 4.1 - 1a,b and 4.1 -

2a,b). While, during the first transect, an ice coverage of up to 9/10 was observed, the maximum ice coverage one month later was not more than 1/10 (in the area of overlap of both transects).

Associated with the stratification caused by freshening and warming of the top layer, the chlorophyll distribution changed markedly, as implied by the fluorescence measurements (Figs. 4.1 - 1c, 2c, 3c). During the first transect, a surface phytoplankton bloom with highest chlorophyll values within the mixed layer was found in the northern part of the section, and a deep chlorophyll maximum in the southern part (Fig. 4.1 - 1c). The transition from the deep chlorophyll maximum to a surface bloom occurred where the ice coverage increased northward from 2/10 to 9/10, between Stations 43 and 41. One month later, the surface bloom maxima were replaced by deep chlorophyll maxima everywhere along the line of repeated stations (Fig. 4.1 - 2c).

From Fig. 4.1 - 3c, showing the second Barents Sea section including its northernmore part, it can be seen that the surface blooming has propagated northward by about 350 km, following the receding ice edge. The transition from a deep chlorophyll maximum in the south and a surface bloom in the north occurs between stations 126 and 124, where the ice coverage increased northward from 1/10 to again 9/10.

Besides these temporal changes in the top 30 m, which could be explained by direct atmospheric forcing, there are also differences of other origin in the deeper levels below. Such differences were observed in the distribution of temperature and salinity in the region of the Barents Sea Polar Front, found over the steep bottom slope between km 140 and km 240 (Figs. 4.1 - 1a,b and 2a,b). Within the month between the sampling along both sections, it seems that relatively warm and saline water (T > 0°C, S > 34.5 ‰) of Atlantic origin spilled over the sill northward onto the shallow part of the shelf, and that a compensatory southward flow of Barents Sea Winter Water with temperatures below 0°C occurred at about 50 m depth. As the Barents Sea Polar Front mainly is oriented zonally, this implies a cross-frontal circulation pattern. However, Fig. 4.1 - 2b also shows the presence of more saline water than Fig. 4.1 - 1b in the deep part of the shelf, suggesting along-front advection.
It is hoped that the current meter record from the central Barents Sea sediment trap mooring, deployed at the front for one year, will reveal more conclusive details of the circulation pattern at this place.

Captions of Figs. 4.1 - 1-3:

Fig. 4.1-1: Vertical distributions of (a) temperature, (b) salinity and (c) chlorophyll fluorescence along the first Barents Sea section sampled from 22 to 26 June.
(The fluorescence measurements are not yet calibrated; however, 0.1 fluorescence units roughly correspond to a chlorophyll concentration of 1 mg/m^3, as given by photometrically analysed samples from E.-M. Nöthig and others of the phytoplankton working group.)

Fig. 4.1-2: Vertical distributions of (a) temperature, (b) salinity and (c) chlorophyll fluorescence along the second Barents Sea section sampled from 21 to 27 July.
Only the southern part of the section is shown, where stations had been occupied also during the first transect one month before.

Fig. 4.1-3: Vertical distributions of (a) temperature, (b) salinity and (c) chlorophyll fluorescence along the second Barents Sea section in total.

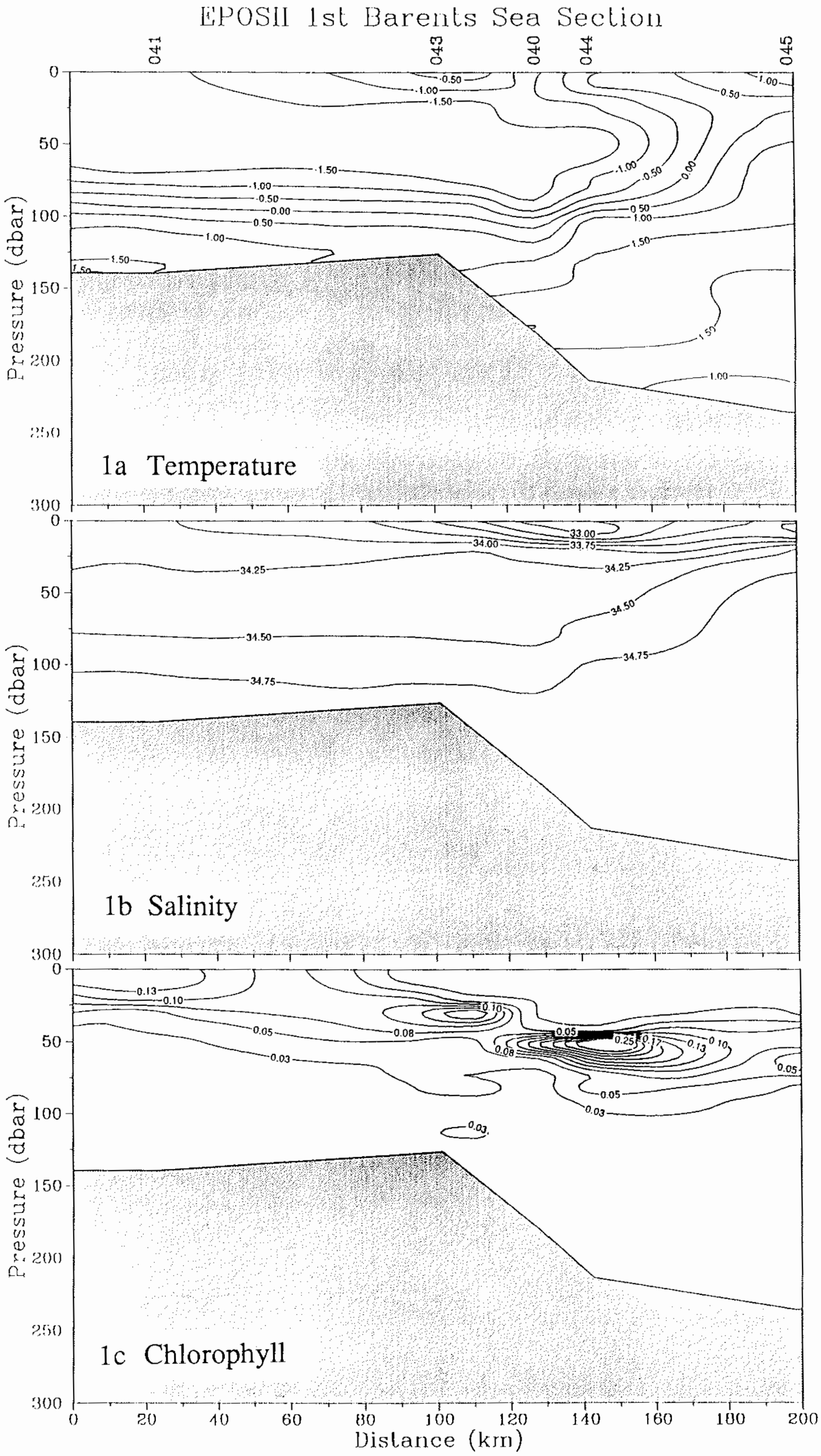

EPOSII 1st Barents Sea Section
041
043
040
044
045
Pressure (dbar)
1a Temperature
1b Salinity
1c Chlorophyll
Distance (km)

Fig. 4.1 - 1a-c

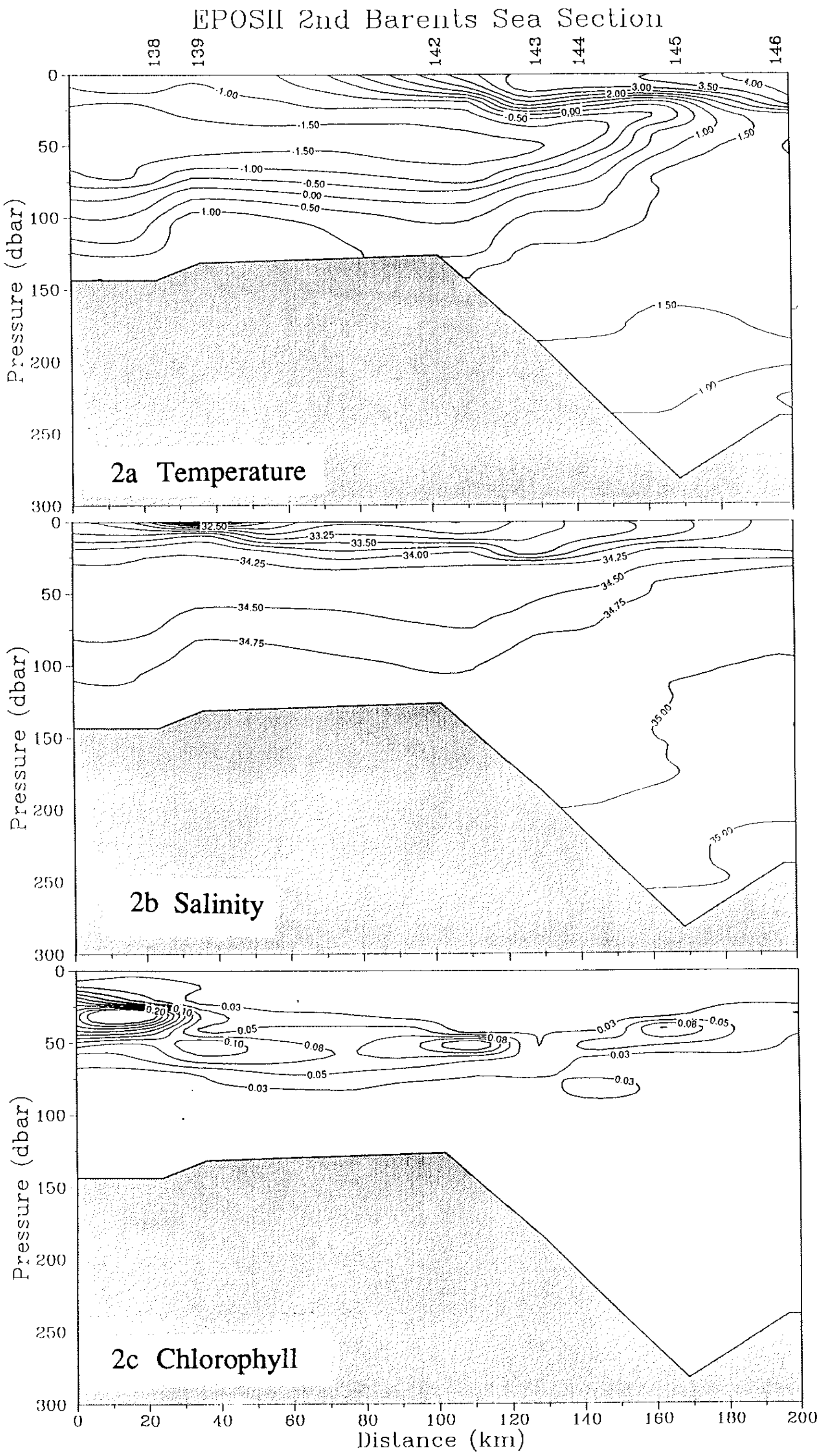
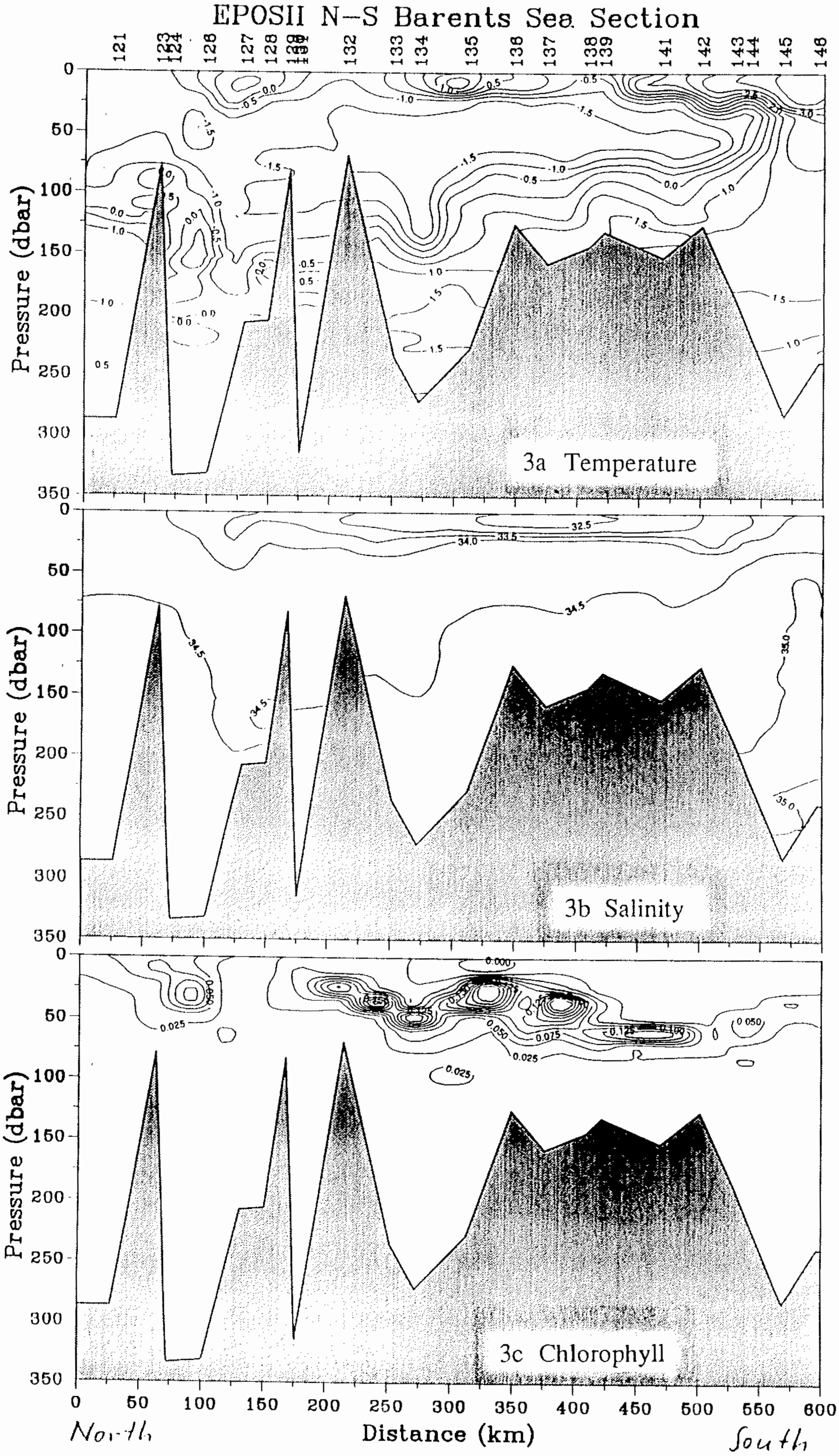

EPOSII 2nd Barents Sea Section
138
139
142
143
144
145
146
Pressure (dbar)
2a Temperature
2b Salinity
2c Chlorophyll
Distance (km)

Fig. 4.1 - 2 a - c



EPOSII N-S Barents Sea Section
121 123 124 126 127 128 132 133 134 135 136 137 138 139 141 142 143 144 145 146
Pressure (dbar)
3a Temperature
3b Salinity
3c Chlorophyll
0 50 100 150 200 250 300 350 400 450 500 550 600
Distance (km)
North
South

Fig. 4.1 - 3 a - c

Storfjord and Storfjord Renna (U. Schauer et al.)

The Storfjord and the Storfjord Renna are areas of the Barents Sea, where remnants of dense bottom water, probably formed in winter, are still found in summer (Quadfasel et al, 1988). Four sections were carried out during the cruise leg (see map "Storfjord Transects"): Two of them north of a 120 m deep sill, which separates the inner from the outer part of the Storfjord, one south of the sill and one across the trough and the northern slope of the Storfjord Renna. Two moorings were deployed for one year south of the sill to record the in- and outflow of the Storfjord with special emphasis to the outflow of cold, saline bottom water.

North of the sill, the whole water column between sill depth and the greatest depth of the fjord, 190 m, is at the freezing point (Fig. 4.1 - 4). The salinity increases smoothly from 34.6 to more than 35.0 at the deepest point. This is an expression of either spatial or temporal variability of the winter surface salinity. At several stations, intrusions of warmer water at depths of 50 m indicate a shallow circulation of Barents Sea water into the inner part of the fjord above the sill depth. The classical fjord circulation pattern with outflow of fresh water at the surface and inflow of salty water at the bottom seems to be reversed to a certain extent. The time records of the moorings will tell more about this question.

While the section south of the sill does not show temperatures above 0°C at the bottom, there is a patch of cold bottom water at the northern slope of the Storfjordrenna (Fig. 4.1 - 5). This indicates that at least during summer there is no continuous outflow from the dense water reservoir of the inner fjord, but rather an intermittant one.

Captions of Figs. 4.1 - 4 and 5:

Fig. 4.1 - 4: Vertical temperature and salinity profile (CTD) at station 50 in the inner Storfjord (June 27, 1991)

Fig. 4.1 - 5: Vertical distributions of (a) salinity and (b) temperature along a section across the Storfjordrenna (stations 70-75, June 29-30, 1991)

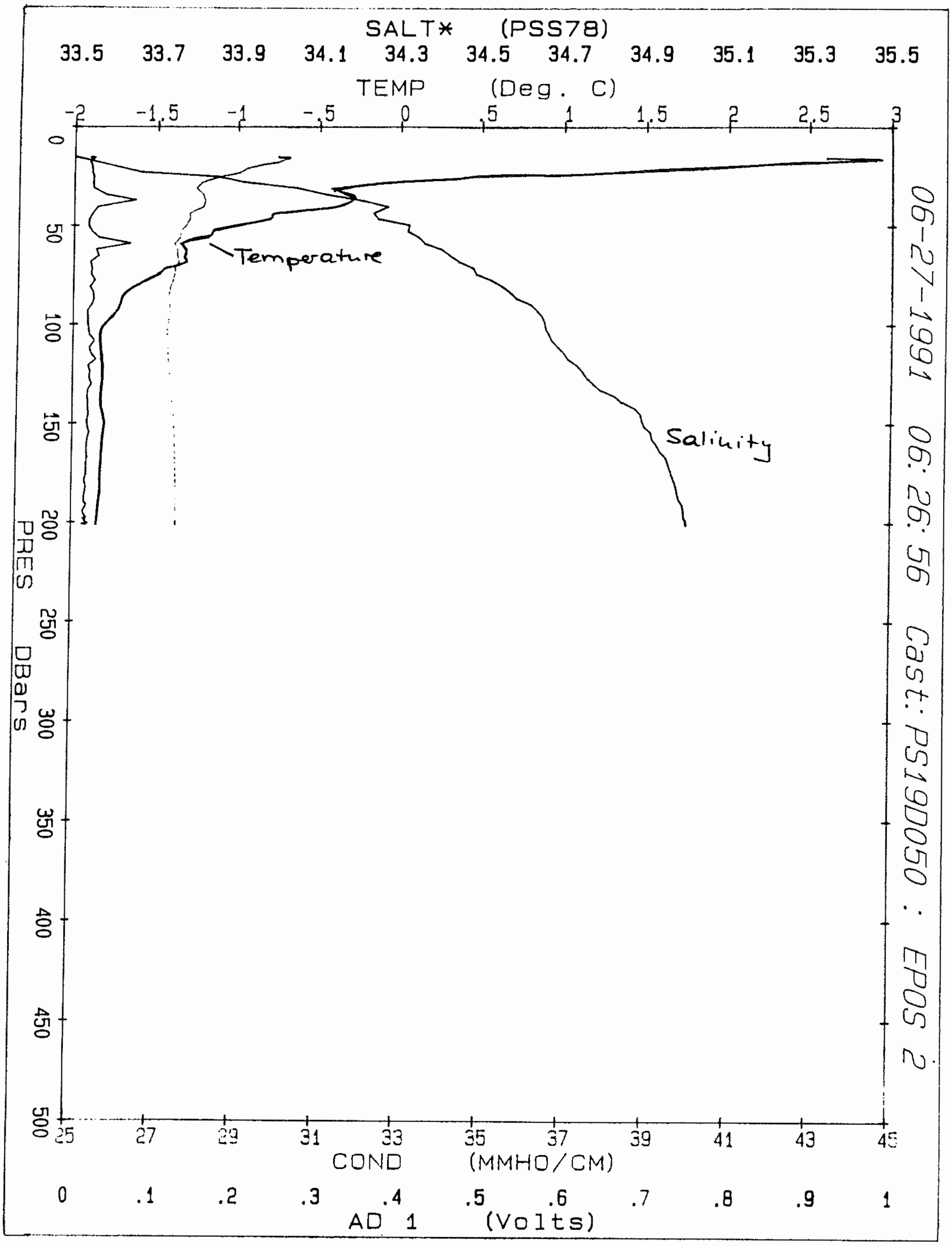

SALT* (PSS78)
33.5 33.7 33.9 34.1 34.3 34.5 34.7 34.9 35.1 35.3 35.5
TEMP (Deg. C)
-2 -1.5 -1 -.5 0 .5 1 1.5 2 2.5 3
Temperature
Salinity
PRES DBars
0 50 100 150 200 250 300 350 400 450 500
06-27-1991 06:26:56 Cast:PS19D050 : EPOS 2
25 27 29 31 33 35 37 39 41 43 45
COND (MMHO/CM)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
AD 1 (Volts)

Fig. 4.1 - 4

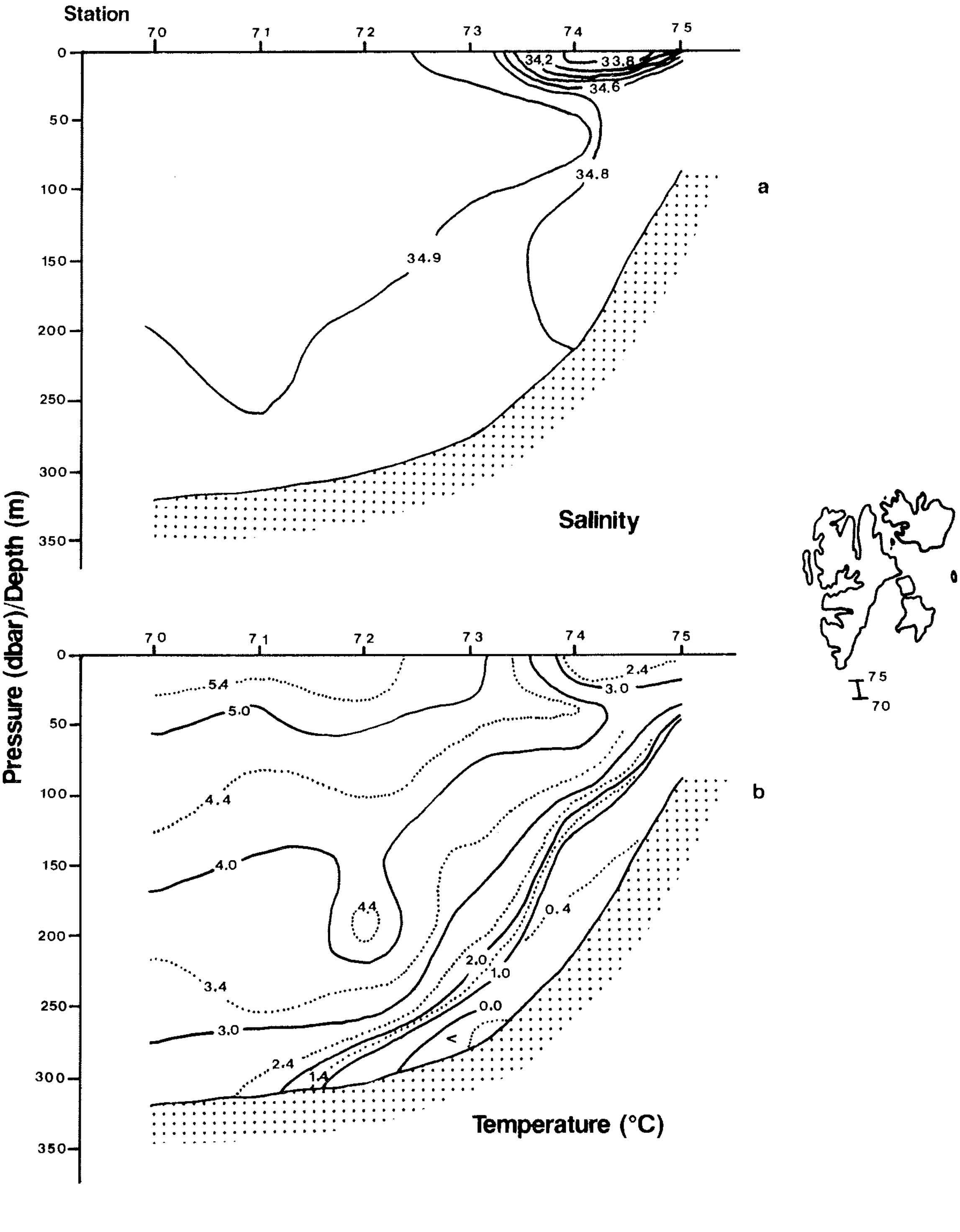

Station
70
71
72
73
74
75
34.2
33.8
34.6
34.8
34.9
Salinity
a
Pressure (dbar)/Depth (m)
5.4
5.0
4.4
4.0
3.4
3.0
2.4
1.4
2.0
1.0
0.0
0.4
Temperature (°C)
b

Fig. 4.1 - 5a-b

The continental slope northwest and north of Svalbard

(U. Schauer et al.)

Four sections were run across the continental slope of Svalbard: along 79° N (Kongsfjord section), over the southern part of the Yermak Plateau, east of the Yermak Plateau (Seven Islands section) and at about 31°E (northeastern section). A core of warm saline Atlantic water originating from the Norwegian Current is visible at all sections. Following the sections towards north-east, there is a continuous decrease of the temperature maximum from 5.1°C at the Yermak Plateau to 2.9°C at the northeastern section, and a weak decrease in the salinity maximum. In the same way the core depth increases from the Fram Strait, where the Atlantic water is still at the surface, to 31°E, where the core is at 200 m. The Arctic Halocline is well pronounced over the deep basin reaching down to 100 m; and it is also visible above the shelf. However, above the core of the Atlantic water, the isotherms rise by about 70 m (Fig. 4.1 - 6). Further analysis will show whether this is due to vertical heat diffusion or a kind of upwelling due to a divergence of the surface layer.

The northeastern section repeats part of a section which had been run by "Polarstern" in 1987. Compared to 1987 (Anderson et al, 1989), the temperature of the whole Atlantic water layer and the water at the shelf edge was by more than 1°C warmer in 1991, indicating a considerable interannual variability.

An anomaly in salinity and several of the nutrients occur at the slope bottom of the Seven Islands and the northeastern sections between 600 and 800 m. Further analysis has to show whether this water originates on the shelf from where it spread along the bottom down to this depth. As for the Storfjord, the mooring records of temperature and velocity are expected to give further insight into the processes related to these features.

Caption of Fig. 4.1 - 6:

Vertical distributions of (a) salinity and (b) temperature
along the transect northeast of Svalbard (depths contours simplified)

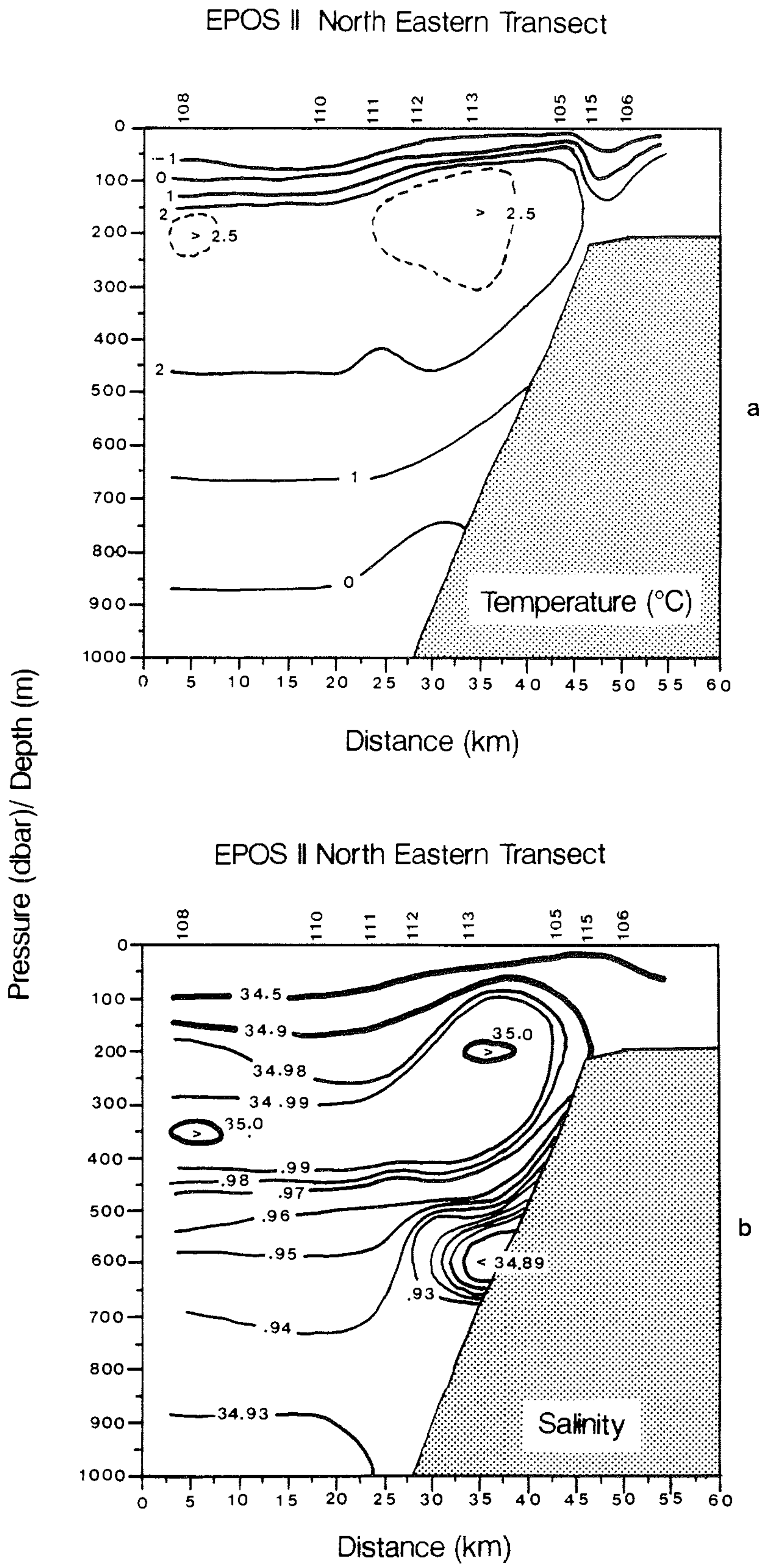

EPOS II North Eastern Transect
108
110
111
112
113
105
115
106
-1
0
1
2
> 2.5
> 2.5
2
1
0
Temperature (°C)
a
Pressure (dbar)/ Depth (m)
Distance (km)
EPOS II North Eastern Transect
34.5
34.9
34.98
34.99
35.0
35.0
.99
.98
.97
.96
.95
.94
.93
< 34.89
34.93
Salinity
b
Distance (km)

Fig. 4.1 - 6a-b

4.2 Hydrochemistry

(A. Luchetta, G. Civitarese & D. Matishov)

Oxygen and nutrients are useful parameters to trace the water masses and to study and understand the biological peculiarities of the investigated area, which is characterized by the occurrence of the Polar Front and the ice cover.
From casts with the *GO* Rosette sampler, about 1500 water samples were collected and analysed on board for the contents of dissolved oxygen, nitrite, nitrate, phosphate, silicate and ammonia.
Oxygen was determined by the *Winkler* method, with a precision better than 0.1 %. Nitrite, nitrate, phosphate and silicate were analysed by a *Chemlab* Continuous Flow Analyser according to the methods reported in the literature (Grasshoff et al., 1983) with a few modifications. The precision for all these determinations was within 2 %.
Ammonia was analysed following the method of Liddicoat et al. (1975), modified by Catalano (1987), with a precision of 3.5 %.

The Polar Front in the Barents Sea:

The area of the Polar front as a highly productive zone in the central Barents Sea is well pointed out by the vertical structure of silicate, nitrate and oxygen at the stations 43, 40, 44 (Figs. 4.2 - 1, 2 and 4) and corresponds to the hydrography and chlorophyll distribution.

When ice begins to melt, the resulting density stratification and the light penetration trigger the biological activity in the surface layers. The occurrence of a spring phytoplankton bloom is pointed out by the complete depletion of nutrients and by the high content of oxygen (maximum saturation value of 119%, conc. 440 µM) in the upper layer (0-30 m) of the central part of the transect (stations 43, 40 and 44).

This layer is shallower at the northern (0-20 m) than at the southern stations (0-40 m). In addition, in the northern part of the transect, the nutrient depletion at the surface is not complete (concentration increases to values of 0.2, 1.2 and 1.9 µM for phosphate, silicate and nitrate respectively), whereas oxygen over-saturation is not as high as in the southern part (< 110%, corresponding to concentrations of 410 µM), suggesting that the phytoplankton bloom trails the ice receding northward. The fluorescence and chlorophyll-a show a similar distribution pattern, characterized by one shallower (10-20 m) maximum at station 41 and one deeper (40-50 m) at stations 40, 44, 45.

Ammonia exhibits two maxima as well (see Fig. 4.2 - 3): One with concentrations > 0.9 µM at about 70-80 m depth at stations 45 and 44, the other one (0.87 µM at 50 m) at station number 41.

In conclusion, these informations are regarded to be typical for ice-edge phytoplankton blooms with the presence of zooplankton activity, according to the models of Demel & Rutkowicz (1958), Gjøsaeter et al. (1983), Rey & Loeng (1985), and Slagstad, see in Loeng (1989).

After one month, nutrients and dissolved oxygen still show the occurrence of a phytoplankton bloom (Figs. 4.2 - 5, 6 and 8). But the nutrient exhaustion (PO_4 < 0.1 µM, NO_3 under detection limit, SiO_2 < 0.2 µM) and oxygen supersaturation (> 120 %) have reached the northernmost station (138).

In comparison with the first station (41) in the first transect across the Polar Front, the ammonia maximum at the station 138 had ascended up to 35 m, whereas its depth at the frontal stations was roughly the same (see Fig. 4.2 - 7). Another maximum with concentrations greater than 1.3 µM is present at station 146 at 50 m.

The deeper layers appear enriched with nutrients, the gradients being less pronounded in most cases.

Captions of Figures 4.2 - 1-8:

Figs. 4.2 - 1-4:	First section across the Polar Front in the Barents Sea, June 24-25, 1991
Fig. 4.2 - 1:	Dissolved oxygen distribution in µM
Fig. 4.2 - 2:	Silicate distribution in µM
Fig. 4.2 - 3:	Ammonia distribution in µM
Fig. 4.2 - 4:	Nitrate distribution in µM

Figs. 4.2 - 5-8:	Second section across the Polar Front in the Barents Sea, July 25-27, 1991
Fig. 4.2 - 5:	Dissolved oxygen distribution in µM
Fig. 4.2 - 6:	Silicate distribution in µM
Fig. 4.2 - 7:	Ammonia distribution in µM
Fig. 4.2 - 8:	Nitrate distribution in µM

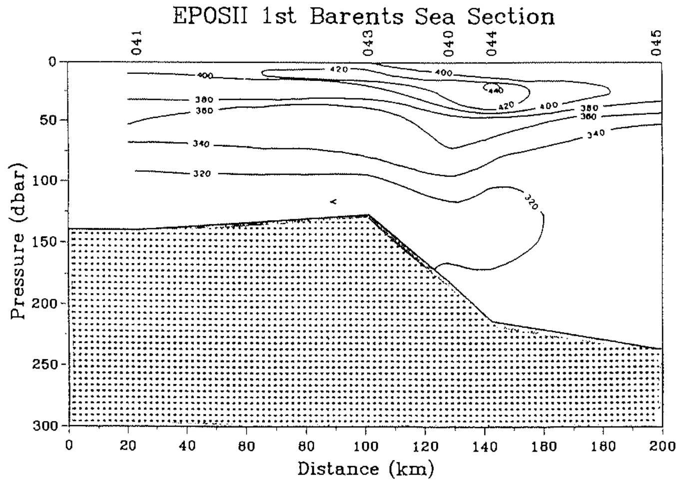


Fig. 4.2 - 1: Oxygen

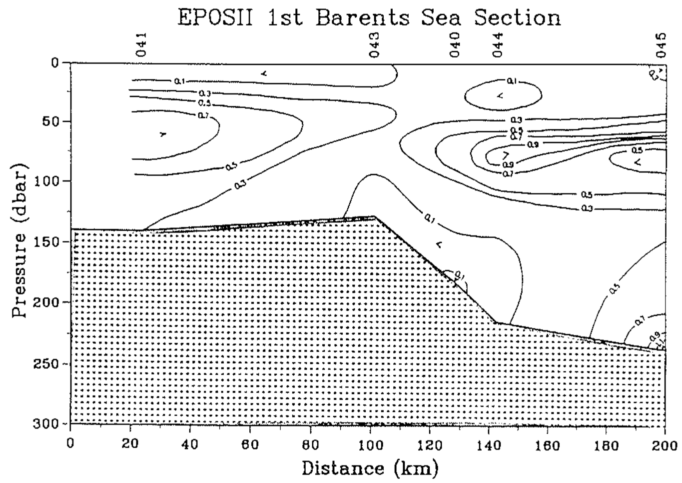


Fig. 4.2 - 3: Ammonia

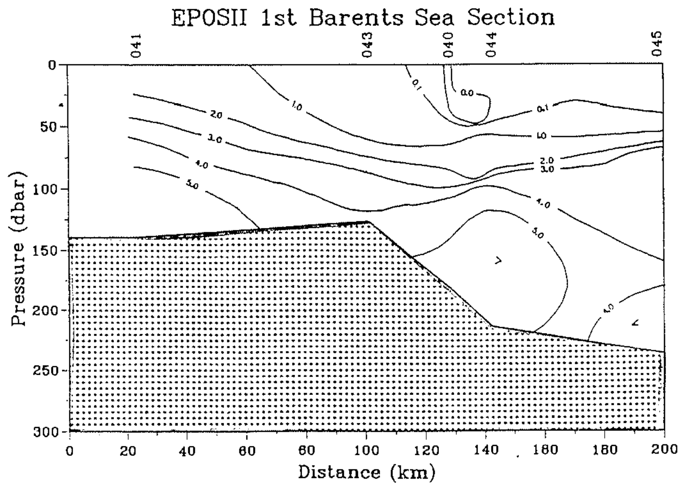


Fig. 4.2 - 2: Silicate

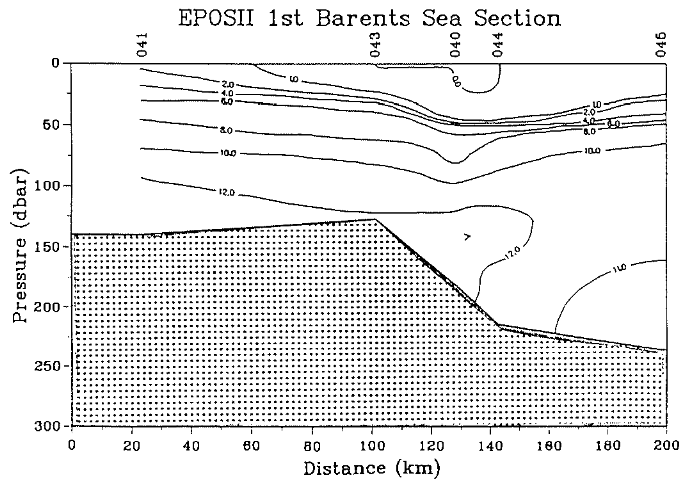


Fig. 4.2 - 4: Nitrate

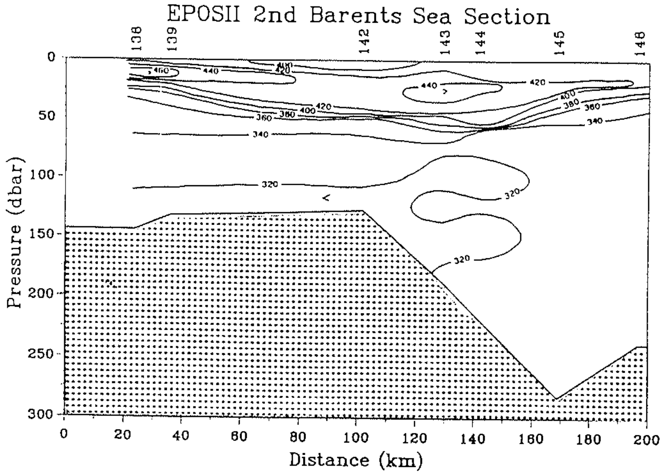


Fig. 4.2 - 5: Oxygen

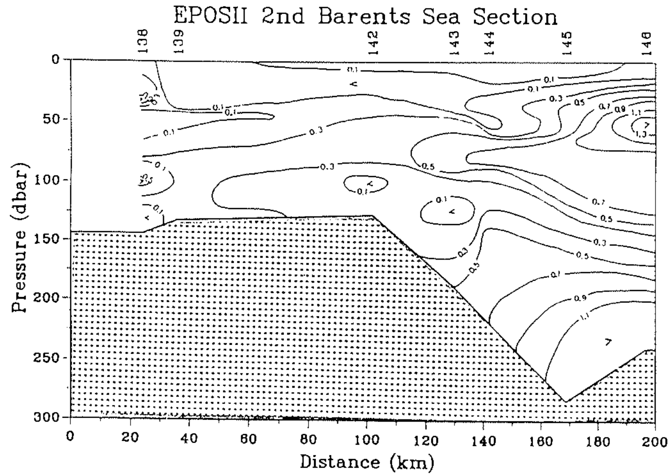


Fig. 4.2 - 7: Ammonia

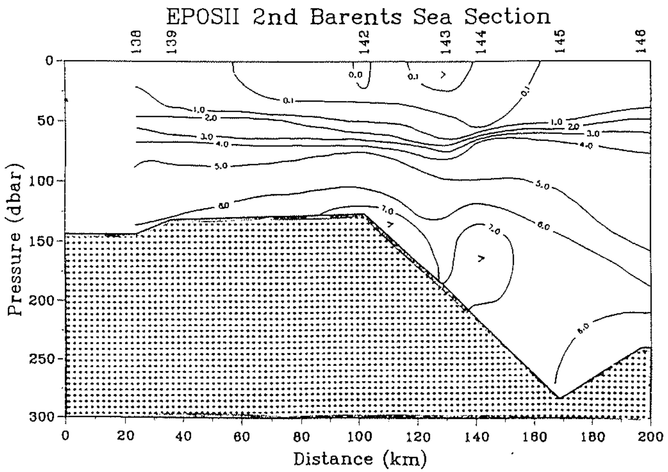


Fig. 4.2 - 6: Silicate

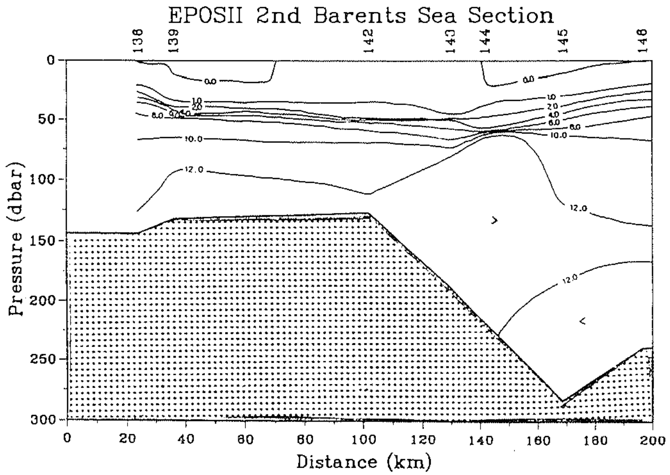


Fig. 4.2 - 8: Nitrate

Storfjord and Storfjord Renna:

The four transects in the Storfjord area exhibit strong gradients for all the measured parameters. Nutrients are low or completely consumed in the upper 15 meters, while dissolved oxygen concentration reaches values from 365 µM to more than 450 µM. Oxygen super-saturation and low nutrient values indicate the presence of a phytoplankton bloom (Figs. 4.2 - 9, 10). This bloom situation is intensified going northward: 110-115% sat., 370, 1.82, 0.23 and 0.89 µM for oxygen, nitrate, phosphate and silicate respectively, are found at the southernmost stations 62-67; the corresponding values being 120% sat., 400, 0.00, 0.08 and 0.07 µM at the mid stations 55-58, and 125% sat., 450, 0.06, 0.05 and 0.07 µM at the northern stations 51-53.
From 100m down to the bottom we find the lowest values of the dissolved oxygen (320 µM , saturation of 95-98 %) and the highest of the nutrients (more than 4.0, with a core > 5.0 µM for silicate and more than 12.0 µM for nitrate).

The stations north of the sill (50 to 61, and in particular the deepest, number 50) are interesting because they seem to be the site of accumulation of dense, cold bottom water. In the layer below 130m, which is characterised by a constant temperature close to the freezing point at station 50, the concentrations of all the nutrients are increased (nitrate from 8.54 to 9.05 µM, phosphate from 0.63 to 0.83 µM, silicate from 3.88 to 4.61 µM) while the oxygen concentrations have decreased from 355 to 339 µM (saturation from 93% to 90%). A water mass with similar characteristics is still present at the stations 52 and 58, whereas this water mass is not any longer recognizable at the stations south of the sill (from 62 to 67) (Figs. 4.2 - 9, 10).

The vertical gradient of nutrients and oxygen at the northern stations, together with the temperature and salinity data, suggest the occurrence of remineralisation processes; this is in agreement with the findings of Anderson et al. (1988).

Across the Storfjord Renna (Stations 70-75), silicate is depleted in the upper water layers of the northern and southernmost part of the section (Fig. 4.2 - 13), while the oxygen saturation values are the highest (118%) at the same stations (Fig. 4.2 - 11). For nitrate, the lower values are clearly recognizable only in the northern part (Fig. 4.2 - 12). This might be correlated with a diversified phytoplankton species composition.

The deeper layers are characterized by the presence of Atlantic waters that intrude from south. The cold bottom layer along the slope, which presumably was formed in the depression north of the Storfjord sill, with its core at Station 73, shows minimum values in oxygen saturation and nitrate, and a high phosphate concentration.

Captions of Figs. 4.2 - 9-13:

Figs. 4.2 - 9-10: W-E-section in the southern Storfjord

Fig. 4.2 - 9: Oxygen saturation values (%)
Fig. 4.2 - 10: Nitrate distribution in μM

Figs. 4.2 - 11-13: S-N-section across the Storfjordrenna

Fig. 4.2 - 11: Oxygen saturation values (%)
Fig. 4.2 - 12: Nitrate distribution in μM

Fig. 4.2 - 13: Silicate distribution in μM

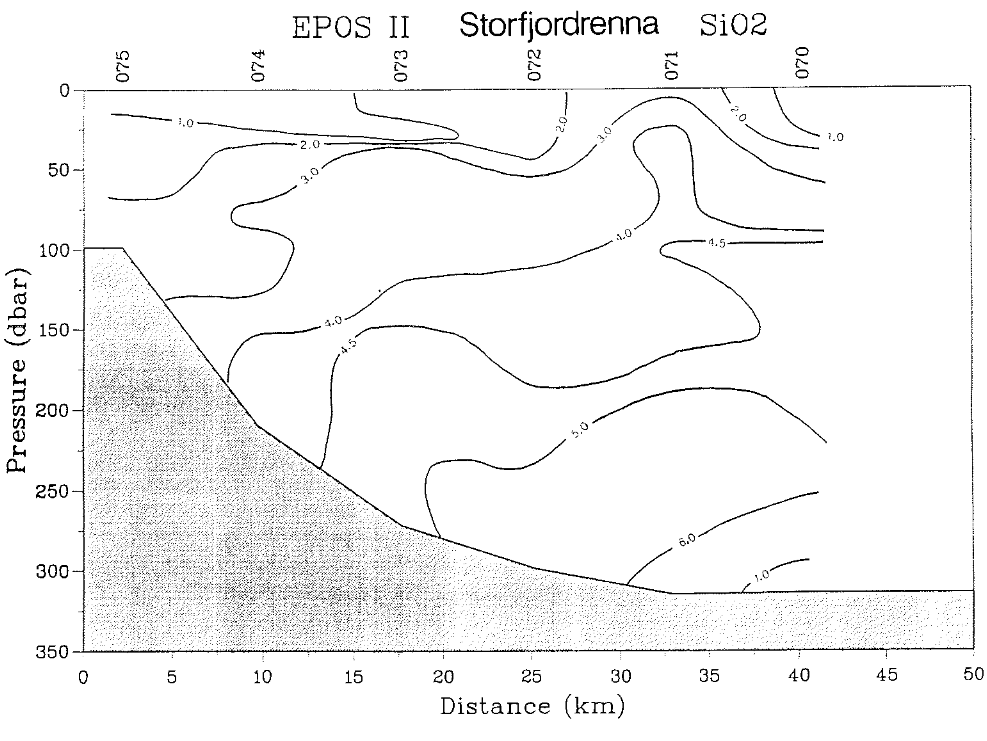


Fig. 4.2. - 13

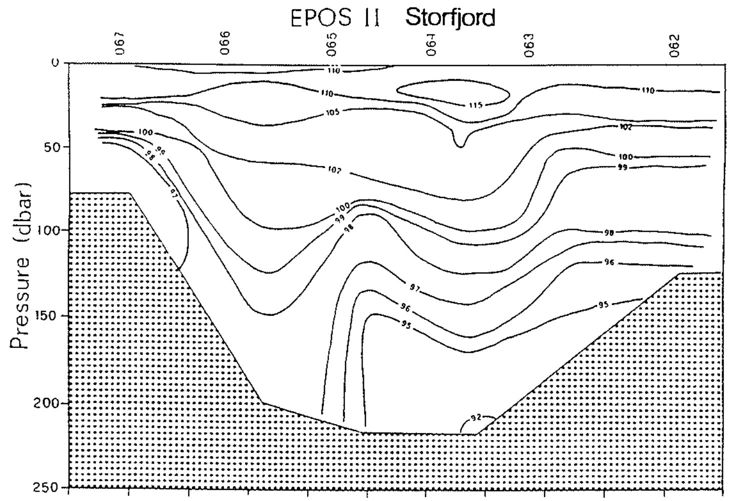


Fig. 4.2. - 9: Oxygen

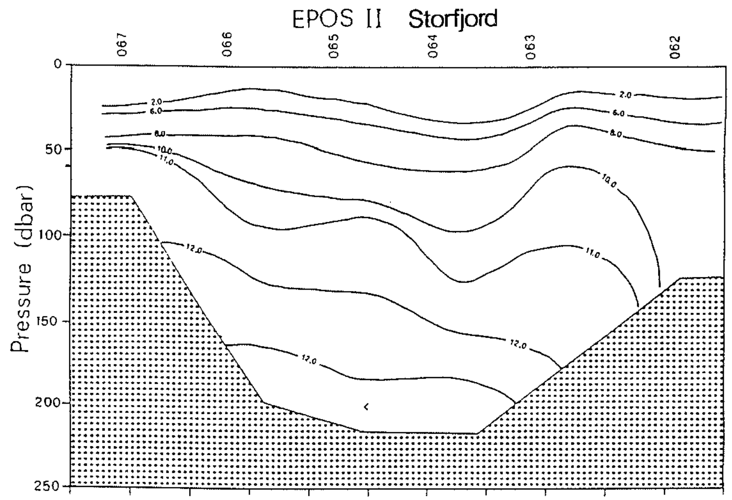


Fig. 4.2 - 10: Nitrate

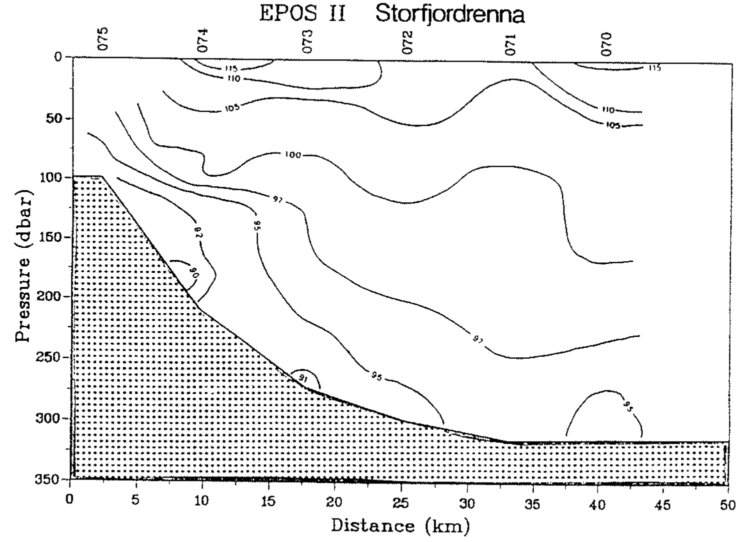


Fig. 4.2 - 11: Oxygen

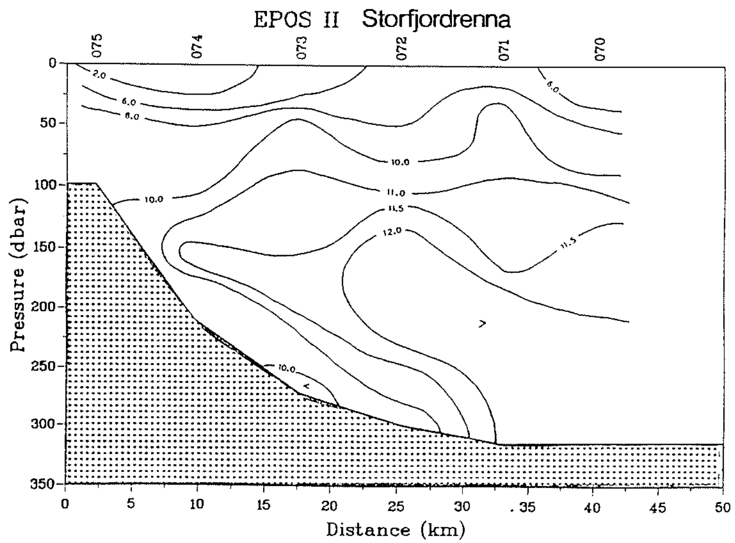


Fig. 4.2 - 12: Nitrate

North of Svalbard:

In the sections north of Svalbard, the nutrients represent well the main water masses (examples are shown in Figs. 4.2 - 14-16). The Atlantic water is isolated against the atmosphere by a layer of Arctic surface water (in the first 50 m) with relatively low salinities. Its contents of nitrate and silicate are as high as 9 µM and 4 µM respectively; and oxygen saturation values are mainly below 100%, concentrations then ranging from 340 to 370 µM. (All the concentrations measured ranged between 340-420 µM for the Seven Islands section and were slightly lower, 340-390 µM, for the Yermak Plateau.) The Arctic Ocean Deep Water has nitrate concentrations of 15 µM, a silicate content of 12 µM and oxygen concentrations of 320-330 µM.

The feature of low salinity at the bottom of the station 113 is reflected in the silicate (Fig. 4.2 - 14) and nitrate data by minima, whereas the lowest oxygen saturation values (< 90%) and high phosphate contents (>0.9 µM) occur at the bottom of the stations 112 and 111 (Figs. 4.2 - 15 and 16). All these peculiarities might have some relation with the shelf stations 115 and 106, maybe by processes like upwelling. Another interesting feature of the oxygen distribution in this transect is the occurrence of an oversaturated core, between 200 and 500m depth, at the station 110 (Fig. 4.2 - 15).

Along the ice free parts of the Seven Islands and the Yermak Plateau sections we have evidence of phytoplankton blooms at the ice edge previous to our measurements. Accordingly, maximum values of oxygen were observed at the station 93 with 425 µM (115% saturation), and at station 85 with 380 µM (112% sat.). The nutrients nitrate, phosphate and silicate were almost depleted, but a maximum of ammonia (1.64 µM) occurred below 25 m.

Northern to central Barents Sea:

The north-south section to the central Barents Sea shows some interesting features:
1) The southern part of the section, from station 146 to st. 132, is characterized by the depletion of nutrients and by oxygen super-saturation (max about 120%) at the surface, as partly described above (Polar Front). From south to north, along the transect, the thickness of this nutrient-depleted (or poor) layer decreases from 50m to about 20m (Figs. 4.2 - 17, 18, 19).
2) A second nutrient minimum occurs at station 126, well indicating the position of the marginal ice zone, located between stations 126 and 124 (Figs. 4.2 - 17, 18).
3) The euphotic depletion of nutrients along the greatest part of the section (from station 146 to 132) is complete only for nitrate (Fig. 4.2 - 17). On the

other hand, silicate is completely exhausted at stations 126, 133, 134, 142-144 (Fig. 4.2 - 18), south of the marginal ice zone.These water masses may indicate main (interim) locations of the ice edges, where spring blooms of diatoms have occurred. In Arctic regions spring blooms are known to be mainly characterized by the presence of diatoms, whereas other, nitrate-limited, species take their place during the following summer blooms.

4) Along the whole section some upwelling or admixing of nutrients occurs from the deeper layers, sustaining the phytoplankton growth. The observed patchiness of oxygen distribution (Fig. 4.2 - 19) is presumably produced by the patchiness of the phytoplankton community.

Captions of Figs. 4.2 - 14-19:

Figs. 4.2 - 14-16: North-eastern slope section

Fig. 4.2 - 14: Silicate distribution in µM
Fig. 4.2 - 15: Oxygen saturation values (%)
Fig. 4.2 - 16: Phosphate distribution in µM

Figs. 4.2 - 17-19: N-S Barents Sea section

Fig. 4.2 - 17: Nitrate distribution in µM
Fig. 4.2 - 18: Silicate distribution in µM
Fig. 4.2 - 19: Oxygen saturation values (%)

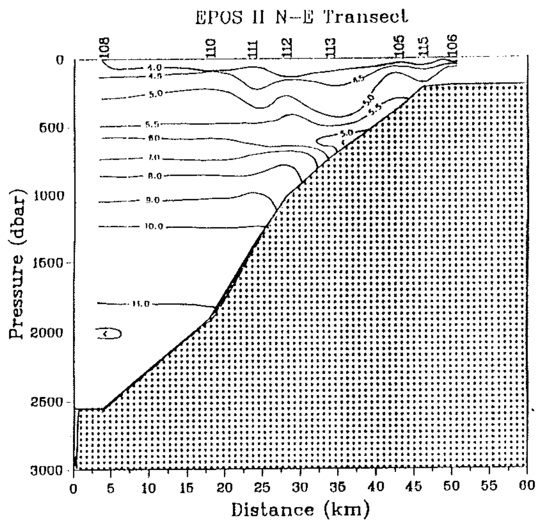


Fig. 4.2 - 14: Silicate

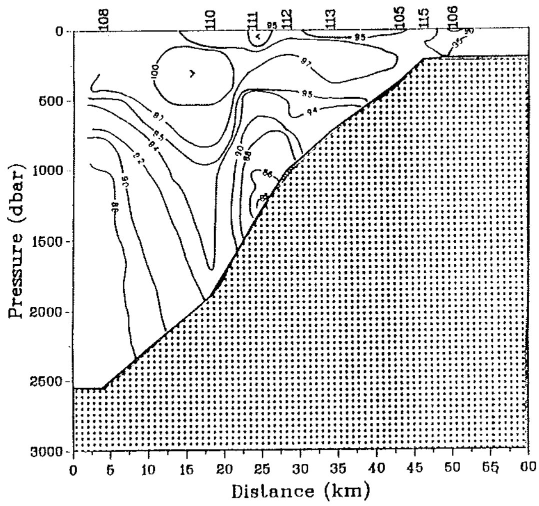


Fig. 4.2 - 15: Oxygen

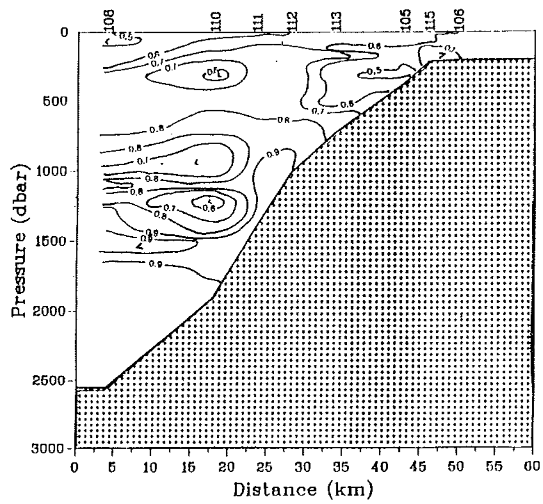


Fig. 4.2. - 16: Phosphate

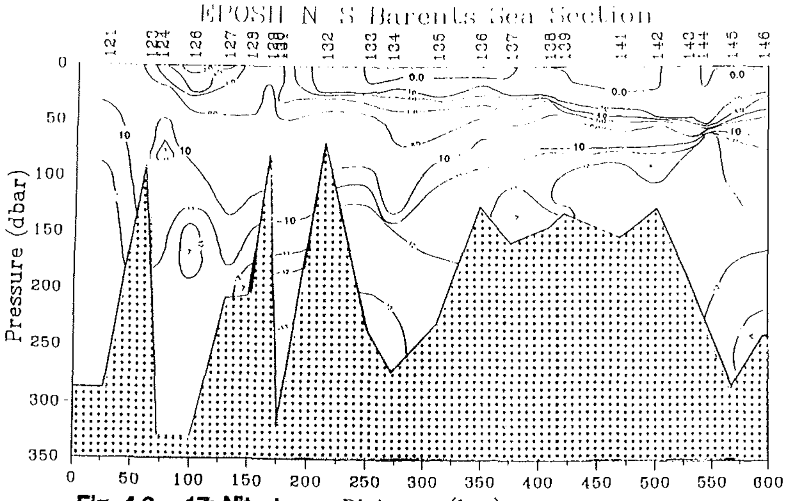


Fig. 4.2. - 17: Nitrate

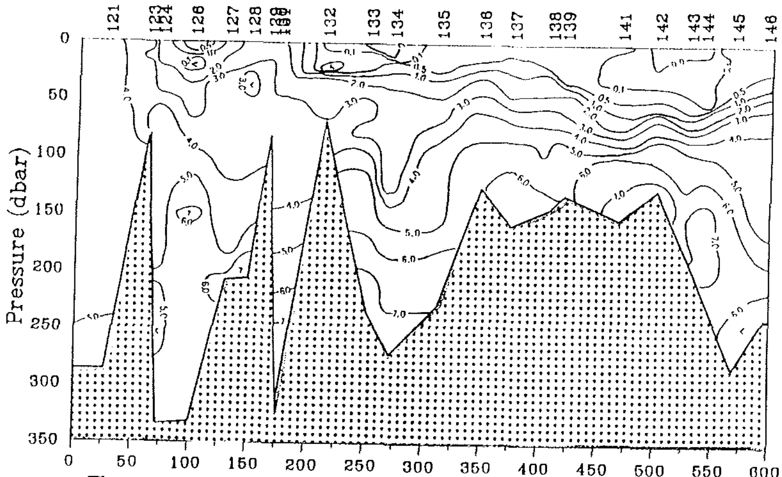


Fig. 4.2 - 18: Silicate

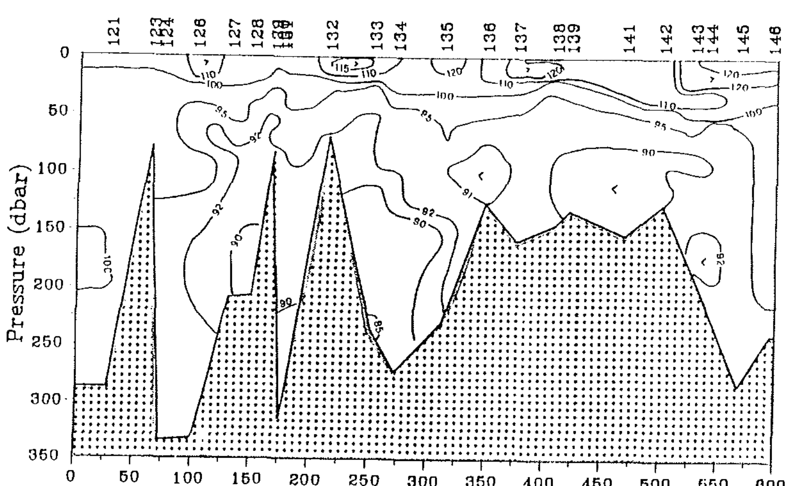


Fig. 4.2 - 19: Oxygen

5. Sea Ice

(M. Inall & P. Parker)

Introduction

The sea ice research on the SEAS cruise has been designed to characterise the ice and ice type distribution and some physical properties of sea ice in the Barents Sea and along its continental margin. The relative contributions of Arctic Ocean pack ice and locally grown first-year ice to the overall ice regime will be assessed.
The data obtained may also be used in the validation of ice type algorithms from satellite sensors and for the understanding of ice types and motions important for the ice regime along the Northern Sea Route.
Ice research was also intended to provide information and material for the ecological work of SEAS (light, nutrient and chlorophyll measurements; sampling of ice algae).

Methods

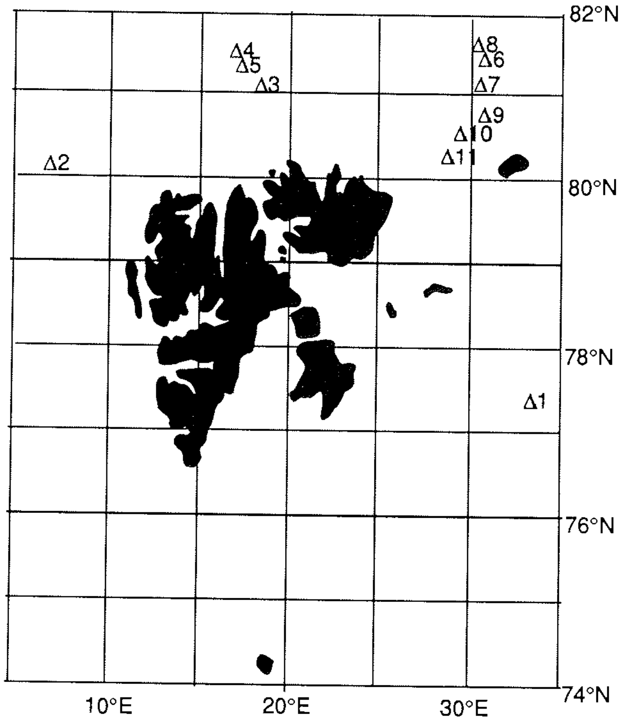
Along Track Observations:
Hourly observations of sea ice characteristics were made between all relevant oceanographic stations. The observations recorded were representative of sea ice conditions encountered over a ten minute observation period.
Characteristics recorded were:

- percent coverage of open water, and of various ice types,
- percent coverage of melt pools,
- snow thickness, ice thickness, floe size,
- degree of ridging and rafting,
- extent of brown ice and brown water.

Basic meteorologocal information from the ship display were also recorded. For most observation periods photographs of ice conditions were taken from the bridge to port and to starboard. When ice breaking, a downward photograph was also taken to gauge ice thickness more accurately.

A continuous video record looking forward from the bridge (during the observation period) was also made to assist with future analysis and comparisons of the sea ice observations which necessarily were not all made by the same person.

Ice Stations /Cruise Stations During ARK VIII /2



ICE STATION NUMBER	CRUISE STATION NUMBER
1	41
2	84
3	94
4	98
5	100
6	104
7	105
8	109
9	116
10	119
11	124

Fig. 5 - 1

On Ice Studies:
There were a total of eleven ice stations, varying from two to four hours in duration. Fig. 5 - 1 shows the positions of each of the stations and the corresponding cruise station numbers. Table 1 gives a summary of the work carried out. Ice thickness measurements were made through 5 cm diameter bore holes. A transect consisted of holes drilled on a straight line at 10 m intervals. No ice cores were taken after the 5th station due to the unfortunate loss of the ice corer broken deep in wet ice at that station.
Immediatly upon extraction of the cores, temperature profiles were measured at ten centimetre intervals with a sharp pointed k-type thermocouple probe. The cores were then stored frozen on board ship and subsequently analysed in ten or twenty centimetre sections for salinity, nutrients (phosphate, nitrate, nitrite and silicate), and chlorophyll.
The under ice CTD required a 20 centimetre diameter hole through the ice. It was found impossible to deploy the instrument through ice which was more than three metres thick or which was very wet, for fear of jamming the drill bit.
At some stations albedo measurements were made from a height of two metres above an undisturbed ice cover.

Results and Preliminary Analysis

Sea Ice Conditions:
The sea ice morphology of the Barents Sea is quite complex. Ice is mainly locally formed; and indeed over a period of many months the Barents Sea may supply ice to the Arctic Ocean. However, from May to September ice, on average, enters the Barents Sea from the Arctic Ocean through the passages between Nordaustlandet, Kvitøya and Franz-Josef-Land. In addition to this influx, multiyear ice may also be formed locally in the northern Barents Sea as ice generally does not disappear completely from these areas in summer. The ridging and divergence caused by intense polar lows, sweeping meridionally through the Barents Sea in winter, serves to further complicate the ice field morphology.

A preliminary analysis of the sea ice observations is shown in Fig. 5 - 2 which gives the total cover of all ice types in tenths. Two points should be noted. Firstly, the ship generally tries to avoid ice by following leads, sometimes kilometres wide. This biases both observations of total ice cover and of ice type, as leads are less likely to occur in thick ice. Secondly the view in Fig. 5 - 2 is not synopic, the observation period spanning some four weeks as indicated in the figure. This period, from late June to late July, typically encompasses the greatest monthly change in ice cover in this area. Thick fog, common at this time of year, was responsible for some gaps in the observations.

Ice Cover In Tenths Observed During ARK VIII/2

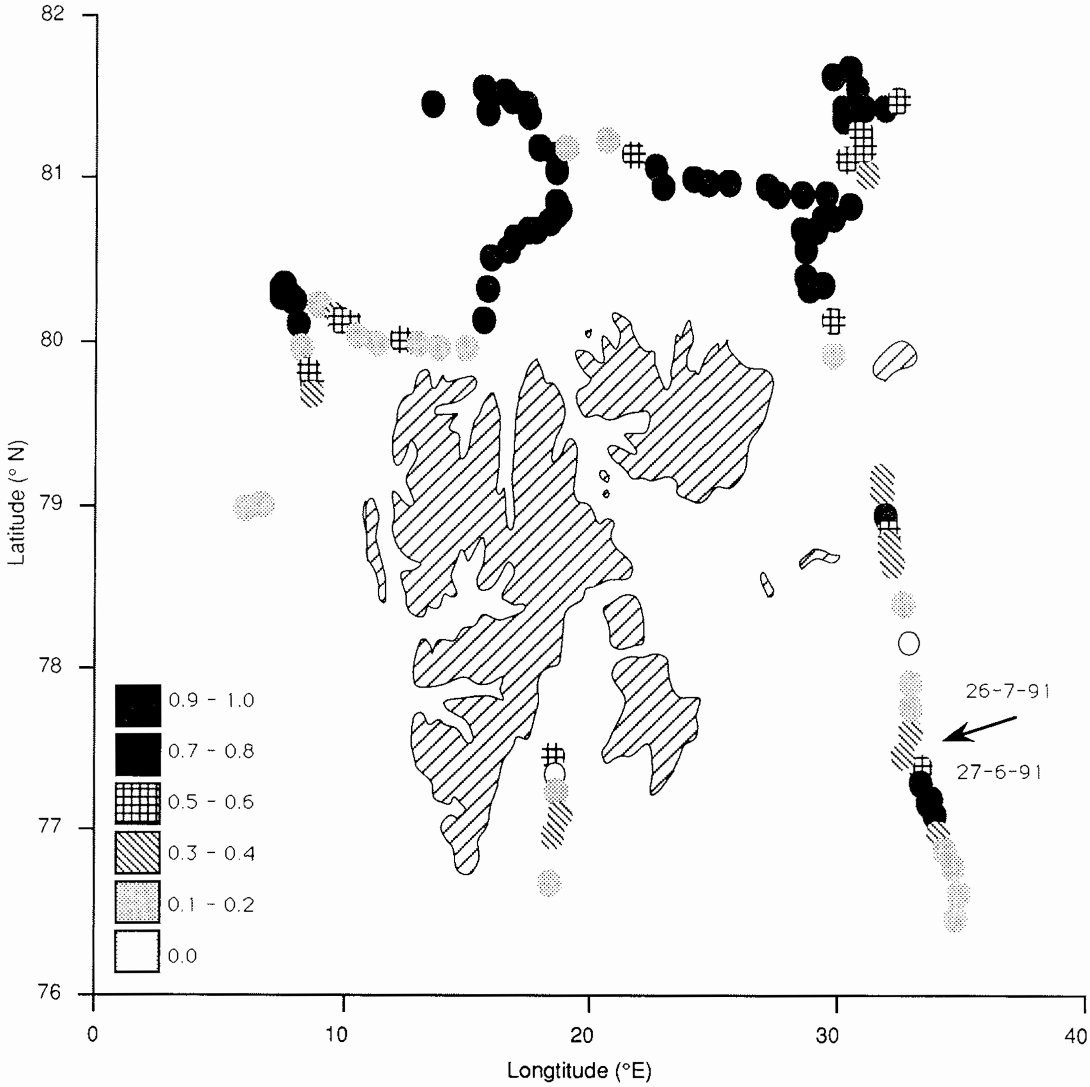
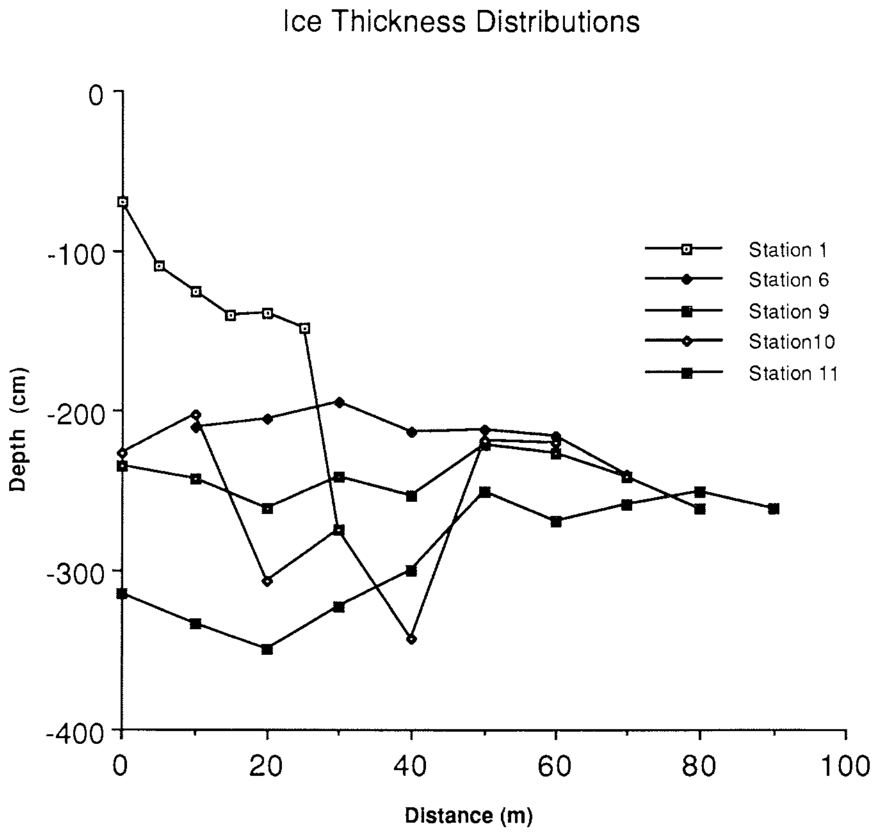


Fig. 5 - 2



Transect Stations	Mean Ice Thickness	No of holes
1	140 cm	8
6	212 cm	7
9	242 cm	9
10	256 cm	7
11	291 cm	10
Other Stations		
2	123 cm	6
3	160 cm	5
4	269 cm	2
5	410 cm	1
8	187 cm	1

Fig. 5 - 3

Overall, the ice conditions encountered were not exceptional for this time of year. The northerly component of the anomalous west-north-westerly winds prevalent during the first two weeks was perhaps responsible for sea ice first being encountered slightly further south than expected.
A more detailed analysis of the observations will be produced in the near future.

Ice Thickness:
Time allowed for transects of bore holes for ice thickness measurements to be carried out at five of the ice stations. The number of holes, the mean thickness and the standard deviations for these five stations are given in Fig. 5 - 3. Statistics for the other stations are from the holes drilled for the CTD or by the ice corer.

All the ice stations were on old ice (second or multiyear), even the first station in the Barents Sea proper. This is less surprising than it may seem, as the sturdiest floes were always chosen to put the ice workers onto. None of the ice station floes north of Spitsbergen were smaller than category 6 (1000m or greater). It was therefore possible to combine the ice thickness data from stations (4) to (11), a total of 43 in all, to give a mean multiyear ice thickness for floes greater than 1000m diameter in the area north of Nordaustlandet.

Ice Cores:
The salinity profiles of the ice cores taken concur with the observation that these floes were multiyear ice. Fig. 5 - 4 shows a typical salinity profile, with almost no salt in the compacted snow at the surface and salinity rising to no more than 4 ppt, indicating significant brine drainage. This profile is typical of multiyear ice, the surface of which is slightly elevated above the sea water level.
Data from the nutrient and chlorophyll analyses will become available at a later date. No attempt has yet been made to estimate heat flux through the ice from the temperature profiles. Temperatures varied from -0.1 to -3.2 °C, indicating relatively mild temperature conditions in the ice.

CTD Profiles:
Similarly little has been done to date with the CTD data other than to produce calibrated temperature and salinity profiles. Of particular interest is a salinity profile taken adjacent to a 3 m high pressure ridge (Fig. 5 - 5). The jagged profile shows a relatively "fresh" (approx. 30 ppt) layer of water down to a depth of 25 metres. This could be a result of melting from the angled wall of the ice keel, with the spikes due the lateral infusion of low-salinity water into an initially salt-stratified environment. The temperature profile does not exhibit the same jaggedness; this could be a result of the much greater diffusivity of heat than of salt.

Station 3 Core Salinity Profile

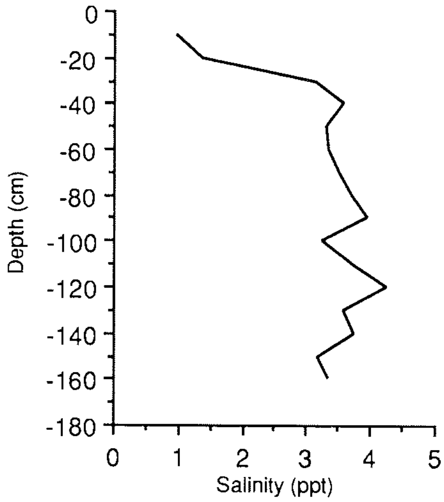


Fig. 5 - 4

Station 94 CTD Profile

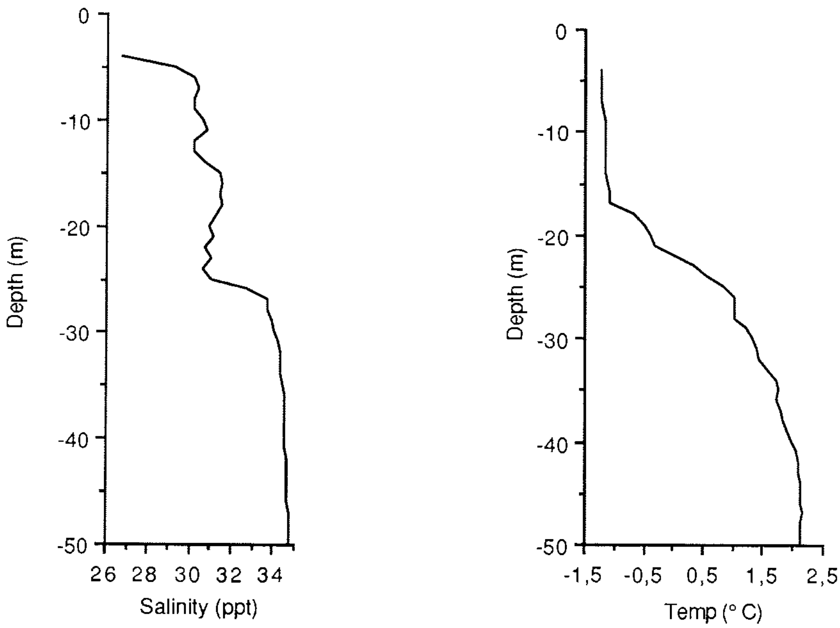


Fig. 5 - 5

Table 5 - 1 ARK VIII /2 Cruise Ice Station Summary

Ice Station	Latitude	Longtitude	Date	Time	Comments
1	77° 27 N	33° 03 E	24-6-91	0930	Two ice cores taken & eight ice depths along transect.
2	80° 23 N	07° 32 E	06-7-91	1310	Four ice cores taken & two ice depths. CTD deployed five times.
3	81° 02 N	18° 32 E	09-7-91	1515	Two ice cores taken. CTD deployed three times.
4	81° 31 N	16° 42 E	10-7-91	1045	One ice core taken, corer stuck in ice, dug corer out by hand.
5	81° 23 N	17° 25 E	11-7-91	0900	One ice core taken. Core two was started however corer stuck in ice at 1.5m depth. Unable to recover corer.
6	81°26 N	31° 38 E	14-7-91	1300	Eight ice depths taken. Polar bear sighted just as ice party was leaving the ice.
7	81° 25 N	30° 45 E	15-7-91	0805	Tried to drill hole for CTD deployment, ice too deep. (10m 41cm)
8	81° 39 N	30° 15 E	17-7-91	0900	Drilled ice-hole (1m 87cm), about to drill hole for CTD when polar bear was sighted. Returned to ship, bad visibility cancelled station.
9	80° 50 N	30° 37 E	20-7-91	0700	Two CTD's deployed, first ice depth 2m 34cm, second 2m 80cm. Further nine ice depths taken 10m apart.
10	80° 44 N	29° 29 E	20-7-91	1800	Transect of eight ice depths taken. Depth of ice on ridge 7m 80cm.
11	80° 20 N	29° 07 E	22-7-91	1300	One CTD deployed, ice hole depth 3m 14cm Transect of ten ice depths taken.

6. Biology

6.1 Phytoplankton and Particle Flux

Phytoplankton distribution and activity processes,
and sedimentation of organic matter

(Nöthig, E.-M.; Andreassen, I.; Duman, M; Gisselson, L.-A.; Gonzalez, H.; Mathieu, T.; Owrid, G.; Rhyzhov, V.; Socal, G.; Sörenson, F.; Wiktor, J.)

Objectives

The spatial heterogeneity of phytoplankton communities has been well documented for temperate latitudes. In ice covered seas, however, observations on the distribution, abundance and variability of phyto-plankton are comparatively few, due mainly to the inaccessibility of these waters throughout the majority of the year. Observations and measurements of the timing, location and duration of phytoplankton blooms and the subsequent input of organic matter into this marine system are of paramount importance to our understanding of the pelagic and benthic ecology of the Arctic shelf sea.

The different hydrographic areas which exist around Svalbard provided the opportunity to carry out a broad investigation on various pelagic regimes in polar waters. Phytoplankton ecology and related sedimen-tation processes will be compared in the different types of water masses, on the shelfs and in the deep waters. The influence of sea ice in the summer on phytoplankton development was also investigated.

The aim of the study was to understand the function of the pelagic system in polar waters in summer, by comparison of all measured parameters in the respective study areas. Data relating to the sedimentation of organic matter should give additional information about the composition and the amount of particulate matter sinking out of the euphotic zone. The comparison of sedimentation patterns with the results of activity measurements of the respective sediments may give ideas about pelagic-benthic coupling.

Altogether, this multidisciplinary study permits a comparison to be made between the pelagic system and the benthos and to relate the distribution and activity patters studied with one another.
The investigations were focussed on the following points:

a. Phytoplankton distribution:

- The observation of phytoplankton distribution including continuous along-track monitoring of surface waters will indicate the spatial and temporal variability of phytoplankton in the surface waters of the Barents Sea during the cruise leg.
- The horizontal and vertical distribution of phytoplankton species composition and biomass in the different areas around Svalbard will be analyzed with special emphasis on the spatial and temporal patterns in relation to sea ice situation, hydrography (water masses, advective and mixing processes), nutrients and grazing pressure exerted by zooplankton. - In particular, these observations may identify the complex hydrological and biochemical processes that influence phyto-plankton distribution not only on the Barents shelf proper (which is well studied), but also in the northern ice-covered regions, and across the slope into the Arctic Basin.

b. Phytoplankton activity processes:

- Elucidation of the rates and kinetics of nitrogen uptake and preferences for different nitrogen nutrients (ammonium, nitrate and urea) in the plankton community, in relation to ice cover, water column stratification, and *in situ* nutrient distribution. The studies also included experiments on the influence of ratios between nitrogen nutrients on the development of plankton communities and nitrogen uptake.

c. Relation of phytoplankton to zooplankton:

- HPLC measurement of phytoplankton pigments in the water column and within the guts of zooplankton were made in order to understand the influence of grazing on the respective phytoplankton assemblages.
(See also zooplankton report, esp. contributions of Mathieu, Gonzales and Graeve.)

d. Sedimentation:

- The short-term sedimentation pattern of organic matter in the different regions was investigated in relation to the pelagic system structure; the composition of organic matter in the water column and in the sediment traps will be compared.
- Sediment trap moorings in the central Barents Sea and northeast of Svalbard will monitor the annual variability in the particle flux in the two regions.

Work at sea:

Phytoplankton

Continuous measurements of temperature, salinity and fluorescence were recorded by a Sea Surface Monitoring System (SSMS) from June 22 to July 29, 1991. The SSMS consists of a Turner fluorometer, a conductivity-temperature cell and a flow meter which records the volume of water passing through the system. It was connected to the ship´s seawater pumping system with the intake pipe located approximately 9 m below the sea surface. Temperature, conduc-tivity, *in-vivo* fluorescence and the volume of water together with calculated salinity and chlorophyll-*a* content, were logged continuously. 4 hourly observations of the SSMS were carried out while the ship was moving between stations. At these times, samples of seawater were collected and filtered for *in-vitro* chlorophyll analysis, and salinity, temperature and *in-vivo* chlorophyll were recorded on the SSMS display. The ship's position (latitude and longitude) and the temperature and salinity from the ship's thermosalinograph were also recorded.

Phytoplankton investigations on horizontal and vertical species distribution as well as on biomass distribution were carried out at almost every station along all transects. Several different methods were used :

- In order to get a qualitative overview of the species composition in surface waters, vertical net samples were taken at 61 stations with an Apstein (hand) net (10 and 20µm mesh size) from the upper 10 m of the water column. These samples were directly analysed on board using an inverted microscope equipped with camera and video systems.
- Samples for quantitative analyses were taken from the rosette water sampling system, attached to the CTD (Neil Brown) and including a fluorescence probe. These samples were taken from surface water and at 20, 40 m depth, in the layer of the fluorescence peak, and also at the bottom of the euphotic zone (1% PAR). Samples were fixed with buffered formalin to an end concentration of about 1% and stored in brown glass bottles.
- In order to investigate the more rare species, 1 to 2 litres of water from selected depths were concentrated by inverse filtration and stored as described above.
- Samples for determination of chlorophyll-a, for HPLC measurements, particulate organic carbon and nitrogen and biogenic silica were also taken from the rosette sampler. For biogenic silica 0.5 - 3 litres were filtered on Whatman GF/F and cellulose acetate filters.

Chlorophyll-a was measured on board; and the other analyses will be carried out in the home laboratories. Water samples for HPLC measurements, particulate organic carbon/nitrogen and biogenic silica were only taken at selected stations.

Water for nitrogen uptake incubations was also taken from the rosette sampler. The depths chosen were the surface layer and the layer of the fluorescence maximum, if a pronounced sub-surface peak was found. Otherwise only surface water was used. Incubations were carried out in an illuminated cooled container. The uptake of nutrients was determined using additions of ^{15}N-labelled substrates, incubating under light, then filtering the particulate material on Whatman GF/F filters for subsequent determination of incorporated ^{15}N. Water samples from the layers, in the water of which the incubations were carried out, were also collected for the analysis of nitrogen nutrients (ammonium, nitrate, nitrite, urea), and particulate carbon and nitrogen.
Longer incubations (about one week) were carried out in addition, to see the effect of enhanced levels of different nitrogen nutrients (mainly ammonium), and on one occasion also of the addition of an ice algal assemblage, on the development of composition and activity of the plankton community.

Sedimentation

Different types of sediment traps were either moored for a longer time period, or used as drifting traps in open water or attached to an ice floe.

Short term deployments of sediment traps:

Trap-No.	Station	at Depth	Duration	Mode of Deployment
1	78	100 m	8 h	drifting
2	81	100 m	9 h	drifting
3	101	100 m	13 h	moored at ice floe
4	105	100 m	20.5 h	moored at ice floe
5	108	100 m	6 h	moored at ice floe
6	112	100 m	20 h	moored at ice floe
7	124	60 m	23 h	moored at ice floe

Long term deployments of sediment traps:

This sediment trap work comprised

(1) a summer deployment of a time series sediment trap, type Mark 6 (with12 cups), combined with an Aanderaa current meter mooring in the frontal area of the central Barents Sea at Station no. 40: 76°36.8´N and 34° 51´E, water depth 198 m, trap at 145 m depth;
(2) the recovery of this summer sediment trap after about 5 weeks;
(3) the re-deployment of the same mooring array at about the same location in the central Barents Sea (Station no. 143 : 76°36.0´N and 34°51.2´E, 211 m deep, trap at 175 m) for about one year;
(4) deployment of a trap (type S/MT 230 with 20 cups) together with an oceanographic mooring array on the slope into the Nansen Basin at Station no. 105 (81°26.48'N and 30°55.62'E, water depth 417 m, trap at 75 m) for up to two years.

Accordingly, during the summer deployment, 12 high-resolution samples were collected in the central Barents Sea (sampling period: 2.5 days). The sediment trap mooring array, re-deployed for 1 year, is provided for collecting between the 1st of August 1991 and the 31st of July 1992; the sampling period is 30.5 days. The trap S/MT 230 mooring deployed for two years will collect samples from the 1st of August 1991 to the 1st of July 1993; the sampling period ranges between 14 days and a month during the first year up to 5 month in the second year. In total 20 samples are expected.

The following studies on the material collected with the traps will be done, mainly in the home laboratories: Microscopical analysis of the sedimented matter, determinations of dry weight of total flux, and chemical analyses of chlorophyll-a, particulate organic carbon and nitrogen as well as biogenic silica. The same methods as applied to the water column samples will be used.

Preliminary results

The investigation area can be divided into four main regions:
- Central Barents Sea shelf I and II
- Storfjord area
- West and Northwest of Spitsbergen (Kongsfjord Renna, Yermak Plateau)
- North of Svalbard (Seven Islands, Northeastern Transect)

In the following the most typical features of the respective areas are briefly presented.

Phytoplankton

Biomass distribution (chlorophyll-a):

Detailed analysis of the continuous data will be carried out later, and only a few of the observations can be presented in this report.

In general, the chlorophyll values in the surface 10 m layer in the whole investigation area were low with a mean value of 1.21 µg/l (S.D. 1.21 µg/l). In the central Barents Sea, high chlorophyll concentrations were observed at the northern end of a north-south transect across the Polar Front, with a maximum of 3.97 µg/l. Chlorophyll levels then decreased slightly further to the north, but then increased at the ice edge. The transects across the Storfjordrenna, to the south of Spitsbergen, and then the transects including the Kongsfjordrenna, Yermak Plateau and at Seven Islands all revealed comparatively low chlorophyll values of less than 1.0 µg/l towards the northern sections. To the northeast of Svalbard, the highest surface values of 4.63 µg/l were recorded in the Renna northwest of Kvitøya. A maximum of 6.05 µg/l was found just north of the north-to-south transect through the central Barents Sea. This occurred at the marginal ice zone, and this zone has previously been shown to have enhanced primary production.

For calibration purposes, a comparison was made between the temperature and salinity observations from both the SSMS and the CTD at a depth of 10 m. The SSMS values were highly correlated for both temperature and salinity with values of >0.93 and >0.96 respectively. From these curves corrections can be applied to the SSMS data.

The vertical distribution of chlorophyll-a showed a similar pattern to that from the surface monitoring, however, in many cases a deep chlorophyll maximum occurred. The latter occurred mainly south of the polar front where nutrients in the surface layers were depleted after the spring bloom.
Typical profiles of each of the main investigation areas are given in the Figs. 1a-g. Highest chlorophyll-a values were always found in the Barents Sea and in the Storfjord. At all other stations chlorophyll-a values were almost never or only slightly higher than 1 µg/l. Exceptions were three stations on the Kongsfjord and Yermak Plateau transects which were shallow and close to the coast. In contrast to the poor plankton concentrations in the water along the transects in the northern part of the investigation area, ice floes which were broken by the ship and turned over, showed a great deal of brown coloration caused by a high concentration of ice related algae (see below).

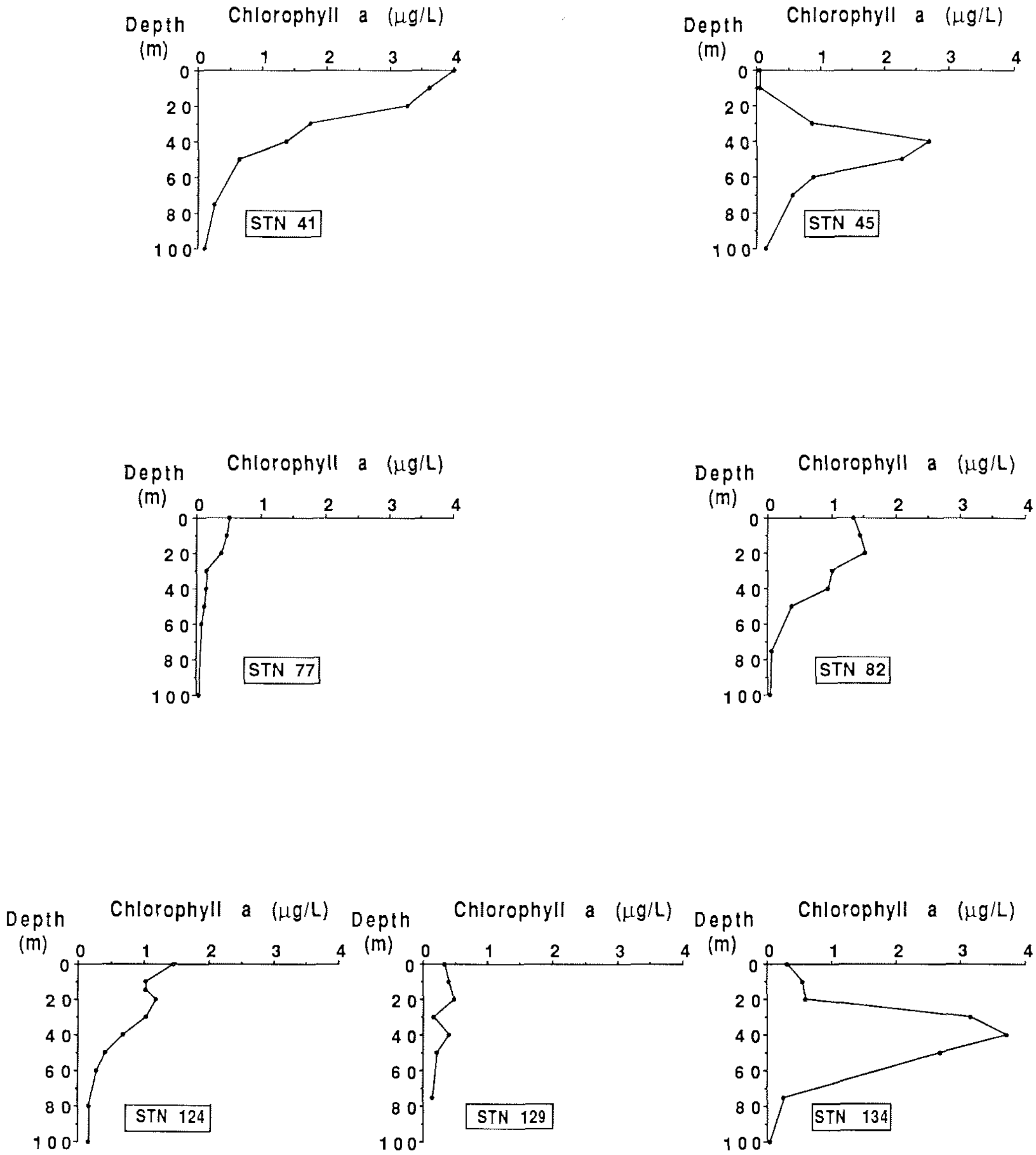
- Central Barents Sea shelf I (Figs. 6.1 - 1a and b):
The first short transect across the Polar Front showed a spring bloom state at the most northern station (41) in the pack ice with chlorophyll-a being highest in the surface, and a late bloom state with a deep chlorophyll-a maximum at station 45. The highest chlorophyll-a values of the whole cruise were measured along this transect with a maximum of 6.8 µg/l at station 43 at 30m. Along this transect the typical picture of the phytoplankton development at the receding ice edge could be observed. North and south of the Polar Front the deep chlorophyll-a maximum seemed to consist of different species indicating a different origin of water masses.

- Storfjord:
Along the three transects conducted in the Storfjord, almost all chlorophyll-a values showed a distinct maximum in the deeper water (between 20 and 70m), with the exception of some stations in the southeast. Chlorophyll-a values were generally lower than on the first transect, however, they reached maximum values of 4.4 µg/l.

- West and northwest of Spitsbergen (Figs. 6.1 - 1c and d):
The two transects (Kongsfjordrenna, Yermak Plateau) carried out west and northwest of Spitsbergen showed fairly similar pattern. Lowest values were found at the deep water stations farther away from the coast. The maximum values of chlorophyll-a always occurred in the surface layers. Maximum chlorophyll-a values ranged mainly between 0.3 and 1.5 µg/l.

- North of Svalbard:
The picture of chlorophyll-a pattern was very similar to those found northwest of Spitsbergen except that the chlorophyll-a values were lower and mainly ranged between 0.2 and 5 µg/l.

- Central Barents Sea shelf II (Figs. 6.1 - 1e,f,g):
The long eastern transect carried out on the Barents Sea shelf showed the same pattern as the short one one month ago: The ice edge had retreated further to the north, so was the surface chlorophyll-a maximum. Again deep chlorophyll maxima were found south of the ice edge. In between, some stations showed almost no real maximum of chlorophyll-a.
Although the fluorescence probe showed very high maxima at about 50 m, the chlorophyll-a values were lower than during the first transect which could result from a shift in species composition. In general, the maxima of chlorophyll were somewhat deeper than during the first transect, indicating that the phytoplankton moved further downward following to nutrient depletion in the upper water layers.



Figs. 6.1 - 1a-g: Vertical distributions of Chlorophyll-a (from water bottle samples)

a-b First transect in the central Barents Sea (Stations 41, 45)
c-d Transect Kongsfjordrenna (Stations 77, 82)
e-g Barents Sea transect north of the Polar Front (Stations 124, 129, 134)

Species distribution

In the samples obtained with nets from the surface waters, about 170 different species were determined. The most frequent species were:

	Species	Frequency of Occurrence (%)
1.	*Gymnodinium* cf. *simplex*	66.7
2	*Nitzschia grunovii*	66.7
3.	*Gymnodinium* cf. *arcticum*	64.9
4.	*Thallassiosira* cf. *gravida*	63.2
5.	*Pseudonitzschia delicatissima*	59.6
6.	*Gymnodinium* sp. (5 x 15 µm)	57.9
7.	*Thalassiosira* cf. *decipiens*	47.4

A minimum of 6 species was found at Station 88 (Yermak Plateau) and a maximum at Station 104 (north of Spitsbergen).

- Central Barents Sea shelf I :

In the northern part of the north-south transect across the Polar Front (Stations 38- 45), the phytoplankton was in the spring bloom phase. The phytoplankton biomass showed a surface maximum, with *Phaeocystis pouchetii* being the dominant species. From north to south *Phaeocystis pouchetii* decreased in the nutrient depleted surface waters. The species composition in the surface waters changed only slightly from north to south, indicating that the Polar Front was not very distinct (see Oceanography). The main species were more typical for Arctic water masses represented by centric diatoms such as *Eucampia groenlandica, Chaetoceros decipiens*, and pennate diatoms such as *Nitzschia grunovii, Nitzschia* cf. *seriata,* thecate dinoflagellates *(Protoperidinium pellucidum, P. depressum),* athecate dinoflagellates, and the Chrysophycea *Dinobryon baltica*. There were obvious changes in species diversity in the frontal zone (station 40 and 44), where maximum numbers of species were found.

- Storfjord:

In the Storfjord phytoplankton species composition was different due to the influence of the neritic environment of Svalbard. Many dinoflagellates were observed such as *Protoperidinium pallidum, Protoperidinium brevipes, Minuscula bipes,* and small *Gymnodinium* cells resembling *G. simplex.*

- West and northwest of Spitsbergen:

The influence of the warmer Atlantic water masses were evident in the species composition along the two transects carried out northwest of Spitsbergen. The influence was more pronounced along the Kongsfjord Renna transect, where diatoms such as *Chaetoceros densus, Nitzschia* sp., and dinoflagellates such as *Gymnodinium* spp., Nanoflagellates, *Cryptomonas* and non-determined flagellates were observed. At the Yermak Plateau transect the hydrographic conditions, esp. surface temperatures, showed a gradual transition from Atlantic to Arctic water masses, proceeding from southeast to northwest. The species composition showed a significant change between Stations 86 and 88: We found at Stations 84, 85 and 86 *Chaetoceros socialis, C. decipiens, C. simplex, C. gracilis, Thalassiosira decipiens, Nitzschia grunovii* and *Protoperidinium brevipes,* being typical for Arctic water masses, and, hence, disappearing at the southeastern Stations 88 and 90. At the latter, athecate dinoflagellates, *Cryptophytes* and other small auto-trophic nanoflagellates dominated.

- North of Svalbard:

The northern transect off Seven Islands was characterised by a low phytoplankton abundance especially in the areas covered with sea ice. Most of the species were Arctic forms with some Atlantic summer species. The most abundant phytoplankton species were: *Thalassiosira* cf. *conscripta, Thalassiosira* cf. *antarctica, Nitzschia* cf. *delicatissima, Fragillaria islandica, Gymnodinium* spp., *Cryptomonas* sp., *Pyramimonas* sp. and many cryophilic species belonging to the genera *Nitzschia* and *Navicula.*
In the northeastern area the abundance of *Melosira arctica* increased. In a sample obtained from the underside of an ice floe a typical under-ice summer community was found consisting of long chains and colony-like forms of *Melosira arctica* . The latter was found at all stations in the northeast and was associated with *Synedra* cf. *tabulata, Nitzschia grunovii and Chaetoceros septentrionalis.* In many cases abundant belts of *Melosira arctica* and associated algae were seen at the margins of ice floes.

- Central Barents Sea shelf II :

From ice covered areas in the north to the open water in the south there was a gradual change in the phytoplankton species composition of the surface waters: At the northern stations species such as *Phaeocystis pouchetii, Chaetoceros socialis, Nitzschia grunovii,* and *Amphiprora hyperborea* prevailed. At the most southern stations, where the influence of Atlantic water was most pronounced, the species assemblage changed from being dominated by diatoms to dominace of dinoflagellates. Many of the dinoflagellates seemed to be heterotrophic. The most abundant forms were *Gymnodinium* spp., *Gyrodinium* spp., *Amphidinium* spp. and *Protoperidinium pallidum.*

Experimental work

Almost all of the chemical and isotopic determinations needed to calculate the uptake rates of the different nitrogen compounds are to be carried out after the cruise. The only available results so far are from the changes in ammonia concentrations during the longer incubations. These suggest that the ammonia uptake is enhanced with enhanced ammonia concentrations, and was therefore not saturated at the *in situ* levels. This is in agreement with our findings in the Antarctic during EPOS 1 (ANT VII/3), when the ammonium uptake was never found to be saturated at the natural concentrations *in situ.*

Sedimentation

Vertical particle flux, measured with short-deployed sediment traps during seven occasions, was relatively low in the northern part of the investigation area (see table below). One trap, deployed at an ice flow in the marginal ice zone in the northern Barents Sea, however, showed higher sedimentation rates. Most of the sedimented material consisted of faeces of various heterotrophic organisms such as copepods, appendicularians and protozoans. The amount of sedimented phytoplankton seemed relatively low, and many cells of the centric diatoms had formed resting stages.

Table: Data to evaluate the flux of phytoplankton material in short-term deployments of sediment traps

Trap-No.	Station	mg Chl-*a* *m^{-2}	mg Chl-*a* *m^{-2}d^{-1}	% Chl.-*a*
1	78	18	0.060	0.3
2	81	26	0.059	0.2
3	101	16	0.016	0.1
4	105	23	0.152	0.7
5	108	11	0.025	0.22
6	112	16	0.019	0.12
7	124	58	0.951	1.6

Summer deployment in the central Barents Sea :

Samples were deep frozen for later analyses. A brief qualitative inspection of the samples with the microscope revealed the following :
The sedimented material in the 12 sampling bottles showed only low vertical particle flux in most cases. Two peaks in sedimentation were found, one corresponding to the period about two and the other to that four weeks after the deployment of the trap. The material in all samples consisted mostly of faeces. A large amount of these faeces were produced by copepods, and only few faeces of other metazoans were found. However, besides these conspicuous faeces other round faecal bodies were seen. The detailed analyses at home together with the results obtained from the water column above the trap will, hopefully, provide an explanation about what is producing these pellets. It is most likely from the shape and content, that small protozoans may be the producers of those faeces, which, as far as we know, were never reported before from the Arctic seas.

The results of all these short- and middle-term moorings showed a typical summer sedimentation signal. Sedimentation rates were relatively low, and the material was mainly composed of faeces. Therefore the vertical particle flux during this time of the year seems mainly to be controlled by the grazing community in the upper water column. The long-term moorings will hopefully give, in one and two years respectively, a more detailed picture of the seasonal pattern of sedimentation in the central Barents Sea and in the Arctic waters at the slope into the deep Nansen Basin.

6.2 Zooplankton

(H.G. Fransz , H.E. Gonzalez , M. Graeve , T. Mathieu , U. Meyer, F. Passelaigue and S.F. Timofeev)

Zooplankton was studied by collection with different nets, by incubation experiments and by lipid analysis. The objective was to obtain information on biomass, species composition, population and size structures, egg and faecal pellet production, and vertical migration. This can add to our knowledge of the life conditions of polar zooplankton, their distribution in relation to water masses and currents, and help to evaluate the grazing pressure on phytoplankton and the sedimentation of organic matter by faecal pellet production. Catches from the multinet taken at different depths will also be studied for algal pigment content to estimate the impact of grazing (T. Mathieu). The following sections describe the various contributions towards the estimation of the different aspects of zooplankton stock and activity.

Size distribution and community structure (S.F.Timofeev)

At the biological stations vertical hauls were made with a bongo net with 200 and 335 micron mesh gauze from 100 m to the surface. To study the communities and size structure of the zooplankton, a total of 80 Bongo net hauls were taken during the entire cruise.
Detailed information on the taxonomic composition, and the size structure of communities at the stations will be available after examination of samples following this cruise. This report gives preliminary information, based on analysis of samples from the bongo net with 335 micron mesh only, and for a selected number of stations.

Size structure of copepod communities:

Copepods were dominant at all stations, with the exception of St. 52-54, and 81 (Table 1). Statistical properties of the size spectrum of the copepod communities are shown in Table 2. As previously observed (Timofeev, in press), there is a decrease in average body size as one passes from oceanic to neritic and nearshore waters. This is very well illustrated by the profiles in the Storfjord (Barents Sea) and Kongsfjord Renna (Greenland Sea).

Table 6.2 - 1:
Relative abundances of taxa (%) in the mesozooplankton (Bongo net - 335µm)

Taxa	Stations										
	41	40	44	45	52	57	64	78	79	81	82
Copepoda	44,6	58,5	24,8	57,0	28,2	34,0	80,5	55,7	57,8	37,4	43,0
Amphipoda-Hyperiidae	0,3	-	-	0,4	0,1	0,1	0,4	3,2	0,8	-	0,1
Euphausiacea	1,7	4,5	7,1	3,2	0,3	0,8	1,6	3,2	0,8	-	0,1
Cirripedia-larvae	-	-	-	-	2,5	9,0	6,9	3,6	1,7	0,1	0,2
Decapoda-larvae	-	-	-	0,4	-	0,1	-	4,6	1,1	0,1	0,1
Ostracoda	-	-	-	-	0,1	-	-	-	-	-	-
Coelenterata	1,2	1,1	0,4	2,0	0,1	0,1	0,6	0,7	0,5	0,1	0,2
Ctenophora	-	1,1	-	-	0,2	-	-	-	-	-	-
Polychaeta-larvae	1,2	0,7	1,6	0,4	0,2	0,4	0,5	-	-	1,1	0,1
Pteropoda	2,3	2,8	0,5	0,4	0,1	0,2	0,4	-	0,8	0,2	0,2
Bivalvia-larvae	-	-	-	-	-	-	0,1	-	-	-	-
Chaetognatha	0,3	-	-	0,4	0,2	0,4	-	0,4	-	0,3	0,6
Echinodermata-larvae	25,9	10,8	7,6	19,5	48,0	42,7	2,4	-	6,3	60,2	53,2
Ascidia-larvae	-	0,7	-	-	-	-	-	-	-	-	-
Appendicularia	22,5	19,8	58,0	16,3	20,0	12,2	6,6	31,8	31,0	0,5	2,3

Table 6.2 - 2:
Statistical properties of size structure of the copepod communities

Stations	Lmin (mm)	Lmax (mm)	Lmid (mm)	CV (%)	As	Ex	N (ind.)
41	0,2	6,3	1,40 + 0,06	67,8	1,50	4,07	250
40	0,2	4,6	1,42 + 0,10	64,8	1,77	3,56	103
44	0,4	5,9	1,83 + 0,12	70,8	1,67	2,98	117
45	0,3	5,7	1,10 + 0,08	82,4	2,25	7,74	143
52	0,6	4,6	1,44 + 0,06	43,3	1,38	6,51	100
57	0,5	4,8	1,60 + 0,04	40,1	0,36	1,88	207
64	0,4	4,3	1,81 + 0,04	36,4	0,19	0,38	208
78	0,3	7,8	3,02 + 0,08	34,8	-6,14	2,58	156
79	0,3	4,0	2,84 + 0,08	38,0	-1,20	0,00	201
81	0,4	8,6	2,72 + 0,09	44,2	0,93	3,76	175
82	1,0	4,4	2,54 + 0,06	32,4	-0,22	-0,96	210

Lmin: minimum body length; Lmax: maximum body length;
Lmid: average body length;
CV: variation coefficient; As: asymmetry coefficient;
Ex: excess coefficient; N: number of individuals

In the Storfjord the average body size of copepoda decreased from the open sea to the fjord from 1,81 ± 0,04 mm (95% SD) to 1,44 ± 0,06 mm (Table 2). Analogously, in the Kongsfjord area the decrease was from 3,02 ± 0,08 mm to 2,54 ± 0,06 mm (Table 2). This change in the size structure of the copepod communities is a reflection of the differences in species and age composition of the communities. This variation is caused by a corresponding gradient in environmental conditions, which for example, are responsible for different rates of development in the species.

Abundance of the major size groups of pelagic crustaceans:
The relationship between abundance and body size in various taxa of zooplankton (Copepoda, Amphipoda-Hyperiidae, Euphausiacea, Cirripedia-larvae) was studied. The data obtained agree with previous data from the communities of western and southern parts of the Barents Sea (Timofeev, in press): $Y = 35{,}0106\ X^{-1{,}8934}$ (for herbivorous and omnivorous animals), and $Y = 1{,}2018\ X^{-0{,}8602}$ (for carnivorous animals), (where Y is abundance in ind. per m^3; X is body length in mm).

Pelagic larvaton in the Storfjord:

In the Storfjord area more than 50 % of the zooplankton consisted of larvae of benthic invertebrates (Table 1). There are three groups of larvae with different distributions according to depth:

1. there is a direct dependence between the abundances of ophioplutei and *Pagurus* (spp.) zoea larvae and depth;
2. there is no connection between abundances and depth in polychaeta larvae;
3. other larvae reveal more complicated situations:

a. larvae of bivalvia were observed only incidentally at the most southern, deepest station 64 (206 m);

b. in the case of nauplii and metanauplii of Cirripedia the abundance was highest at the shallow station (132 m), and at the deepest station (206 m); but low at the station with medium depth (170 m), which is the northernmost of the profile;

c. the cyprid larvae of Cirripedia have a distribution which is not related to depth, although their abundances increased continuously from north to south.

In the southern part of the Barents Sea the mass occurrence of Cirripedia larvae was observed during the spring phytoplankton bloom (Manteiphel, 1941; Zelikman,1977). Apparently, analogous situations occur in coastal waters near Spitsbergen. A maximum abundance of these larvae (75 ind.m^3) was, for example, found in Hornsund (77° N, 15° E) in June (Weslawski, Kwasniewski, Wiktor, 1991). In Storfjord the abundance is not as high (up to 60 ind./m^3). The relatively high abundance of cyprid larvae (up to 30 % at the St. 64) may be an evidence of a spawning peak of Cirripedia in the recent past, 4-6 weeks ago.
Coinciding with the Cirripedia in the Barents Sea was the planktonic crustacean *Thysanoessa inermis* Kröyer (Euphausiacea), which also spawnes during the spring bloom (Manteiphel, 1941; Zelikman,1977). Metanauplii are the dominant stage in the larval population of *T. inermis* in the Storfjord in the investigation period. Consequently, the spawning peak of *T. inermis* was nearly two weeks ago. In summary, it can be assumed from the Cirripedia and Euphausiacea abundance that the spring bloom terminated at the end of June 1991.

Distribution and structure of zooplankton populations (H.G. Fransz)

In addition to sampling for biomass and species distribution with the bongo net and multinet, samples were taken at the biological stations (41 stations) with a 50 mm-net (the "Fransz net"). This was hauled vertically in 3 epipelagic depth ranges from 50 m, 100 m and 300 m (or bottom) to the surface. In total 117 hauls were made. As the net retains all developmental stages of zooplankton species, additional information can be obtained with regard to population structure, state of development and in situ spawning activity (eggs to female ratio). The 3 depth ranges were used to indicate vertical variation and to some extent variance. The volumes filtered were measured by a flow meter. The samples will be analysed to obtain numbers per m^3 of the developmental stages of copepod species, and combined numbers of other species or groups. Specific biomass and size class biomass will be estimated later by applying length-dry weight-relationships published for the different species in comparable conditions.
To develop a sorting routine for identification of the different species and stages using fresh material, and to obtain a first impression of the distribution of populations, 30 samples of a series of 10 stations representing the different transects encircling Spitsbergen, were sorted on board. At all stations two copepod species were clearly dominant: a calanoid of the *Calanus* genus and the cyclopoid *Oithona similis*. Typical population structures (Figs. 6.2 - 1 and 2) show a dominance of young nauplii of *Calanus*, and of eggs and females of *Oithona*. This indicates a high spawning activity and a specific difference in life cycle.

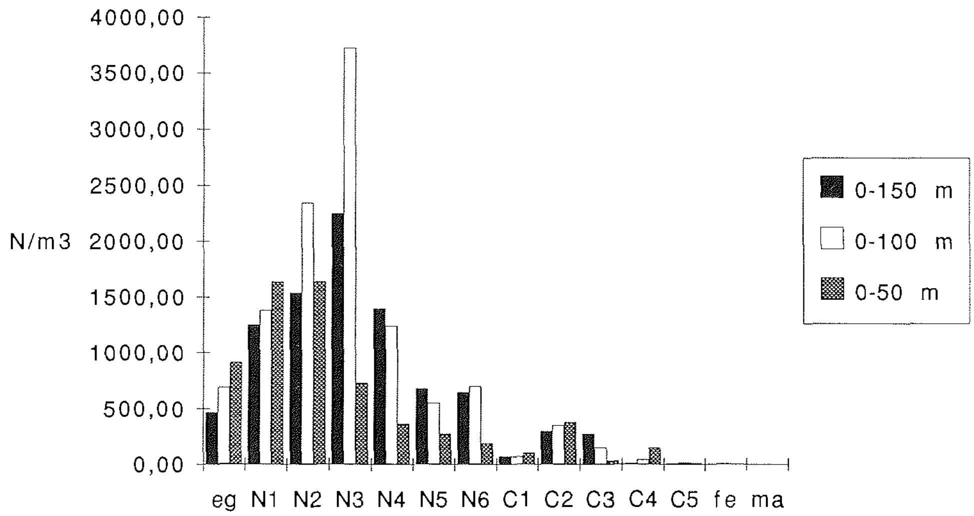


Fig. 6.2 - 1: Distribution of developmental stages
(eggs = eg, nauplii = N, copepodids = C, and adults = fe, ma) of *Calanus finmarchicus* in the inner Storfjord (Station 52).

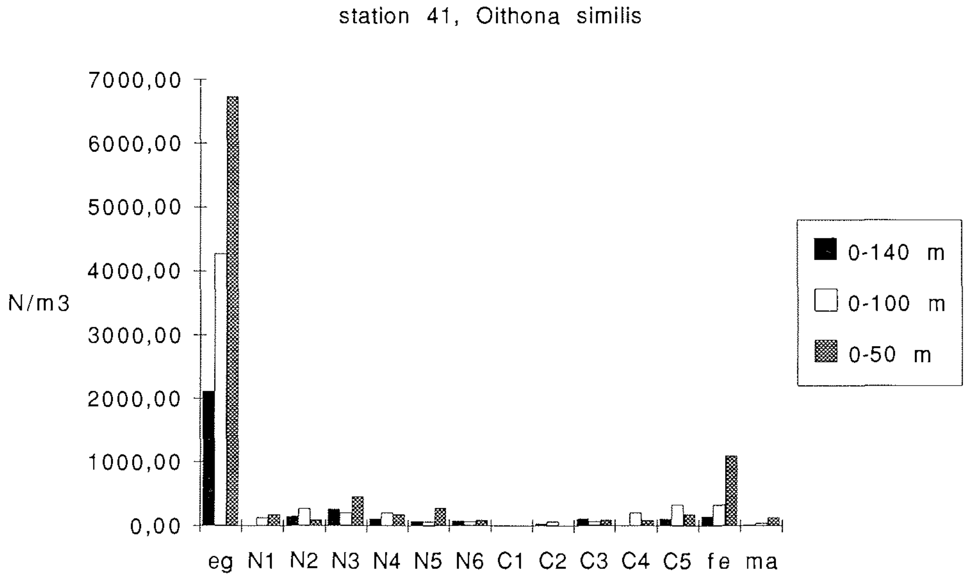


Fig. 6.2 - 2: Stage distribution of *Oithona similis* near the marginal ice zone in the Barents Sea (Station 41).

Calanus finmarchicus dominated in the western stations influenced by Atlantic inflow, from Storfjord to the transect north-east of Spitsbergen. According to Fig. 6.2 - 3 its abundance and the egg/female ratio decreased from south to north. This boreal species seemed to fade away in the Atlantic outflow into polar waters.

Calanus glacialis was dominant in the east Spitsbergen current and the ice edge zone east of Spitsbergen. As indicated in Fig. 6.2 - 4 it was actively breeding in the marginal ice zone with its relatively high algal density. *C. glacialis* also occurred frequently, together with *C. hyperboreus* and *C. finmarchicus,* at the northernmost stations. But here, the Arctic species were only present in stages C3 to C5 and as non-spawning females. The yet to be analysed final transect into the Barents Sea will probably provide valuable information about the fate of *C. glacialis* as it passes from polar to more boreal conditions, and its response to increasing food levels at the marginal ice zone.

Oithona similis had a widespread distribution (Figs. 6.2 - 5 and 6). It spawned very actively in the frontal zone of the Barents Sea, but showed a remarkable decline in abundance from eggs to nauplii. It maintained its abundance and reproduction in the more Atlantic waters, even north of Spitsbergen where the algal densities were low. However, here its peak shifted from eggs to young nauplii. *O. similis* may depend on its internal energy stores, and also on scavenging of moribund orga-nisms in the outflowing Atlantic water.

From Figs. 3 to 6 it is clear that abundance and reproduction is often highest in the top 50 m of the water column. This may be related to the hydrographic structure, with a 50 to 100 m thick Arctic water layer on top of a warmer, but poorer, mass of Atlantic or Barents Sea water.

Captions of Figs. 6.2 - 3-6:

Fig. 6.2 - 3: The distribution of *Calanus finmarchicus* in the Atlantic section near Svalbard from Storfjord to the north-eastern transect.

Fig. 6.2 - 4: The distribution of *Calanus glacialis* in the polar front transect of the Barents Sea.

Fig. 6.2 - 5: The distribution of *Oithona similis* in the Atlantic section from Storfjord to North-east transect.

Fig. 6.2 - 6: The distribution of *Oithona similis* in the polar front transect of the Barents Sea.

Explanations:
eg = eggs; N1 - N6 = nauplius stages;
C1 - C5 = copepodit stages; fe = females; ma = males;
abscissa: depths of sampled water layers

Fig. 6.2 - 3 stations 52, 78, 84, 98, 108, Calanus finmarchicus

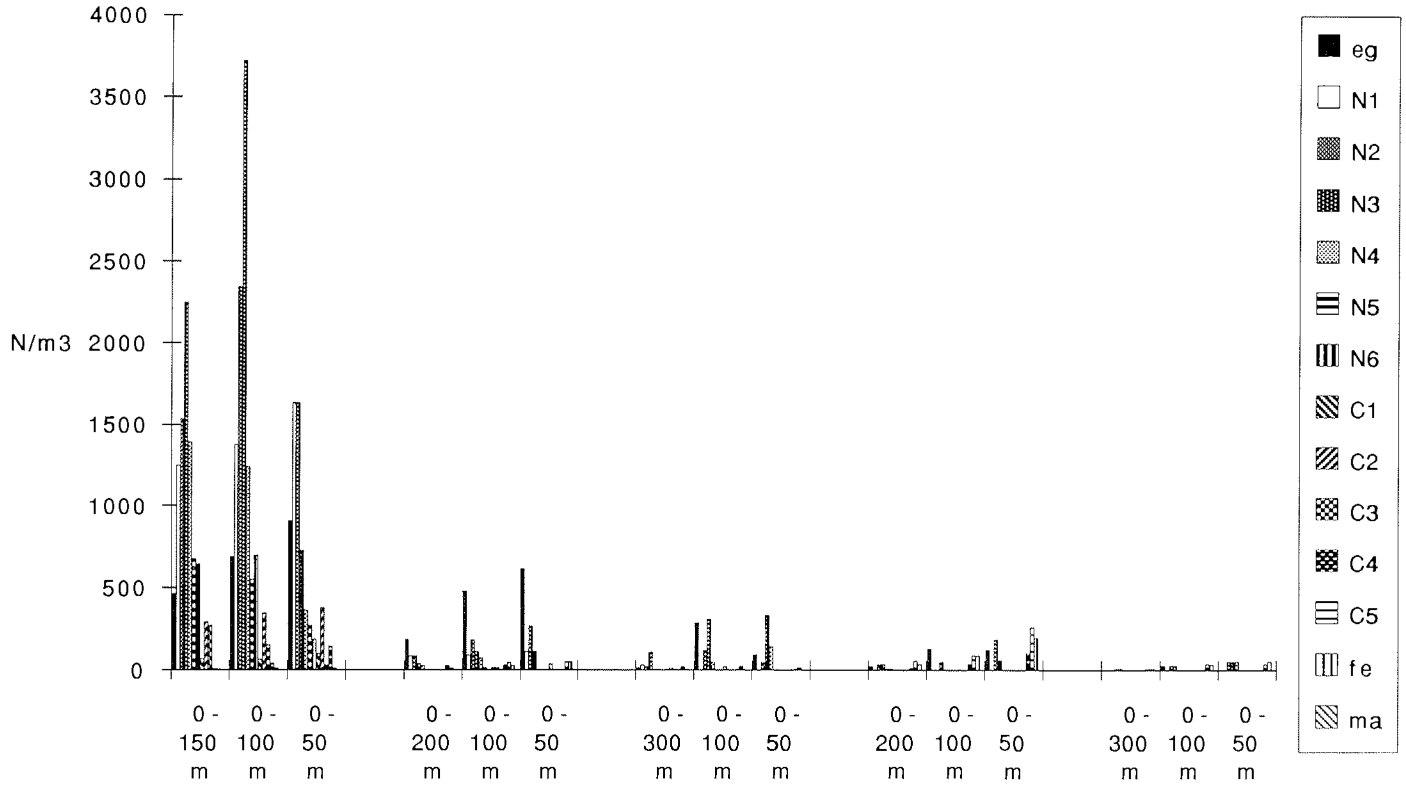


Fig. 6.2 - 4 stations 40, 41, 44, 45, Calanus glacialis

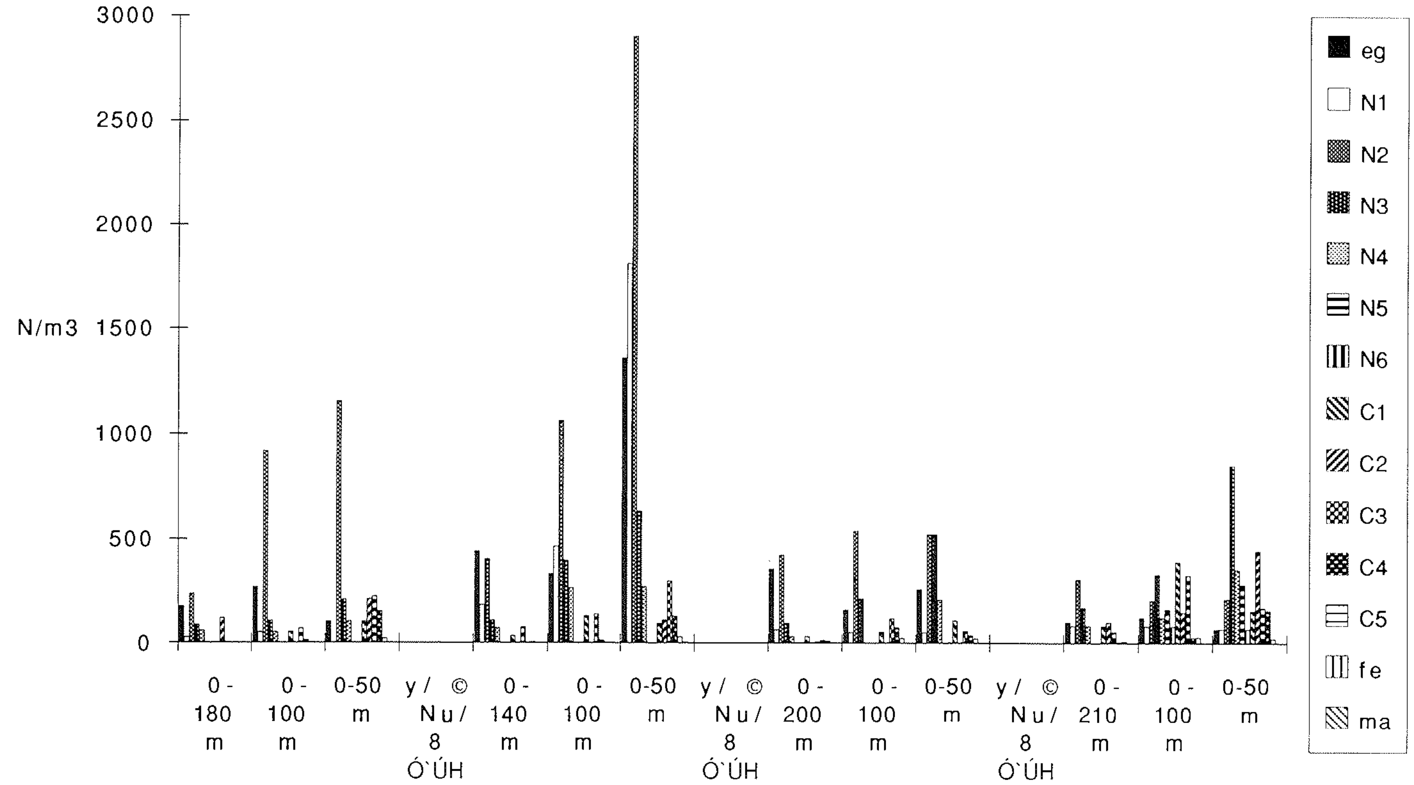


Fig. 6.2 - 5 stations 52, 78, 84, 98, 108, Oithona similis

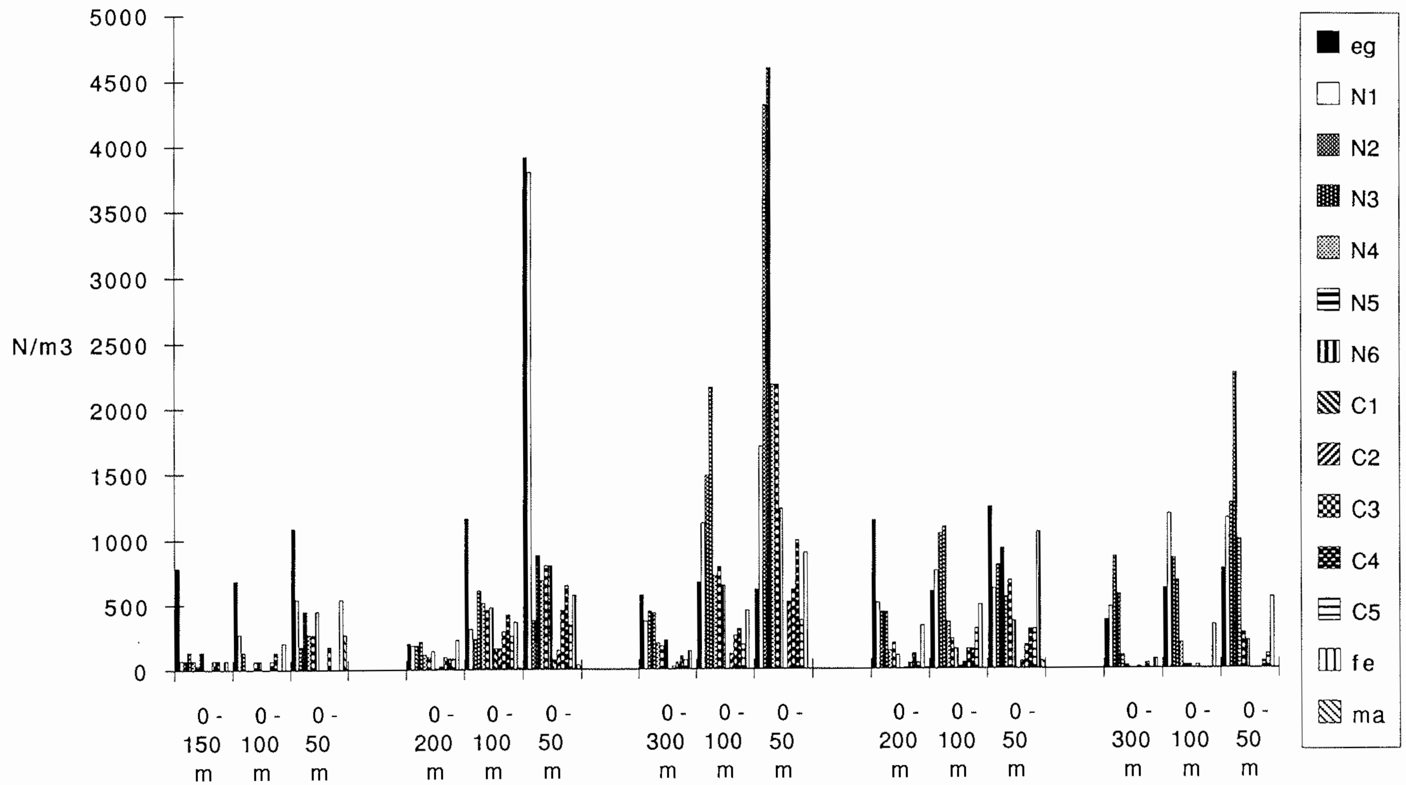
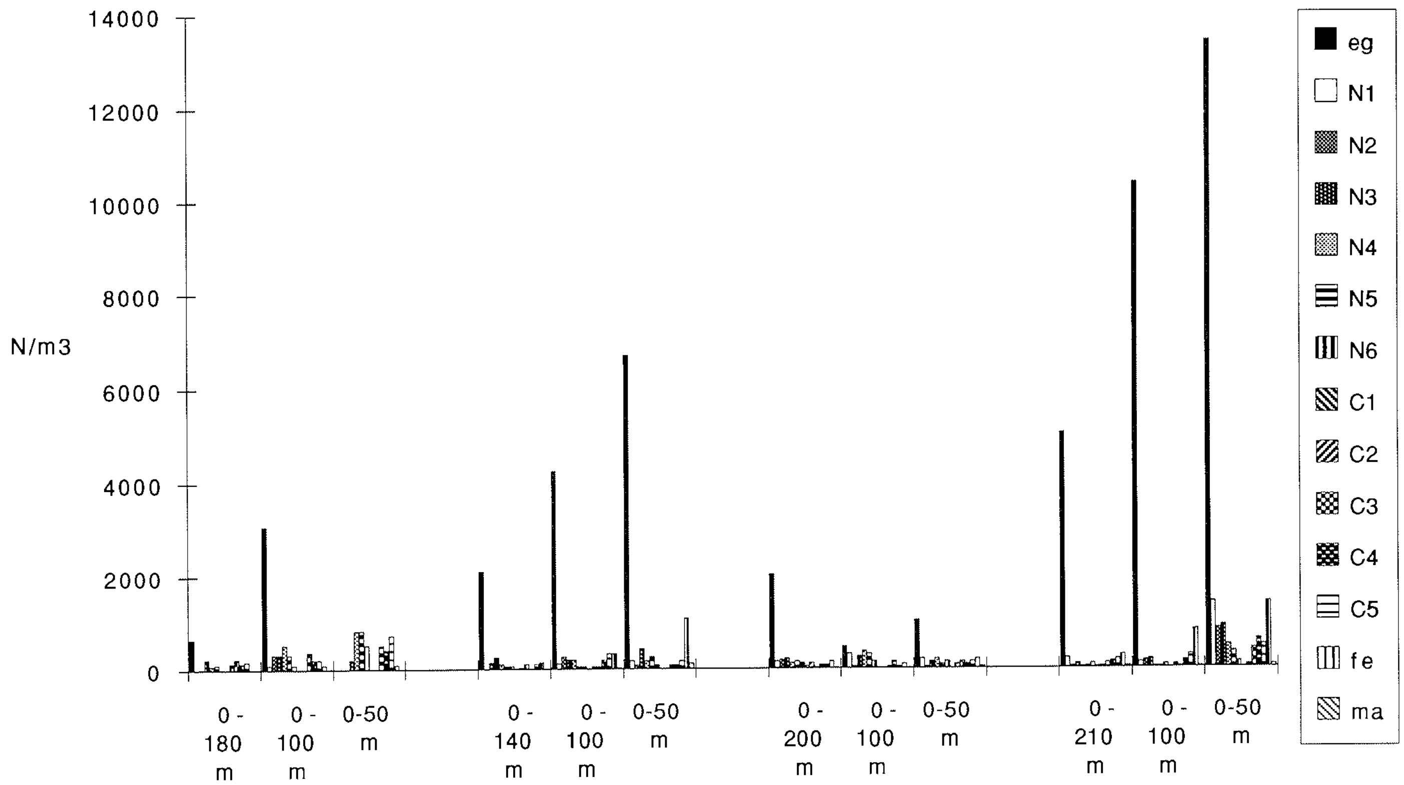


Fig. 6.2 - 6 stations 40, 41, 44, 45, Oithona similis



Secondary production and reproductive physiology of *Calanus*

(U. Meyer)

Secondary plankton production in the Arctic seas is dominated by herbivorous calanoid copepods. Their biomass is regulated by food availability. When somatic growth stops in adult females, surplus food may be completely utilized for the production of eggs. Therefore, egg production is directly related to food availability and can be used both as an indicator of feeding conditions and as a direct measure of net secondary production. The application of this method requires a detailed knowledge of the reproductive biology of the species considered.

Methods:

Zooplankton were collected from the upper 100 m (euphotic zone) by bongo nets (mesh size 200 and 335 µm). The 200 µm bongo net was used for the determination of abundance and biomass; and from the 335 µm bongo net, living animals were extracted for laboratory experiments.

Multinet samples (200 mm meshes) from different depths were taken to provide vertical profiles of zooplankton distribution especially in the region of the Atlantic Current. This allows us to study the advection of Greenland Sea zooplankton into the Arctic Ocean.

Females of *Calanus finmarchicus* were kept either under conditions of surplus food or in filtered seawater for several days. Thereafter females of each group were kept at 10 different food concentrations (from 0-300 µg C/l) of the diatom *Thalassiosira antarctica.*

Actual egg production experiments were carried out with females of *C. finmarchicus* or *C. glacialis* at 25 stations. Egg production during the first 24h in incubations is a measure of the actual rate in the field.

Preliminary results:

The samples taken for determination of biomass and distribution will be evaluated in the laboratory in the AWI.

Egg production in the experiments was clearly positively related to food concentration. In contrast to previous experiments, the females of *C. finmarchicus* showed a long response time to the change in feeding conditions (over several days). During the experiment, the animals showed a relatively high egg production rate already at low food levels. Animals that starved before the onset of the experiments did not reach the egg production of females kept at initial surplus food conditions.

Actual egg production was related to food availability. On stations with low food levels e.g. north of Spitzbergen, both females of *C. finmarchicus* and *C. glacialis* did not reproduce.

Macrozooplankton, in particular the euphausids (F. Passelaigue)

The sampling of the larger zooplankton was carried out by 19 operations with a number of plankton nets of 7 m length, 1.60 m in diameter and of 2 mm mesh, fastened on a single wire and hauled obliquely or vertically (the "Passe net"). During the first 6 operations, the nets were fitted with an acoustically controlled opening-closing system, allowing them to sample different bathymetric levels simultaneously. Unfortunately, the acoustic releases were disturbed by the noise of the ship. Moreover, due to the great number of different gears used during the cruise, it was not possible to carry out plankton sampling and vertical light recording at regular periods during the 24 h cycle. For these reasons, the study of the spatio-temporal distribution of the zooplankton according to changes in the *in situ* irradiance, and of the possible diel vertical migrations, could not be fully performed as planned. Later, the sampling was carried out by vertical or oblique hauls of 1, 3 or 4 nets without the opening-closing system. The samples, often poor in animals, will be studied at the laboratory.

The irradiance ($W*m^{-2}$), measured to depths of more than 400 m, showed, at a depth greater than 50 m, a ratio of 10 to 1 between "midday" and "midnight".

Some of the catches provided living individuals, particularly the euphausid *Thysanoessa inermis*. These were kept in filtered seawater. The faecal pellets produced and the gut content of some of them, frozen in liquid nitrogen, will be analyzed at home. Other living euphausids were placed in an experimental device to study their locomotory reactions to light changes, which can determine their vertical migrations. The preliminary results showed that in alternating light and dark periods of 12 hours (LD 12 12), the vertical distribution seemed to be nearly homogeneous during the light phase, however with increasing activity in the upper level towards noon, as well as at the beginning of the total darkness. In continuous darkness (DD), nearly all swimming activity was in the upper layer, with a maximum at about noon.

Distribution and vertical flux of faecal pellets of metazoan (copepod) and protistan origin

(H. E. González)

The vertical flux of particles (especially of sinking faecal pellets), and the vertical feeding migrations of macrocrustaceans (s. report Passelaigue), constitute important processes which largely determine the export of organic matter from the photic zone to deeper layers.
In order to assess the vertical (upper 300 m) and spatial (around Svalbard) distribution of faecal pellets produced by protists (i.e. heterotrophic flagellates, ciliates, radiolarians), crustaceans (i.e. copepods) and other individuals (e.g. *Oikopleura*), the following samples were collected:

1. - Water samples (200 ml) from five levels between surface and 150 m depth were taken from the CTD-Rossette and preserved in hexamin buffered formalin (1% v/v). These samples will be analysed for the small pellets ("minipellets"), produced by protists. Preliminary obser-vations using the inverted microscope, demonstrated that these organisms were very abundant during this cruise.

2. - Faecal pellets and microzooplankton (i.e. tintinnids, radiolarians) were collected using a 50 mm plankton net ("Fransz net"). Vertical hauls from 300, 100 and 50 m depths to the surface were carried out in order to assess the distribution of these particles and individuals.
3. - Sediment trap samples were obtained using a drifting cylindrical sediment trap deployed at 100 m depth (usually it was anchored to a drifting ice floe).

The following experiments were performed:

- Faecal pellet production rate was estimated in laboratory conditions (at 5 °C.) using females of *Calanus finmarchicus*. The diatom*Thalassiosira antarctica* was added (twice a day) as food at nine concentrations from 15 to 300 mg C l^{-1}.
- Biological processes (i.e. coprophagy, coprorhexy, bacterial utilization) are important in the re-utilization and recycling of most of the organic matter which is packed in faeces within the photic zone. Laboratory experiments were carried out to estimate the relevance of the coprophagy and coprorhexy in copepods (*Calanus finmarchicus* and *Oithona similis*), processes which could determine the ingestion and/or fragmentation of faeces.

The different treatments used:
a. Control: Individuals of the species *Calanus finmarchicus* were kept in the laboratory at 5°C, in 250 ml chambers. Copepods (one per chamber) were

isolated from the faeces that they produced by a 300 µm net (only faeces could fall through the net). Diatoms of the species *Thalassiosira antarctica* were given as a food in concentrations from 20 to 30 mg Chl-a m^{-3}. Once a day the medium was changed and the faeces counted.
b. Coprophagy: similar to the control, but 4 individuals of the copepod *Oithona similis* were added (they could reach the faeces).
c) Coprorhexy: similar to the control, but the copepods *Calanus finmarchicus* could reach the faeces (potential coprophagy and coprorhexy).

Preliminary results:

In the present report, results of the experiments will be given only partially; most of the samples collected will be analysed in Bremerhaven.
As expected the faecal production rate increased as a function of the food concentration, s. Fig. 6.2 - 7. A high variability in the faeces production rate between different individuals was observed (up to two orders of magnitude in individuals from the same sex and size), however, the variability within individuals was low.

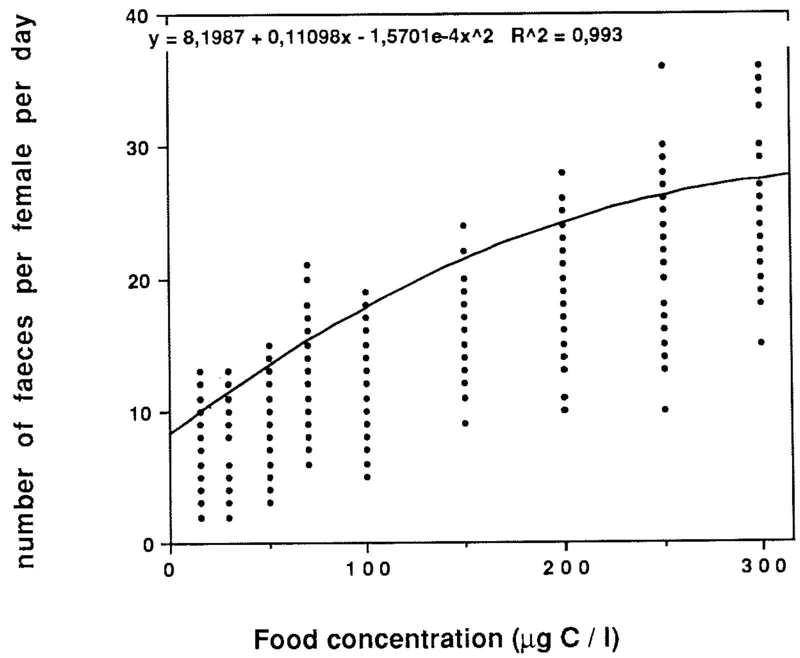


Fig. 6.2 - 7: Faecal pellet production rate (number of faeces per female per day) in the copepod *Calanus finmarchicus*, under different food concentrations (each dot represents from 1 to 7 observations; n=331).

In experiment N°1 (Fig. 6.2 - 8), the same seven individuals were tested in three different treatments (control, coprophagy and coprorhexy, as described above). Fig. 8 showes that in five (of seven) cases, significant differences (Kruskal-Wallis-test, $p < 0.05$) were found between the control and the other two treatments. The two non significant cases (one and four) corresponded to individuals which produced a low number (< 10) of faeces per day. Coprophagy experiments demonstrated that *Oithona similis* was able to feed on faeces produced by *C. finmarchicus*. This cyclopoid copepod has been found to be very abundant throughout the cruise, and it seems to be adapted to extreme conditions (i.e. scarce food). Its ability to consume particulate organic matter like faeces and probably other aggregates as well as phytoplanktonic cells released from the ice constitutes an adaptation which allows this species to develop continuous reproduction, even in oligotrophic areas.

The results of the experiments will be used for the interpretation of the in-situ vertical distribution of faeces, in conjunction with biological and oceanographic processes. In shallow areas < 300 m (more than 70% of the area covered by this cruise), the export of organic matter as faeces could be relevant in the bentho-pelagic coupling.

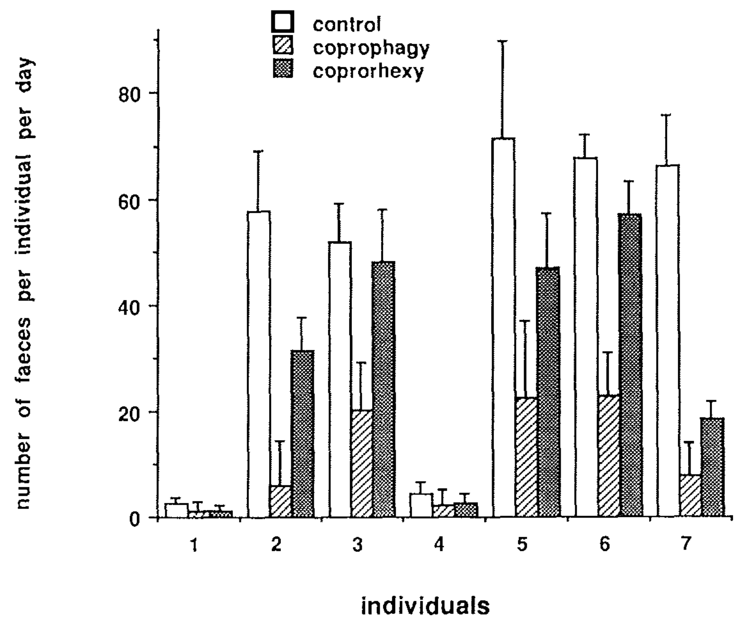


Fig. 6.2 - 8: Number of faeces per individual and day in *Calanus finmarchicus*. Each individual copepod (seven replicates) was maintained for 12 days in three different treatments: control, coprophagy and coprorhexy (four days in each). The line at the top of each bar represents the standard deviation (n=4).

Investigation of lipids in herbivorous copepods (M. Graeve)

a. Feeding experiments:

In the Greenland Sea, as well as in the Barents Sea, the three calanoid copepod species *Calanus finmarchicus*, *C. hyperboreus* and *C. glacialis* dominate the zooplankton biomass. These copepods are able to produce high amounts of lipids, especially wax esters. With the aid of these compact energy stores, they preserve energy over a long period of time. The poly-unsaturated fatty acids (PUFA) in the lipids of the phyto-plankton are incorporated largely in the storage- and membrane-lipids of these herbivorous zooplankton. To obtain more information about the energy flux between the phytoplankton and zooplankton, poly-unsaturated fatty acids serve as markers. Hence, the dietary state of the copepod species, which is given by the fatty acid pattern, was analysed with gas chromatography at various stations.
Subsequently the diet of the copepods was changed with pure algal cultures according to the regional regime found, for example from diatom diet to dinoflagellates and vice versa. During this cruise, 9 feeding experiments were carried out mainly with adult females and the copepodid stage V.

1	*C. hyperboreus* fem.	- Changed from diatoms to dinoflag.
2 and 3	*C. hyperboreus* V.	- Changed from diatoms to dinoflag.
4 and 5	C. *glacialis* fem.	- Changed from diatoms to dinoflag.
6	*C. glacialis* V.	- Changed from diatoms to dinoflag.
7 and 8	*C. finmarchicus* V.	- Changed from dinoflag. to diatoms

Both experiments with *C. hyperboreus* V showed a good response after 24 - 30 days. After this period the animals accepted the cultured algae and the marker PUFA which had been identified. The percentage value of the 18:4-fatty acid as a marker (18 : 4 = the numbers of carbon atoms : numbers of double bonds) increased in the experiment # 2 from 0.7% to 19.8%, and from 1.4% to 8.7% in the experiment #3.
These are preliminary results; the whole experimental results have to be confirmed after further calculations in the institute.

b. Spatial variability of fatty acids and alcohols in copepods and phytoplankton

The zooplankton during this cruise leg was dominated by *C. finmarchicus* (females and copepodites V). This species is typical for the Atlantic water on the Spitsbergen shelf. The samples, which were analysed already on board, originated mainly from the Yermak plateau. All these samples showed high amounts of the 18:4-fatty acid with up to 22% of the whole lipids. This marker acid was found previously in summer phytoplankton communities, which were dominated by dinoflagellates.

The portions of wax esters in the lipids of *C. finmarchicus* fem. and stage V were quite different, with 40% for the adult females and 70% for stage V (average values). The distribution of the fatty acids of the phytoplankton samples indicated a post-bloom plankton community due to the homogenous distribution of the marker fatty acids.

The remaining phytoplankton and zooplankton samples will be analysed later in Bremerhaven.

Vertical structure and correlation with phytoplankton (T. Mathieu)

During this cruise, we tried to contribute to the description of the vertical structure of plankton community, for which we used a multiple closing net (multi-net) with a mesh size of 200 mm to catch zooplankton. The 160 samples from 33 stations will be assessed in the laboratory to determine the biomass. Zooplankton horizontal and vertical distribution patterns will be related to phytoplankton distribution .

6.3 Zoobenthos and Fishes

(D. Piepenburg, N. Chernova, J. Gutt, M. Kendall, A. Neyelov, K. Opalinski, E. Rachor, M. Rauschert, L. Saldanha, M. Schmid, Chr. v. Dorrien)

Introduction

The ecology of the waters at the periphery of the ice-covered Arctic Ocean is poorly understood, as it is difficult to reach this region and to work there. During the ARK VIII/2-cruise of RV "Polarstern" in the summer of 1991, the high-Arctic, ice-covered continental margin north and east of Svalbard and the adjacent Barents shelf were the main target of the international and inter-disciplinary EPOS II research project called SEAS. The benthological and ichthyological programme of this cruise leg was considered as a contribution to the overall objective of studying the pelago-benthic coupling in these polar regions.

Objectives

As part of a joint benthic study, integrating various approaches and scientists, our working group concentrated on research on evertebrate benthos and fish. Our investigations may be grouped into three consecutive phases:

(1) faunistic inventory and zoogeographical analyses,
(2) delimitation of benthic communities and analyses of their spatial distribution, faunistic composition and ecological structure, and
(3) investigations of dispersion patterns, population structures and autecological adaptations of selected key species.

The results will be compared to those from other Arctic and eventually Antarctic regions (Fram Strait and Weddell Sea resp.) under several headings:

- Which species occur on the shelves and in adjacent deeper areas ? Is there any trend to "eurybathy" in the depth distribution of typically polar species ? Do "autochthonous" species or immigrants from boreal regions dominate the fauna ? Can we describe a decreasing Atlantic influence in the composition of the fauna from west to east ? What does the contemporary species composition tell us about the origin and evolutionary history of the fauna ?

- What are the characteristics of the communities in terms of distribution patterns and structural properties (e.g. faunistic composition, densities, biomass, diversity, prevalent modes of life, size spectra), and which factors are governing them ?

- Do the dispersion patterns of benthic populations have different spatial scales (local = within-station, regional = between-station) ? What are the causes determining the observed patterns ?

- Which information on growth, production and life cycles can be derived from the population structures of selected species? What is the type and duration of their life cycles ? Are there adaptations to the polar environment in terms of growth pattern and reprodution strategy ?

- Does the metabolic performance of selected polar species, measured as respiration rates, indicate an evolutionary cold adaptation ? How high are the energy fluxes and productivity values of macrobenthic populations estimated from metabolic measurements in relation to those derived from other independent methods ?

- How are demersal fishes related to the evertebrate benthos by their feeding ?

- What role do lipids play in the energy budget of polar species ? What does lipid content and composition tell us about the temporal patterns of food supply and about trophic relationships ?

Eventually, the synthesis of the various results will allow us to (1) to assess the interrelationships between community and population structures, dispersion patterns, autecological adaptations and environmental conditions, and (2) to distinguish the key factors shaping the different shelf ecosystems in polar waters.

During the SEAS project special emphasis was placed on (a) analyses of macro- and meiobenthic community distribution and composition (Piepenburg, Gutt, Schmid, Kendall, Rauschert and Rachor), (b) assessment of the abundance and dispersion patterns of epibenthic populations using bottom imaging methods (Gutt, Piepenburg), (c) distribution, zoogeography, taxonomy and feeding strategies of fish species (Chernova, Neyelov, Saldanha and v. Dorrien) and (d) respiration measurements of macrobenthos and fish obtained from trawl catches and core samples (Schmid, v. Dorrien, Opalinski).

Sampling and sample treatment

Several sampling methods were used to get as much information as possible on the bottom biotopes investigated and to cover adequately a broad size spectrum of the fauna ranging from meiobenthos to fish:

For the inventory of the mega-epibenthos an *underwater imaging system* (Ocean Floor Observation System, OFOS) which combines video photography and an underwater still camera (FTS) were employed in addition to the traditional *Agassiz trawl* (AGT). A larger *bottom trawl* (GSN) caught vagile suprabenthic animals incl. demersal fish, which are poorly sampled by the AGT. Moreover, for the sampling of macrobenthic infauna (and meiobenthos) a *box corer* (GKG) or a *multigrab* (MG) were used, and additional meiofauna samples were obtained with a *multicorer* (see Rachor and Kendall).
To document their original life colouration and shapes, numerous photographs were taken of selected benthic animals (M. Rauschert).

Benthos samples were taken at a total of 37 stations in the shelf and slope regions around the Svalbard archipelago (Fig. 6.3 - 1, Tab. 6.3 - 1).

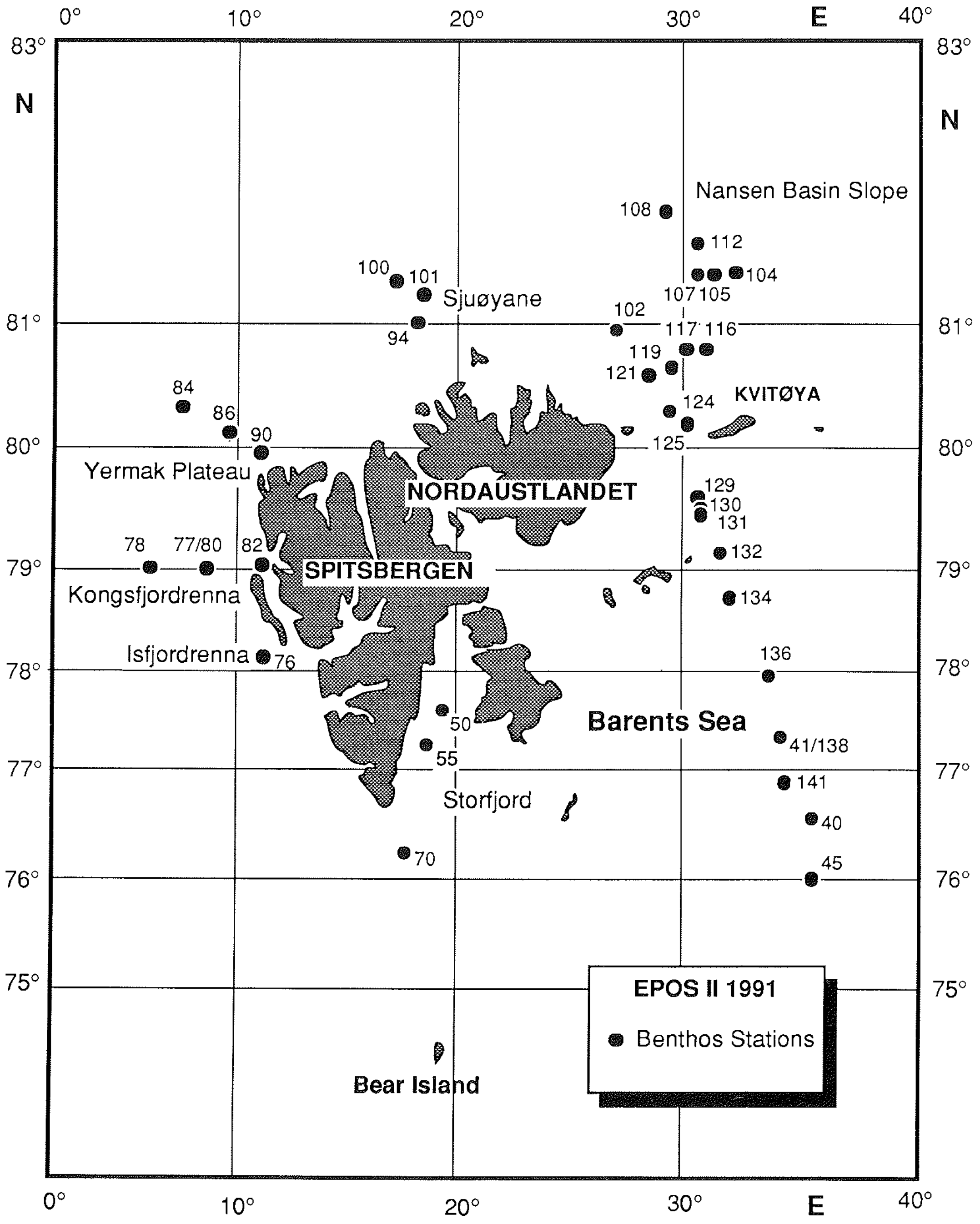


Fig. 6.3 - 1: Map of benthos stations sampled during ARK VIII/2

Table 6.3 - 1: List of benthological stations during ARK VIII/2

Gears:		
	AGT	Agassiz trawl
	FTS	still camera system
	GSN	bottom trawl
	OFOS	Ocean Floor Observation System
	GKG	box corer
	MG	multi grab

#	Stat	Date	Latitude	Longitude	Depth	Gear	other
Central Barents Sea							
1	040	22.6.91	76°36' N	34°50' E	200 m	GSN #1	
		23.6.91				OFOS #1	
2	041	24.6.91	77°22' N	33°18' E	150 m	OFOS #2	
			77°21' N	33°19' E	150 m	AGT #1	
3	045	25.6.91	75°59' N	34°48' E	250 m	GSN #2	
						OFOS #3	
Storfjord							
4	050	27.6.91	77°34' N	19°06' E	180 m	OFOS #4	GKG
			77°33' N	19°05' E	180 m	AGT #2	
5	055	28.6.91	77°12' N	18°19' E	100 m	OFOS #5	
						AGT #3	
6	070	29.6.91	75°59' N	17°10' E	320 m	OFOS #6	GKG
						AGT #4	
Isfjordrenna							
7	076	1.7.91	78°16' N	10°42' E	340 m	AGT #5	
Kongsfjordrenna-Transect							
8	077	2.7.91	79°09' N	07°59' E	960 m	GSN #3	
9	078	2.7.91	79°00' N	06°00' E	1800 m	OFOS #7	GKG
		3.7.91	79°00' N	05°45' E	2000 m	AGT #6	
10	080	4.7.91	79°02' N	07°51' E	1000 m	OFOS #8	St.077 GKG
11	082	5.7.91	79°01' N	10°45' E	330 m	OFOS #9	
			79°01' N	10°48' E	300 m	AGT #7	
Yermak-Transect							
12	084	6.7.91	80°19' N	07°28' E	640 m	AGT #8	GKG, MG
13	086	7.7.91	80°08' N	09°49' E	550 m	AGT #9	MG
						OFOS #10	
14	090	8.7.91	79°58' N	11°15' E	160 m	OFOS #11	GKG
			80°00' N	11°24' E	150 m	AGT #10	
Shelf north of Svalbard							
15	094	9.7.91	81°02' N	18°30' E	190 m	FTS #1	
						OFOS #12	

Tab. (continued)

#	Stat	Date	Latitude	Longitude	Depth	Gear	other
Sjuøyane-Transect							
16	100	11.7.91	81°22' N	17°28' E	850 m	OFOS #13	GKG, MG
						AGT #11	
17	101	12.7.91	81°12' N	18°35' E	400 m	OFOS #14	MG
			81°12' N	18°33' E	400 m	AGT #12	
Northeastern Transect (Nansen Basin Slope)							
18	102	13.7.91	80°58' N	27°14' E	90 m	FTS #2	
19	104	14.7.91	81°26' N	31°39' E	200 m	OFOS #15	
						AGT #13	
20	105	15.7.91	81°25' N	31°00' E	240 m	OFOS #16	MG
						AGT #14	
21	107	16.7.91	81°25' N	30°40' E	350 m	GSN #4	
22	108	17.7.91	81°40' N	30°05' E	2500 m	FTS #3	GKG, MG
			81°36' N	30°28' E	2100 m	AGT #15	
23	112	19.7.91	81°32' N	30°40' E	900 m	OFOS #17	MG
			81°32' N	31°05' E	850 m	AGT #16	
Kvitøyarenna-Transect							
24	116	20.7.91	80°50' N	30°39' E	100 m	FTS #4	
25	117	20.7.91	80°50' N	30°06' E	200 m	FTS #5	
26	119	20.7.91	80°45' N	29°29' E	470 m	OFOS #18	MG
	119a	21.7.91	80°43' N	29°07' E	550 m	AGT #17	
27	121	21.7.91	80°43' N	28°32' E	150 m	FTS #6	
Barents-Sea-Transect							
28	124	22.7.91	80°21' N	29°08' E	360 m	FTS #7	GKG
	124a	22.7.91	80°21' N	29°21' E	280 m	FTS #8	
29	125	23.7.91	80°08' N	30°02' E	290 m	GSN #5	
30	129	24.7.91	79°30' N	30°25' E	100 m	FTS #9	
31	130	24.7.91	79°28' N	30°31' E	230 m	FTS #10	
32	131	24.7.91	79°27' N	30°30' E	330 m	FTS #11	MG
33	132	24.7.91	79°11' N	31°44' E	80 m	FTS #12	
34	134	24.7.91	78°39' N	32°09' E	280 m	AGT #18	GKG
						OFOS #19	
35	136	25.7.91	77°59' N	32°55' E	150 m	OFOS #20	
			77°59' N	32°58' E	140 m	AGT #19	
36	138	25.7.91	77°28' N	33°01' E	160 m	FTS #13	
37	141	26.7.91	76°57' N	33°31' E	150 m	AGT #20	

The station plan covered various gradients in order to foster the intended comparative analyses, i.e. gradients in terms of topography (shelf-slope, bank-depression), large-scale hydrography (West Spitsbergen Current - "Atlantic Boundary Current" at the slope - Arctic shelf water), ice regime (permanent ice cover - seasonal ice cover), and zoogeography (eastward decreasing Atlantic and increasing continental influence at the shelf margin). The sampling was concentrated on (1) four shelf-slope transects: (a) Kongsfordrenna, (b) Yermak Plateau, (c) Seven Islands (Sjuøyane), and (d) Nansen Basin Slope; (2) the Storfjord region, and (3) a long transect crossing the Arctic Barents Sea shelf from Kvitøyarenna in the north to the central Barents Sea just south of the Stor Bank.

Whenever feasible, a set of different sampling methods (corer/grab, trawl, imaging methods) were used at the same station for optimal coverage of the benthic habitats and their various fractions (Tab. 6.3 - 1). This was achieved at 16 stations. Trawls were accomplished at a total of 25 stations (20 AGT hauls, 5 GSN hauls); remote bottom imaging was performed at 33 stations (20 OFOS casts, 13 FTS casts); and quantitative grab samples were taken at a total of 16 stations (10 GKG, 9 MG; see also report of Kendall, Rachor & Rauschert).
The macrofauna of the grab samples was sieved over a 0.5 mm screen and preserved mainly in a buffered 4 % formalin-seawater solution. Meiofauna samples were preserved partly in total or after decantation over a 63mm screen.

The autecological studies on selected "key species" of the benthic ecosystems investigated will include 1) the assessment of parameters of population structures (e.g. size frequencies, age structures, sex ratios, fecundities), 2) the calorimetric and biochemical analyses of body compounds with special emphasis on lipid content and composition, and 3) ecophysiological experiments with live specimens kept in cooled aquaria over longer periods. The "key species" considered are from different taxa ranging from actiniarians to fish, and represent different modes of life, e.g. suspension-feeders, deposit-feeders, predators or sessile and vagile species.

The live specimens of appr. 50 species (actiniarians, gastropods, bivalves, cephalopods, polychaetes, pantopods, isopods, amphipods, decapods, echinoderms, and fish) were kept on board in a lab container cooled to 0°C. They then were transferred to Kiel and Bremerhaven for various ecophysiological investigations. Their behaviour and metabolic response to the experimental variation of environmental conditions such as e.g. temperature and food supply will be studied.This includes the measurement of respiration rates as a parameter of metabolic activity. Similar experiments have already been carried out on board (see report of Opalinski).

For the population studies all specimens of the species considered (or, when numerous, a representative subsample) were sorted from the catch and preserved for later analyses by freezing at -25° C or in a borax-buffered 4%-formalin-seawater-solution.

For biochemical analyses a total of 15 samples was taken, comprising whole specimens of various species, sexes and sizes or different organs of those specimens, i.e. muscle, gonads, hepatopancreas and liver respectively. The samples were preserved in chloroform-methanol or by freezing at -80º C. The results of these studies will yield new information on the strategy of energy utilization of polar benthic species and on their trophic relationships to the pelagic realm. These studies will be carried out in cooperation with G. Kattner and M. Graeve (AWI).

Preliminary results and sub-group reports:

A. Bottom imaging (J. Gutt, D. Piepenburg)

The OFOS was deployed at a total of 20 stations yielding appr. 16 hours of video images of bottom transects and a total of appr. 4000 stereoscopic still pictures. For more information see report below.

The "Fotoschaukel" (FTS) was used in addition with the same main scientific objectives. The FTS basically consists of a vertically oriented camera combined with an oblique strobe and provides high-resolution still pictures of the sea bottom. A total of 842 photographs each imaging appr. 1 m^2 of the sea bottom were taken at 13 stations (Tab.1), i.e. at each station there were 60 to 70 pictures distributed along a transect of appr. 300 m length. The colour slides already developed on board demonstrate that our information on benthic biotopes normally based only on trawl catches or corer samples is considerably increased by this method. The photographs provide "in-situ"-views of epibenthic habitats and will be analysed to determine the identity, the absolute abundance, and the small-scale distribution patterns of epibenthic species (brittle stars etc). The excellent quality of the slides, due to the format of the film material used (size 60 x 60 mm) and to the constant and relatively low distance of the camera to the bottom, allows the identification of even relatively small epibenthic animals.

Feasibility study on the assessment of benthic communities using the Ocean Floor Observation System (OFOS) (J. Gutt, D. Piepenburg)

The Ocean Floor Observation System (OFOS) is an imaging method for large-scale marine geological surveys. The major aim for its use on this cruise was to find out if the OFOS can contribute scientific results within the framework of the faunistic investigation of the macroepibenthos.

Objectives:
Various imaging methods have already been used successfully from R/V Polarstern in polar waters to investigate the following parameters of the benthos:
- Absolute abundances (densities)
- Biomass
- Bottom coverage by macrofauna
- Small scale distribution patterns
- Community structures
- Behaviour of selected species.

This information either can not or can only partially be obtained by "traditional" sampling gears; the area of the large box corer is not sufficient for the estimation of the density of larger organisms (> 5cm) while the unquantifiable and variable catchability of the Agassiz trawl provides at best semiquantitative results. The observation of the animals in their natural environment provides qualitative information which is not available from the material caught. In combination with other methods these results lead to a much better understanding of the ecosystem.

Techniques of operation:
The OFOS consists of a rig with a low-light-level black-and-white video camera and a stereo still camera with strobes and permanent lights; a compass hangs below. The video signal passes by a single conductor cable, on line, to the control unit aboard. The rig is operated by using the cable of the winch so that it flys in a certain distance above the bottom, while the ship is moving slowly (<0.5 knots) or just drifting. The video image was only used to monitor the performance of OFOS as its poor optical resolution limits its ability to provide scientifically valuable images. Photographs (colour slides) for scientific analysis can be taken every 10 seconds.

To make the major part of the macrofauna visible, close proximity to the bottom is required. Due to the vertical movement of the ship the distance to the bottom usually varies between 2.5 and 3.5 m. From this and the angle of the lens of the still camera (60°) a photographed area between 5 and 10 qm is achieved. At such distances, the best optical resolution is close to 5 mm. The exact size of the photographed area is calculated using the computer-aided stereo-image analysing system (stereo comparator) at the institutes. The photographs are usually taken at constant time intervals to get a statistically sound estimate of the absolute densitiy of organisms. The time of operation close at the bottom is usually one hour, but in some cases, half an hour. The length of such transects is between 0.3 and 2 km, depending on the drift of the ship.

Due to the limited optical resolution, only very large animals can be identified such as sponges, feather-stars, star-fishes, and large fishes. Of the most abundant macrobenthic organisms in the shallower part of the area of investigation (< 400 m depth), only a fraction of the most abundant specimens, the brittle stars (ophiuroids), can be counted and identified due to their size. This strategy of performing a nonselective photographic survey is suitable for stations on the shelf (< 200 m depth) which have a high density of visible organisms. At deeper stations, a different methodological approach is advisable as the abundance of the epifauna is low: This entails the selective triggering of the still camera when any kind of an object is visible in the video image. As a result, only those very large organisms which are recognizable on line in the video image are photographically recorded. To obtain a suitable sample size for a statistical analysis in this case, a much longer transect is necessary. Because of the limited station time and the need to make all results comparable we stuck to triggering of the still camera at constant time intervals even though the densities of organisms were sometimes low.

Preliminary results from the video images:
The OFOS surveys were carried out at 20 stations yielding 16 hours of video observations and approx. 4000 stereo photographs of the sea floor. The first three casts, in the central Barents Sea were carried out for optimisation of the methodology required for the benthological demands of the expedition. At station no. 45, tracks of the otter trawl, used just before the OFOS, were clearly seen. They showed poor penetration of the gear into the sediment; several brittle stars (ophiuroids) were still present in the area swept by the net. The six stations in the fjords and outer fjords south and west of Spitzbergen yielded a poor epifauna consisting of few brittle stars, fishes (rays, flatfishes), shrimps and some sessile organisms. Evidence of infaunal life was indicated in some locations (e.g. stns. 78, 86) by patches of large holes in the sediment. The macrofauna on the continental slope (3 stations between 500 and 900 m depth) north of Spitzbergen was also poor. At station no. 112 (900m) a dense "field" of sea pens (*Umbellula encrinus*) was found. On the northern shelf (4 stations < 250 m) the sediment surface is largely composed of stones which were often overgrown by sponges, between which there were some star fishes (asteroidea) and brittle stars. In the central Barents Sea, the most abundant organisms on soft sediment at approximately 300 m (stn. 134) were shrimps, small fishes, star fishes and large brittle stars (*Ophiopleura* sp. and *Gorgonocephalus* sp.). In

shallower water (stn. 136) besides the abundant large brittle stars the feather star *Heliometra* sp. was dominant.
Full analysis of the photographic images will take place in Bremerhaven and Kiel.

Perspectives:
For future work on benthos ecology using imaging methods gear which operates at a constant and close distance (< 1 m) to the bottom is necessary. For the investigation of the community structure a colour video camera could provide the best information for species identification. To obtain process-orientated results for explaining different benthic assemblages, direct video-controlled measurements of environmental parameters and *in situ* experiments should be carried out.

B. Evertebrates:

Epi- and endofauna of trawl catches

(D. Piepenburg, J. Gutt, M. Schmid, M. Kendall, M. Rauschert)

At least 278 species were sorted from the trawl catches, including 33 polychaetes, 39 molluscs, 70 crustaceans, 44 echinoderms, and 41 fish. The number of species per station ranged from 18 to 72 for the AGT-catches and from 43 to 74 for the bottom trawl (GSN-) catches. These values are minimum estimators of the "true" species numbers because complete taxonomic resolution was not possible on board of the ship. The numbers of several taxa, especially sponges, hydrozoans, actiniarians, bryozoans, gastropods, polychaetes and amphipods will rise when the material will be examined by taxonomic experts.

Echinoderms were numerically dominant in most of the catches (*Ctenodiscus crispatus, Pontaster tenuispinus, Strongylocentrotus pallidus, Ophiacantha bidentata, Ophiopholis aculeata, Ophiura sarsi, Ophiocten sericeum, Molpadia arctica*), but on occasions sponges, molluscs (*Astarte crenata, Bathyarca glacialis*), crustaceans (*Pandalus borealis*), and fish (see cruise report of the fish group) were also of importance. The composition of the catches is strongly influenced by the species-specific efficiencies of the sampling methods used, e.g. small infaunal species are certainly underestimated in the trawl catches.

First analyses of the composition of the catches indicate that there are distinct benthic communities at the shelf banks, in the shelf troughs and at the deeper slope regions. The bank fauna is characterized by hard-bottom species living on stones or shell-bearing animals whereas soft-bottom, mostly infaunal species dominate the fauna of the slope and especially of the shelf troughs. There is, therefore, evidence that sediments at the shelf margin are eroded and/or resuspended by relatively strong bottom currents whereas sediment accumulation processes predominate in slope and trough regions.

A surprising result is the considerable catch of sub-Arctic species like *Pandalus borealis* and *Sebastes marinus* at the northern Barents Sea slope. These findings show (1) that, in terms of zoogeography, the study area is not completely isolated from sub-Arctic regions, presumably due to the Atlantic Return Current, and (2) that the food supply is obviously sufficient for the species concerned, presumably due to a relatively high input of organic matter advected from more productive southerly regions (e.g. the Barents Sea shelf or the waters west of Spitsbergen).

There is strong evidence that the study period (July) coincides with the time of reproductive activity of many benthic species. Many female amphipods and decapods or male pantopods carried ripe eggs and, occasionally, empty eggs indicating that a brood had hatched very recently. Brood-carrying species like some pantopods and isopods were frequently observed with their offspring. These results are in good agreement with the findings of the pelagic investigations suggesting considerable abundances of meroplanktic larvae (see cruise report of zooplankton group).

Macro- and meiobenthic infaunal studies

(M. Kendall, E. Rachor, M. Rauschert)

Endofauna (infauna) can be sampled quantitatively, and their distribution and abundance in terms of both numbers and biomass is regarded as being a reflection of the vertical and advective food particle flux regimes. Superimposed on this pattern there will be the biogeographical differences due to the different water masses and temperature and ice regimes as well as the influences of topography and sedimentology.

The principal aims of the benthic infaunal studies carried out during EPOS II were as follows:

1) to assemble data on changes in community structure along ecological (e.g. across the Polar Front, down the continental slope) and biogeographic gradients (e.g. Atlantic - Arctic);
2) to use the quasi-stationary endofauna is an indicator integrating the vertical and advective sedimentary regimes over long periods;
3) to contribute to an ongoing study of geographic (latitudinal) variation in

patterns of infaunal diversity;

4) to test predictions concerning changes in the relative body size of macrofaunal and meiofaunal animals at high latitudes and when approaching the deep Arctic basins;
5) to compliment the work of other groups investigating the ecology of benthic invertebrates.

During ARK VIII/2, macrofauna and meiofauna were sampled, mainly from waters deeper than 300 m along the different slope transects. Quantitative samples were taken at as many locations as ship time and bottom sediments allowed; a full list of stations is set out below. The main gear used was the multi-box sampler (5 separate samples of 225 cm^2); alternatively subsamples of 0.1 m^2 were taken from large box-samplers. Meiofauna was subsampled from the 225 cm^2 boxes or was taken from the multicorers of the sedimentological group.

For some years it has been held that the diversity of infaunal communities decreases as one moves from the tropics towards the poles. The original work which formed the basis for this hypothesis has recently been criticised on the grounds of the different methodologies that were used for the collection of the samples on which it was based. It was therefore considered that some reappraisal of this hypothesis, based on standardised techniques, was required. To this end, members of the Community Ecology Group at Plymouth have undertaken the collection of standard macro- and meio-benthic faunal samples at a range of tropical (Indonesia), temperate (Europe) and Arctic (Spitsbergen) sites. Further studies are planned for the near future.

In order for these comparisons to be valid, all the samples considered must be from similar depths and sediments, and hence at the onset of our programme it was agreed that they should come from either muddy sand or mud at depths between 30 and 200 m. Furthermore, in order to take full advantage of recent development in multivariate analysis 5 meio- and 5 macrobenthic samples are needed at each station. During the current cruise it has proved difficult to meet these requirements in the waters around Svalbard, where most shallow sites have a poorly sorted sediment dominated by very coarse glacial debris. As a result only 6 full sets were taken, mostly towards the end of the cruise, in the Barents Sea. Even there, the sediments encountered were often far from ideal, making it impossible to use the same methodology for the collection of meiofauna throughout the cruise.

As high power microscopy is impractical on a moving ship, the material collected will be examined when it is returned to Plymouth and Bremerhaven. Animals will be extracted from each sample, sorted by species, and both the total weight and that of the largest single individual of each will be assessed.

This will permit the plotting of size spectra. Comparisons with other latitudinal studies carried out by PML will be on the basis of K-dominance plots and ABC curves.

Once the quantitative samples have been sorted and analysed, the results will be compared with the work of I. Kröncke in the deep Nansen Basin (ARK VIII/3) as well as in the eastern Barents Sea, where samples from the Murmansk RV "Dalnie Zelentsy" were taken as far east as to inshore waters of Novaya Zemlya (s. Annex).

As a very preliminary result the hypothesis seems to be supported that the fauna down the slope becomes impoverished, especially when western (Atlantically influenced) and eastern transects are compared. Samples in specific shelf areas like in the depressions of Storfjord, Kongsfjordrenna and the Renna northwest of Kvitøya indicate a very abundant fauna, which may be explained by the advection and accumulation of organic matter.

Some preliminary infaunal studies have already been carried out on "Polarstern" in support of work on sediment chemistry by Hall and Hulth. In order to identify any potential for bioturbation by the macrofauna in experiments on nutrient flux, selected sediment cores (10 cm dia) were sectioned at intervals of 3 cm and the fauna extracted. The results in relation to bioturbation will be reported elsewhere.

In examining this material, taxonomic resolution was seldom better than to the level of genus while the small sample size precluded the efficient sampling of large bodied, rarer animals. Nevertheless it remains valid to make some preliminary comments on the macro-infauna.

Samples taken in the Central Barents Sea were impoverished. A single core from this site contained 14 individuals (NI) belonging to 7 taxa (NT). The tube-building polychaetes *Spiochaetopterus typicus, Myriochele oculata* and *Maldane sarsi* accounted for more than half the animals present. Only a single living individual was taken below 3 cm although unoccupied tubes of *Spiochaetopterus* were abundant. At the deepest Storfjord site far more animals were recorded (NT= 16 ; NI=39). The fauna was similar to that found in other Spitzbergen fjords by other expeditions. The same might also be said for the material from the inshore 330m station off Kongsfjord (NT = 11; NI=31), although there a spionid polychaete of the genus *Prionospio* dominated rather than the small sabellids found, for example, in the Icefjord. *Prionospio* was also the numerical dominant at 870m on the Hinlopen transect. Three replicates from this site were examined, and once again diversity was far higher than in the Barents Sea (NI=56, 73, 49; NT= 19, 24, 20). Three addditional taxa were also of importance, *Maldane, Byblis* and *Brachydiastylis.* At 550m on the

Yermak Plateau the fauna was particularly diverse (NI=55; NT=29). Once again the fauna were concentrated in the top 3 cm with only maldanid and cirratulid polychaetes penetrating into the stiff clay found at greater depth.

In addition to the quantitative work, macrofauna was sampled qualitatively at several stations. For analyses of size classes of *Ctenodiscus* and *Pourtalesia*, and of contamination of *Pandalus* with heavy metals (Dr. Zauke, University of Oldenburg), sub-samples were taken from a few trawls.

It is hoped that before comparisons are made with the parallel studies performed in the eastern Barents Sea and in the Nansen Basin by I. Kröncke, it will be possible, with the assistance of our Russian colleagues from Murmansk and St. Petersburg, to organise a workshop to standardise the taxonomy to ensure that it is fully compatible with earlier work in this area.

Amphipods (M. Rauschert)

During the benthic investigations 57 gammaridean amphiphods have been separated and identified mostly to species level. The small size of many animals, the limited literature available on board, and also the movement of the ship make it necessary to carry out more precise identifications in the home institute. Three small specimens (appr. 1.5-2.5 mm) could not be identified, even not to family level.

Specimens of the family Lysianassidae were poorly represented in the catches of the Agassiz and the otter trawl, but were numerous in the baited fish traps (*Anonyx, Tmetonyx* and others).

Six parasitic nematodes were found in one specimen of *Anonyx* cf. *nugax* (22 mm). This indicates a specific importance of this amphipod in the food chain.

Table 6.3 - 2: Preliminary list of gammaridean amphipods:

Ampeliscidae

1. and 2. unidentified spp.
3. *Ampelisca eschrichti*
4. *Byblis gaimardi*
5. *Byblis longicornis*
6. *Haploops setosa*
7. *Haploops* cf. *sibirica*
8. *Haploops tubicola*
9. *Haploops* spec.

Amphilochidae

10. unid. sp.
11. *Amphilochus* spec.

Eusiridae

12. *Cleippides quadricuspes*
13. *Eusirus longipes*
14. *Eusirus* spec.
15. *Rhachotropis aculeata*
16. *Rozinante fragilis*

Gammaridae

17. *Gammaracanthus loricatus*
18. *Gammarus* cf. *wilkitzkii*
19. *Gammarus* spec.
20. *Maera loveni*

Isaeidae

21. *Gammaropsis melanops*
22. *Gammaropsis* spec.

Ischyroceridae

23. *Ischyrocerus anguipes*
24. *Ischyrocerus* spec.
25. *Jassa* spec.

Liljeborgidae

26. *Liljeborgia fissicornis*
27. *Liljeborgia* spec.

Lysianassidae

28. and 29. unid. spp.
30. *Anonyx cf. nugax*
31. *Anonyx cf. sarsi*
32. *Eurythenes gryllus*
33. *Lepidepecreum umbo*
34. *Socarnes bidenticulatus*
35. *Socarnes sp.*

Oediceratidae

36. and 37. unid. spp.
38. *Acanthostepheia cf. behringiensis*
39. *Aceroides latipes*
40. *Monoculodes sp.*

Paramphitoidae

41. *Epimeria lotricata*
42. *Paramphitoe hystrix*

Pardaliscidae

43. unident. sp.
44. *Pardalisca cuspidata*

Phoxocephalidae

45. and 46. unid. spp.
47. *Harpinia sp.*

Pleustidae

48. *Parapleustes sp.*

Podoceridae

49. unid. sp.
50. *Dulichia macera*
51. *Dulichia sp.*

Stegocephalidae

52. unid. sp.
53. *Andanielle cf. pectinata*
54. *Stegocephalopsis ampulla*
55. *Stegocephalus inflatus*

Stenothoidae

56. *Metopa* cf. *borealis*
57. *Metopa* spec.

Evertebrate respiration measurements

a. Report D. Schmid:

The respiration measurements were carried out by two different methods. The first method used was an intermittent flow respirometer, the second a closed bottle system. To obtain a constant temperature (± 0.1 °C) the whole system was placed in a 1m*2m freezer.
A total of 20 different species were investigated on board covering a range of different life styles and feeding behaviours.

The purpose of the on board measurements was to get an immidiate idea of the oxygen consumption of freshly caught animals. We also took the opportunity to work with animals which do not survive well in aquaria, i.e. some brittle stars, cephalopods and some amphipods.

The continuously-measuring intermittent flow respirometer showed that there are considerable variations in the oxygen consumption of an animal during the experimental period. There can be several reasons for these variations. Firstly, the stress plays a certain role especially for vagile organisms. However, previous measurements showed that there is an acclimation of the animal to the chamber after several hours.

The oxygen consumption of animals with different life styles differred substantially. Vagile crustacean predators (e.g. *Sclerocrangon ferox*) have consumption rates which are almost as high as of small benthic fish, whereas deposit feeding brittle stars or polychaetes have very low respiration rates.

A size dependancy of consumption rates could not yet be detected. Additional experiments have still to be performed in the laboratory in Kiel. Measurements on amphipods caught in the fish traps (see cruise report Saldanha) showed very high respiration rates. The animals were lured by fish bait; so they had consumed large amounts of food just before the measurements. Amphipods from trawl catches showed significantly lower values.

Further measurements in the laboratory in Kiel will strenghten the preliminary results we attained on board "Polarstern" and give an answer to the objectives set out earlier. Other experiments will show if there is a kind of "domestication effect" of animals kept in aquaria over longer periods. This would result in lower standard metabolic rates.

b. Report K. Opalinski:

Aims of the research:

- The estimation of oxygen consumption by key species of Arctic benthic animals belonging to different ecological and trophic groups;
- Eco-physiological experiments on the influence of external factors (e.g. temperature, oxygen concentration, dial cycle) on the metabolic rate of Arctic marine invertebrates;
- The collection of benthic animals for electrophoretical examinations (for Dr. J.M.Weslawski, Sopot).

Methods:

The oxygen consumption of animals was determined by a method using closed vessels. Oxygen concentration in the vessels was measured by using an oxygen meter (type OXI 196, from WTW, Germany). Vessels of the following volumes were used: 50, 100, 200, 250, 350, 750, 1000 and 2000 cm^3. The measurements were carried out on single animals at about the temperatures of the animal´s natural environment. After the measurements the complete animals were weighed (wet weight) and preserved (frozen) for dry weight determinations. Respiration (oxygen consumption) was calculated in mm^3 O_2 per individual per hour, and metabolic rate in mm^3 per g of wet wt. per hour. For oxygen consumption measurements, animals from the Agassiz and Otter trawls and the Bongo net were used. Only animals from the depths shallower than 250 m were used. Species determinations were done by D. Piepenburg (IPÖ, Kiel).

Results:

1. Oxygen consumption of benthic animals.
1170 measurements of oxygen consumption by animals belonging to 31 taxa were done. These animals belonged to the following ecological groups: benthic infauna and epifauna, epibotic fauna, near-bottom living fauna, bentho-pelagic and pelagic fauna. They represent the feeding types of carnivores, necrophages, selective and non-selective deposit feeders, suspension feeders (like suctorial and filter feeders).

2. Eco-physiological experiments.
a. Influence of temperature on metabolic rate of benthic animals (Fig. 6.3 - 2). The experiments were carried out on epibiotic species (*Ophiocantha bidentata*, Ophiuroidea), near-bottom living species (*Ampelisca eschrichtii*, Amphipoda) and bathy-pelagic species (*Pandalus borealis*, Decapoda). *O. bidentata* had a

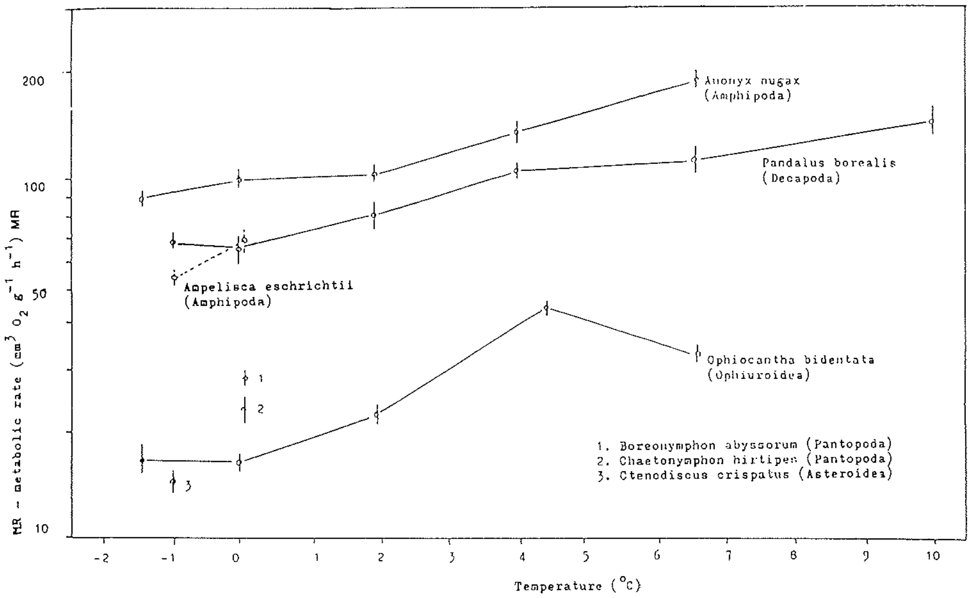


Fig. 6.3 - 2: Influence of temperature on the metabolic rate (MR = oxygen uptake) of benthic invertebrates: *Ophiacantha bidentata* (epibiontic); *Pandalus borealis* (bentho-pelagic); *Anonyx nugax* (near-bottom living species); mean values of MR (mm^3 O_2 $g^{-1}h^{-1}$) with standard error

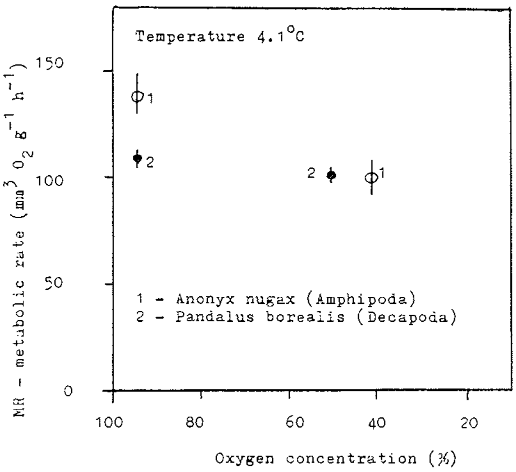


Fig. 6.3 - 3: Influence of oxygen concentration (saturation) of sea water on the metabolic rate of 1 - *A. nugax* (conformer); 2 - *P. borealis* (regulator);

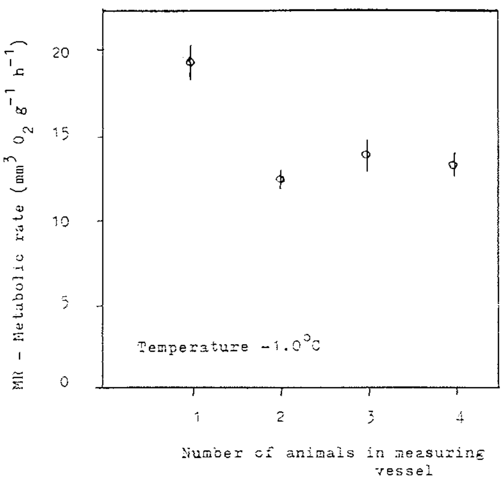


Fig. 6.3 - 4: "Group effect" on the metabolic rate in *Ophiacantha bidentata;* (other explanations : Fig. 6.3 - 2)

narrow zone of relative temperature independence (from -1.0 to 0.0 °C), then its metabolic rate increased to "a point without return" at 4°C and then decreased. *P. borealis* has the narrow zone of relative temperature independence too, but its metabolic rate increases slowly up to 10°C. The zone of relative temperature independence in *A. nugax* is much greater than in *O. bidentata* and *P. borealis* from -1.5 to 2.0°C.

b. The influence of oxygen concentration on metabolic rate.
The influence of the oxygen concentration in water on the metabolic rate of benthic animals was examined using *Pandalus borealis* (a bentho-pelagic species) and *Anonyx nugax* (a near bottom living species). The decrease of oxygen concentration to ca 50% of saturation does not change the metabolic rate of *P. borealis* (a compensation type reaction) but decreases the metabolic rate of *A. nugax* (a conformistic type reaction) (Fig. 6.3 - 3).

c. "Group effect" in Ophiuroids.
The metabolic rate of single specimens of *Ophiocantha bidentata* (Ophiuroidea) is ca 30% higher than of an animal measured in "small group" (2 to 4 animals in one measuring vessel). It suggests that aggregation in ophiuroids may have a bioenergetical effect (Fig. 6.3 - 4). This phenomenon (the lowering of metabolic rate in aggregated animals) was not observed in another ophiuroid species, *Ophiura sarsi.*

d. Dial cycle in benthic animals.
The metabolic rate in the 24-hours cycle was measured in the bentho-pelagic species, *Pandalus borealis* an an epibenthic species, *Ophiura sarsi.* The metabolic rate of *P. borealis* is elevated in late morning - probably the period during which *P. borealis* feeds on zooplankton dinking down as part of its vertical migration cycle. In the same period a very small elevation of the metabolic rate of *O. sarsi* (ca 14%) can be seen (Fig. 6.3 -5).

e. The utilisation of lipids as energetic substrate in the metabolism of the early larval stages of *Sclerocrangon ferox.*
The calculation of data is not yet finished. This work was done in cooperation with M. Graeve, AWI, Bremerhaven.

3. Benthic macrofauna collections.

From each catch of Agassiz and Otter trawls and fish traps samples of macrofauna were collected and preserved (frozen). A total of 25 samples were taken.

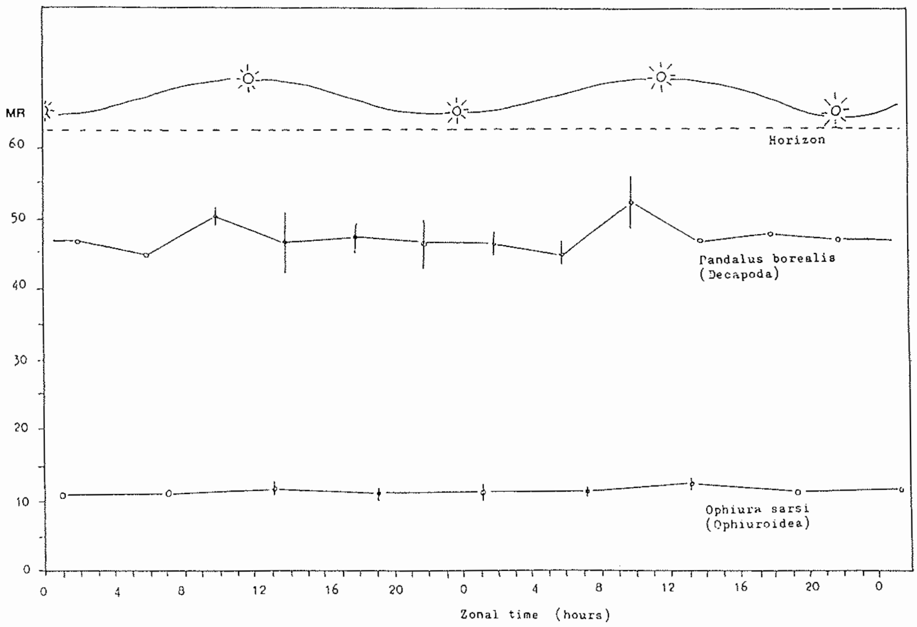


Fig. 6.3 - 5: Dial cycle of metabolic rate (MR) of *Pandalus borealis* (bathy-pelagic) and *Ophiura sarsi* (epibenthic); MR = $mm^3\ O_2\ g^{-1}h^{-1}$; (other explanations: Fig. 6.3 - 2)

Prospects:

On the basis of the collected data several papers will be prepared (preliminary aims: Oxygen consumption in different groups of benthic animals; Metabolic adaptations to low temperatures in Arctic invertebrates; Dial cycle of Arctic benthic animals during the summer season; Yolk utilisation in the respiratory metabolism of the larvae of *Sclerocrangon ferox*).

There are further prospects for:

- calculations of energy flow (oxygen utilisation) in different groups (communities ?) of the shallow benthic compartment of the ecopsystem (in cooperation with the benthologists and P. Hall),
- comparison of the metabolic rate of animals measured in situ, on board, and after long-term culture in laboratory conditions - the effect of "domestification" (in cooperation with D. Schmid).

C. Benthic fish investigations

(N. V. Chernova, Ch. von Dorrien, A. V. Neyelov, L. Saldanha)

Fish were collected from 20 Agassiz (AGT) and 5 Otter trawl (OT) catches. In most cases the total catch was sampled, but at St. 82 a subsample of 50% was taken, and at St.125 the catch was only qualitatively sorted. The catches were made at depths between 100 m (St. 55) and 2100 m (St. 108). For further information on stations see also Table 6.3 - 1. In addition, smaller numbers were caught in fish traps, Passalaigue nets and Bongo nets (Myctophidae, Gadidae, Zoarcidae).

All trawl samples were devided in three parts for the following investigations
1) for experiments with living fishes, as well as food composition analysis and age determinations (Ch. von Dorrien),
2) for stomach contents and calorimetric analyses (L. Saldanha),
3) for taxonomy, zoogeography and morphological investigations (N. Chernova, A. Neyelov).

Altogether, over 8000 fish weighing more than 180 kg from about 43 species were captured in the trawls (Table 6.3 - 3). These belonged to 29 genera of 14 families. The families are as follows: Cottidae, Zoarcidae, Gadidae (4 genera), Liparididae, Lumpaenidae (3 genera), Pleuronectidae (2 genera) while all others (Scorpaenidae, Agonidae, Osmeridae, Anarhichadidae, Rajidae, Cottunculidae, Macrouridae, Cyclopteridae) were represented by a single genus.

The genus *Lycodes* (Zoarcidae) was the most divers with 9 species. The most common species were *Hippoglossoides platessoides*, *Sebastes marinus* and *Leptagonus decagonus,* which were caught at two thirds of all stations. The species *Triglops nybelini, Lycodes pallidus, L. eudipleurostictus, Boreogadus saida* and *Artediellus atlanticus* appeared at almost half of the stations.

Next 3 pages: Table 6.3 -3: List of fish caught in Svalbard area during the cruise ARK VIII/2 of RV *Polarstern*

(individuel fish numbers per species per haul)

Station:		40	42	45	50	55	70	76
Location:		Central Barents Sea			Storfjord			Isfjord
		Front	N Front	S Front	North	Middle	South	
Depth:		200	150	250	180	100	320	340
Gear:		OT	AGT	OT	AGT	AGT	AGT	AGT
1 *Raja radiata*	Starry ray							3
2 *Raja hyperborea*	Arctic ray							
3 *Mallotus villosus*	Capelin	2 203		1 312				
4 *Gadus morhua*	Cod	1		4			1	
5 *Melanogrammus aeglefinus*	Haddock			1				
6 *Boreogadus saida*	Polar cod	115	4	84	57	6		
7 *Onogadus argentatus*	Silvery rockling							
8 *Macrourus berglax*	Rough rat-tail							
9 *Sebastes marinus*	Red-fish	8		144			7	5
10 *Artediellus atlanticus*	Hookear sculpin	121	11	42				
11 *Icelus bicornis*	Twohorn sculpin	3	14		11	5		
12 *Triglops nybelini*	Nybelin´s sculpin	52	75	26	1	4		
13 *Triglops murrayi*	Moustache sculpin							
14 *Gymnacanthus tricuspis*	Arctic sculpin					9		
15 *Cottunculus microps*	Polar sculpin							
16 *Leptagonus decagonus*	Atlantic poacher	60	2	43				17
17 *Anarhichas minor*	Spotted catfish						1	
18 *Lumpenus lampretaeformis*	Snake blenny			2		6	2	2
19 *Anisarchus medius*	Stout eelblenny					23		
20 *Leptoclinus maculatus*	Spotted snake blenny	6		22				
21 *Lycenchelys kolthoffi*	Kolthoff´s wolfeel							
22 *Lycodes eudipleurostictus*	Doubleline eelpout	1			1			
23 *Lycodes rossi*	Threespot eelpout	5	1	1				
24 *Lycodes reticulatus*	Arctic eelpout							
25 *Lycodes pallidus*	Pale eelpout	15			17			
26 *Lycodes frigidus*	Cold-water eelpout							
27 *Lycodes seminudus*	Longear eelpout							
28 *Lycodes squamiventer*	Scalebelly eelpout				7			
29 *Lycodes esmarki*	Esmark´s eelpout							
30 *Lycodes vahli*	Vahl´s eelpout						2	5
Lycodes spec.			1					
31 *Gymnelis retrodorsalis*	Aurora pout							
32 *Lycodonus flagellicauda*								
33 *Lycodonus spec.*								
34 *Liparis fabricii*	Gelatinous seasnail		1		52			
35 *Liparis gibbus*	Dusky seasnail	1	2	3	1	1		3
36 *Careproctus reinhardti*	Sea tadpole	1		1			1	
37 *Careproctus ranula*	Tadpole							
38 *Careproctus spec. 1*								
Careproctus spec. 2								
39 *Paraliparis bathybius*	Deepsea seasnail							
40 *Eumicrotremus spinosus*	Spiny lumpsucker							
41 *Hippoglossoides platessoides*	Long rough dab	133	12	64	2	6	21	5
42 *Reinhardtius hippoglossoides*	Greenland halibut							
43 *Hippoglossus hippoglossus*	Halibut			1				
Rajidae								3
Osmeridae		2 203		1 312				
Gadidae		116	4	89	57	6	1	
Scorpaenidae		8		144			7	5
Cottidae		176	100	68	12	18		
Agonidae		60	2	43				17
Zoarcidae		21	2	1	25		2	5
Liparididae		2	3	4	53	1	1	3
Pleuronectidae		133	12	65	2	6	21	5
Ohter families		6		24		29	3	2
Sum		2 725	123	1 750	149	60	35	40
Number of species		15	10	15	9	8	7	7

Station:	77	78	82	84	86	90	100	101	104	105
Location:	Kongsfjordrenna-Transect			Yermak-Transect			Sjuøyane-Trans.		NE-Transect	
	Middle	Deep	Djupet	NW	Middle	Shelf	Deep	Slope		
Depth:	960	2 000	300	640	550	150	850	400	200	240
Gear:	OT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT
1 *Raja radiata*										
2 *Raja hyperborea*	4			1						
3 *Mallotus villosus*										
4 *Gadus morhua*										
5 *Melanogrammus aeglefinus*										
6 *Boreogadus saida*			4							
7 *Onogadus argentatus*	14			1						
8 *Macrourus berglax*					1					
9 *Sebastes marinus*	2		2			14		5	42	14
10 *Artediellus atlanticus*								25	5	13
11 *Icelus bicornis*						1				
12 *Triglops nybelini*									4	14
13 *Triglops murrayi*						1			3	2
14 *Gymnacanthus tricuspis*										
15 *Cottunculus microps*	2			6			1			
16 *Leptagonus decagonus*			125	3	7			8		1
17 *Anarhichas minor*										
18 *Lumpenus lampretaeformis*			1							
19 *Anisarchus medius*										
20 *Leptoclinus maculatus*										
21 *Lycenchelys kolthoffi*										
22 *Lycodes eudipleurostictus*	2			33	25		24	4		
23 *Lycodes rossi*			6							
24 *Lycodes reticulatus*										
25 *Lycodes pallidus*	2			2	3		4			
26 *Lycodes frigidus*		15								
27 *Lycodes seminudus*				2	8			3		
28 *Lycodes squamiventer*							2			
29 *Lycodes esmarki*							2			
30 *Lycodes vahli*										
Lycodes spec.										
31 *Gymnelis retrodorsalis*										
32 *Lycodonus flagellicauda*	1						11			
33 *Lycodonus spec.*					1					
34 *Liparis fabricii*										
35 *Liparis gibbus*			4							
36 *Careproctus reinhardti*				2	1					
37 *Careproctus ranula*							1			
38 *Careproctus spec. 1*	1									
Careproctus spec. 2										
39 *Paraliparis bathybius*	3	5								
40 *Eumicrotremus spinosus*						1				
41 *Hippoglossoides platessoides*			3					5		1
42 *Reinhardtius hippoglossoides*	23									
43 *Hippoglossus hippoglossus*										
Rajidae	4			1						
Osmeridae										
Gadidae	14		4	1						
Scorpaenidae	2		2			14		5	42	14
Cottidae						2		25	12	29
Agonidae			125	3	7			8		1
Zoarcidae	5	15	6	37	37		43	7		
Liparididae	4	5	4	2	1		1			
Pleuronectidae	23		3					5		1
Ohter families	2		1	6	1	1	1			
Sum	54	20	145	50	46	17	45	50	54	45
Number of species	10	2	7	8	7	4	7	6	4	6

Station:	107	108	112	119a	125	134	136	141
Location:	(Nansen Basin Slope)			Kvitøya-Renna	Barents-Sea-Transect			
Depth:	350	2 100	850	530	290	280	140	150
Gear:	OT	AGT	AGT	AGT	OT	AGT	AGT	AGT
1 *Raja radiata*	2							
2 *Raja hyperborea*								
3 *Mallotus villosus*	5				1			
4 *Gadus morhua*								
5 *Melanogrammus aeglefinus*								
6 *Boreogadus saida*	5				40	7	10	1
7 *Onogadus argentatus*	7							
8 *Macrourus berglax*								
9 *Sebastes marinus*	975			1	30	1	1	
10 *Artediellus atlanticus*	437				50	16	7	44
11 *Icelus bicornis*							4	11
12 *Triglops nybelini*	136			3	50	125	81	33
13 *Triglops murrayi*								
14 *Gymnacanthus tricuspis*								
15 *Cottunculus microps*	17		1	5		1		
16 *Leptagonus decagonus*	28			20	15	1	2	6
17 *Anarhichas minor*	4							
18 *Lumpenus lampretaeformis*								
19 *Anisarchus medius*								
20 *Leptoclinus maculatus*								
21 *Lycenchelys kolthoffi*	9				1			
22 *Lycodes eudipleurostictus*	2		8	2	4			
23 *Lycodes rossi*	1							
24 *Lycodes reticulatus*	15				17		1	1
25 *Lycodes pallidus*			1	8		18	5	2
26 *Lycodes frigidus*		1						
27 *Lycodes seminudus*	6			8	17			
28 *Lycodes squamiventer*			1					
29 *Lycodes esmarki*								
30 *Lycodes vahli*								
Lycodes spec.								
31 *Gymnelis retrodorsalis*							2	
32 *Lycodonus flagellicauda*								
33 *Lycodonus spec.*								
34 *Liparis fabricii*							2	
35 *Liparis gibbus*	1				4			
36 *Careproctus reinhardti*	1				1	2	1	
37 *Careproctus ranula*								
38 *Careproctus spec. 1*								
Careproctus spec. 2							1	
39 *Paraliparis bathybius*								
40 *Eumicrotremus spinosus*								
41 *Hippoglossoides platessoides*	215			5	30	15	3	10
42 *Reinhardtius hippoglossoides*	12		1		20			
43 *Hippoglossus hippoglossus*								
Rajidae	2							
Osmeridae	5				1			
Gadidae	12				40	7	10	1
Scorpaenidae	975			1	30	1	1	
Cottidae	573			3	100	141	92	88
Agonidae	28			20	15	1	2	6
Zoarcidae	33	1	10	18	39	18	8	3
Liparididae	2				5	2	4	
Pleuronectidae	227		1	5	50	15	3	10
Ohter families	21			5		1		
Sum	1 878	1	12	52	280	186	120	108
Number of species	19	1	5	8	14	9	13	8

Taxonomy and zoogeography of fishes caught around Spitsbergen

(A. Neyelov, N. Chernova)

Currently 63 species of fishes are known from the area around Spitsbergen from the littoral zone to abyssal depths of about 3000 meters (Andriashev 1954, 1964 (in Russian); Nizovtsev et al. 1976 (in Russian); Pethon 1985; Weslawsky et al. 1990).
43 species of fishes have been caught during the ARK VIII/2 cruise. The list of these species is presented as Table 6.3 - 3.

In the case of the following 5 species records from the area around Spitsbergen extend their known distribution, as previously they were only recorded from Greenland coasts, Iceland and/or Norwegian coasts: *Lycodes esmarki*, *L. squamiventer*, *L.vahli gracilis*, *Lycenchelys kolthoffi*, *Careproctus ranula*.
19 species were only previously known from areas to the south-west or south-east of Spitsbergen, and hence records from this cruise expand their range to the north of Spitsbergen (Table 6.3 - 4).
Two species are probably new to science; these are a *Lycodonus* sp. and a *Careproctus* sp.
In summary, records from this cruise have expanded the known range of 26 species.

While working with specimens of 2 species of *Lycodes* (*L. reticulatus* which was described from Greenland by Reinhardt and *L. rossi* described from Spitsbergen by Malmgren), it became apparent that there was a very large overlap in many characters. We now consider that these may be the same species. Further analysis will be done after the cruise, which, we hope, will establish the validity of this assumption. This will be carried out by N. Chernova, Ch. von Dorrien, A. Neyelov and, if possible, A. Andriashev.

Table 6.3 - 4: Species which are new to the area of investigation (ARK VIII/2).

Rajidae:	1. *Raja radiata* Donovan
Osmeridae:	2. *Mallotus villosus* Müller
Myctophidae:	3. *Benthosema glaciale* (Reinhardt)
Gadidae:	4. *Onogadus argentatus* (Reinhardt)
Macrouridae:	5. *Macrourus berglax* Lacepede
Anarhichadidae:	6. *Anarhichas minor* Olafsen
Lumpenidae:	7. *Anisarchus medius* (Reinhardt)
Zoarcidae:	8. *Lycodes esmarki* Collett
	9. *L. rossi* Malmgren
	10. *L.pallidus* Collett
	11. *L.eudipleurostictus* Jensen
	12. *L.frigidus* Collett
	13. *L.squamiventer* Jensen
	14. *L.vahli gracilis* M.Sars
	15. *L.seminudus* Reinhardt
	16. *Lycodonus flagellicauda* (Jensen)
	17. *Lycodonus* sp. nov.
	18. *Lycenchelys kolthoffi* Jensen
Cottidae:	19. *Artediellus atlanticus* Jordan et Evermann
	20. *Triglops murrayi* Günther
Cottunculidae:	21. *Cottunculus microps* Collett
Liparididae:	22. *Liparis gibbus* Bean
	23. *Careproctus reinhardti* Kröyer
	24. *Careproctus ranula* ? (Goode et Bean)
	25. *Careproctus* sp. nov.
	26. *Paraliparis bathybius* Collett

Feeding relations and calorimetry

(L. Saldanha)

Samples were collected at the slope stations deeper than 300 m to asses fish feeding strategy and carry out calorimetry on the main species (predatores and prey) (in collaboration with Ch. von Dorrien).
Comparisons with results in temperate seas will be made.
The contents of more than 300 guts belonging to 14 fish species were examined aboard and a further 400 fish specimens await examination. All these material will be studied in detail in the laboratory (Guia Marine Laboratory), and numerical methodology will be employed to asses feeding strategies and feeding guilds.
The species studied feed on a large spectrum of prey ranging from ophiurids and sea urchins to other fishes. The main prey for most fish are probably amphipods.
Comparisons of the abundance of prey in the stomach contents and the structure of the benthic communities will help to understand the feeding guilds, prey preference or opportunistic behaviour.

Fish traps were employed 4 times (using capellin as bait) at depths ranging from ca. 300 to 1000 m. One set of fish traps was lost in the Kongsfjorden Transect.
The experiments were ecologically interesting, particularly the last two, in a pack ice zone (St. 100 and 112), at depths of 859 and 980 m (respectively).
Some 22 fishes (1 + 2 + 19) were collected as well as many species of amphipods (that were feeding on the bait) and were still feeding on them when the traps were recovered.
In one or two cases fish were probably feeding on the bait but further examination of the respective stomach contents are still needed.

On the basis of the occurrence in the stomach contents of the fish 18 species (ca. 300 specimens) of benthic invertebrates were selected for calorimetry (ophiurids, echinoids, asteriods, crinoids, polychaetes, amphipods, decapod crustaceans and bivalves). These specimens were collected from the benthic samples taken simultaneously with the fishes.
All specimens were oven dried for later determination of calorific content (at the Guia Marine Laboratory, University of Lisbon).

Experimental work, population and community studies

(Ch. F. von Dorrien)

Aim of the investigations was the study of the abundance, population dynamics and community structure of the Arctic bottom fish fauna north and east of Svalbard. On selected key species measurements of respiration rates were carried out for energy flux studies.
After identification of the species carried out in cooperation with colleagues from Murmansk (N. Chernova) and Leningrad (A. Neyelov) all specimens were counted and weighed. Based on calculation of the swept area using the ships satellite navigation data, abundance and biomass figures will be calculated. Species composition and distribution patterns of the shallow bottom fish assemblages around Svalbard and in the Barents Sea will be analysed for comparison with the shelf fauna off North East Greenland.

One main aim was the evaluation of growth and production of key-species in the bottom fish fauna. Investigations were carried out on two cottid (*Artediellus atlanticus, Triglops nybelini*) and nine zoarcid (genus *Lycodes*) species. For age-class determination the otoliths of 330 specimens were taken out and their sex noted. For these specimens stomach content analysis and calorimetry of the body and food organisms will be carried out in collaboration with L. Saldanha, Lisbon. Additionally 800 specimens of cottid and zoarcid species were frozen at -30 °C. These will be returned to the Institut for Polar Ecology Kiel University, where their age and the composition of their food will be determined. Furtheron 450 specimens of *Sebastes marinus* were frozen for investigations at the Bundesforschungsanstalt für Fischerei Hamburg.

All living species were sorted from the catches immediately and put into buckets with cold water. Afterwards they were transferred to aquaria in a cooled container (0°C). At the current moment there are living 160 specimens of 18 species; these will be transferred to Kiel and Bremerhaven.

For the determination of the energy expenditure of different species, the respiration of 114 individuals of 11 species were measured. Of these, 8 experiments were carried out in an Intermittent Flow System for a period of between 4 and 14 hours. After a breakdown of this system the other measurements had to be made in closed bottles for shorter periods (2-3h). Individuals were given at least two days to recover from stress of catching. Oxygen tensions were measured with polarographic oxygen sensors. All experiments were carried out in a refrigerator at 0°C. The data will be analysed in detail at the Institute for Polar Ecology in Kiel. Together with the data on abundance and biomass, these will allow for an evaluation of the energy flux through the bottom fish fauna in Arctic ecosystems.

Perspectives in benthos work (D. Piepenburg et al.)

The benthological research programme performed during EPOS II comprised a broad variety of studies, with different approaches aimed at different fractions of the bottom fauna. There were, for instance, analyses of distribution and structure of meiobenthic and macrobenthic communities, assessments of micro- and meso-scale dispersion patterns of benthic populations, and measurements of the metabolic performance both on the level of communities (micro- and meiobenthos) and individuals (macrobenthos). The various investigations were carried out by a joint working group of several scientists collaborating in the taking and initial processing of samples as as well as in their evaluation and interpretation.

It is planned that the latter step, the evaluation of the data and the synoptic interpretation of the various results, will be performed during workshops in order to foster the interdisciplinary cooperation and promote joint publications integrating various aspects of the investigations carried out during SEAS.

We think that a "synoptic" symposium convening all working groups of EPOS II should be prepared by smaller "within-working-group" workshops. With regard to the investigations on benthic ecology we propose three consecutive "small" workshops, i.e. workshops of only four to eight members of the benthic working group:

(1) A workshop dealing with the proper identification of the species caught:

The principal objective of this workshop is to produce a reliable species list of the trawl catches, corer samples, and bottom images. This list will serve as the basis of the zoogeographical examinations and of the subsequent analyses of community distribution and composition. The workshop should take place after the first sorting of the samples, approximately in the second half of 1992. For convenience, it should be held at a place with easy access to taxonomic experts specialized in the Arctic fauna. To our opinion, the natural choice would be the Zoological Institute in St. Petersburg, Russia.

(2) A workshop to ensure the necessary standardization of the statistical data analyses:

One goal of the benthic investigations is to outline the distribution and structure of distinct bottom species assemblages in relation to the environmental conditions. These studies involve the application of several multivariate techniques which are relatively difficult to perform. We propose that this workshop attended by four members of the benthic working group should take place after summer 1992. Since at the Plymouth Marine Laboratory (UK) there is internationally acknowledged expertise concerning the use of multivariate statistics in marine ecology we propose Plymouth as location for this workshop.

(3) A workshop on the comparison of the oxygen uptake of the sediment and of the macrofauna:

During EPOS II measurements of oxygen uptake were performed both on the level of sediment cores inhabitated by meio- and microbenthos communities and of single macrofauna specimens. Estimates of the energy flow through the populations of certain macrofauna populations may be derived by extrapolation from the individual respiration rates and the absolute abundance figures obtained by underwater imaging (epifauna) or corer sampling (endofauna). These values can then be related to those from measurements of sediment cores taken at the same stations. Eventually, it will be possible to give good estimates of a total benthic energy budget comprising components from a broad size range of benthic organisms. This workshop should be held at the end of 1992, either in Poland or in Gothenburg (Sweden) or in Kiel (Germany).

6.4 Sediment Biogeochemistry and Microbiology

Biogeochemistry

(T.H. Blackburn, P.O.J. Hall and S. Hulth)

Introduction

The knowledge about biogeochemical processes in sedi-ments of the Arctic shelves and slopes is very poor. Recent investigations in the water column indicate the likely importance of processes (such as nutrient regeneration and organic matter degradation) in surficial shelf sediments for the chemical compo-sition of water masses of the Arctic seas, and especially for formation of the nutrient maximum that has been observed in the upper halocline over a wide region of the Arctic Ocean. However, no previous measurements of biogeochemical/micro-biological processes in European Arctic shelf and slope sediments have to our knowledge been carried out.

Our aims during EPOS II were to study benthic biogeo-chemical and early diagenetic processes, such as organic matter oxidation, nutrient regeneration and overall carbon, nitrogen, phosphorus and silicon cycling in surficial shelf and slope sediments of the Barents Sea and adjacent waters in the Svalbard area. We have also planned to link our measurements with bacterial enrichment studies, as well as with benthic biological (e.g. respiration) and sedimentation measurements hopefully allowing us in a joint effort to provide information on whole community benthic metabolism (oxygen and carbon budgets for the sea-floor) as well as on benthic-pelagic coupling from a biogeochemical point of view.

Work carried out

Sediment-water exchange:

Virtually undisturbed sediment cores (10 cm diameter) were collected with a Multiple corer (MUC; from Univ. of Göteborg). The cores were incubated at 0°C (appr. in-situ temperature) with ambient overlying bottom water for sediment-water exchange measurements of oxygen, CO_2, total alkalinity, calcium, nutrients, dissolved organic carbon (DOC) and dissolved free amino acids (DFAA)/primary amines. The oxygen, ammonium and some of the CO_2 samples were analysed on board, while the other samples were brought back to Göteborg and Århus for analysis.

Nitrification:

In incubations similar to the sediment-water exchange ones, acetylene (an inhibitor of nitrification) was added to the water overlying the sediment. The difference in ammonium release rates from the sediment before and after addition of acetylene was used as a measure of nitrification rates. The determinations of ammonium in samples from these experiments were run on board.

Sediment and pore water:

Sediment cores were collected with the MUC and sliced into one or two cm depth intervals. The pore water was separated from the sediment by centrifugation and filtration (0.45 mm pore size filters). Uncentrifuged sediment samples were collected for later determinations (back home) of water content, porosity, carbon (organic and inorganic), nitrogen, phosphorus (organic and inorganic), opaline silica and manganese. The chlorophyll-a/ phaeophytin content of the sediment was determined on board (E.-M. Nöthig). Sediment was also extracted with KCl for determination of adsorbed/ exchangeable ammonium (analysed on board) and amino acids/amines (to be analysed back home). The pore water samples were analysed for ammonium, nitrate, total alkalinity and CO_2 on-board, and will be analysed for calcium, other nutrients, DFAA/primary amines and DOC back home. ^{210}Pb will also be determined in sediment cores to get information on sediment accumulation rates.

Closed sediment incubations:

Sediment was collected with a large box corer (GKG), sieved over 1 mm screens, homogenized, filled into centrifugation tubes and incubated at 0°C (appr. in-situ temperature) for 7-11 days for determination of solute reaction rates (e.g. nutrient regeneration rates, organic carbon oxidation rates) in sediments. The reaction rates were determined as a function of depth in the sediment (sediment from the 0-2, 2-4 and 4-6 cm depth horizons were incubated). Samples from these incubations were analysed for total alkalinity, CO_2, ammonium, and nitrate on board. Other nutrients, calcium, DFAA/primary amines and DOC will be run at home.

Oxygen microprofiles:

Oxygen microelectrodes were used to measure oxygen profiles and oxygen penetration depths into sediments. Sediment used for these measurements were collected either with the MUC or with the GKG (from great depths).

Measurements were carried out immediately after sediment collection. The consumption of oxygen during closed incubations of small intact sediment cores was also studied with microelectrodes.

Denitrification:

^{15}N-labelled nitrate was added to the water over intact sediment cores, and the cores were incubated at in-situ temperature for measurements of denitrification rates in sediments. Measure-ments of N-isotope ratios will be conducted back home. This procedure allows us to determine the source of nitrate consumed during denitrification (diffusing into the sediment from the overlying water or produced in the sediment during nitrification).

Sulfate reduction:

^{35}S-labelled sulfate was injected into intact sediment cores which were incubated at in-situ temperature for measurements sulfate reduction rates. S-isotope determinations of the incubated samples will be carried out back home.

Altogether 19 stations were sampled, and at most of them the full program as described above were conducted. We worked at stations # 40, 45, 50, 55, 70, 78, 82, 84, 86, 98, 100, 101, 105, 108, 112, 119, 134, 143 and 146.

Summary:

We have, by conducting the work described above and the analyses of samples brought home, determined rates of solute sediment-water exchange (including oxygen uptake), nitrification, denitrification, nutrient regeneration (including ammonification), organic carbon oxidation, calcium carbonate precipitation/ dissolution, sulfate reduction and dissolved free amino acid/primary amine production and/or consumption in shelf and slope sediments of the Barents Sea and adjacent waters in the Svalbard area. We have also measured the distribution of oxygen (microprofiles) and other solutes in pore waters, as well as of fixed (C, N, P, Si, Mn, ^{210}Pb) and exchangeable (ammonium, amines) substances in these sediments.

These studies have not previously been performed in Arctic seas in the Svalbard area. Also, to our knowledge, the combination of measurements conducted in this project have not earlier been carried out anywhere.

Studies of the microbial diversity in Arctic sediments

(H. Gerberding, H.W. Jannasch)

Objectives

- Physiological characterization of nitrifying- and sulfur compound- utilizing aerobic bacteria and nitrate-, sulfate- and bicarbonate reducing anaerobic bacteria.

- Quantification of natural populations.

- Determination of the incorporation rate of ^{14}C- labelled bicarbonate and acetate into the microbial biomass.

Work at sea

Sub-samples of box- and multicorer samples were obtained at 19 stations (Stations # 40, 50, 55, 70, 78, 81, 82, 86, 91, 98, 100, 101, 105, 108, 12, 119, 134, 143, 146) at water depths between 70m and 2570m.
Enrichment cultures were inoculated with samples taken from oxic and anoxic sediments. The estimation of viable ammonia- and thiosulfate- oxidizing bacteria and nitrate- and sulfate- reducing bacteria was prepared with most probable number (MPN) dilutions in liquid media.
Sediment samples and sediment cores with intact vertical zonations were employed for radiotracer experiments at depth intervals of 3 cm. Samples from batch culture incubations were obtained by filtration, and sediment cores were fixed by freezing for later determination.

All experiments were incubated under *in situ* temperature conditions.

Preliminary results are not yet available (July 28, 1991).

6.5 Birds and Mammals

(C. Joiris)

Seabirds, pinnipeds (seals) and cetaceans (whales) were systematically counted when *Polarstern* was on the move, in order to establish their density and, using allometric equations, to calculate their daily food uptake. So doing, one can establish the link with the other compartments of the ecosystem (phyto- and zooplankton, fish, benthos).

For the whole cruise (362 half-an-hour counts, state on July 26), "normal" amounts of birds and seals were encountered, comparable with data obtained during previous cruises in the same region (in the table: data on selected species; local birds only, i.e. birds moving between breeding and feeding grounds around Spitsbergen were excluded).
Numbers of whales, however, were very low: a few minke whales *Balaenoptera acurostrata* and a Bottlenose whale *Hyperoodon ampullatus* only (remark: Whitebeak dolphins *Lagenorhynchus acurostris,* Bottlenose whales and 2 probable Blue whales were encountered in Atlantic water on July 28).

Table 6.5 - 1: Seabirds and marine mammals counted during ARK VIII/2

Species		Total	Number per count
Fulmarus glacialis	Fulmar	2616	7,23
Pagophila eburnea	Ivory Gull	253	0,70
Rhodostethia rosea	Ross's Gull	29	0,08
Rissa tridactyla	Kittiwake	11308	31,24
Uria lomvia	Brünnich's Guillemot	4495	12,42
Alle alle	Little Auk	4385	12,11
	Σ birds	29472	81,41
	Σ cetaceans	7	0,02
	Σ seals	626	1,73
Ursus maritimus	Polar Bear	21	0,06

(July 26, 1991)

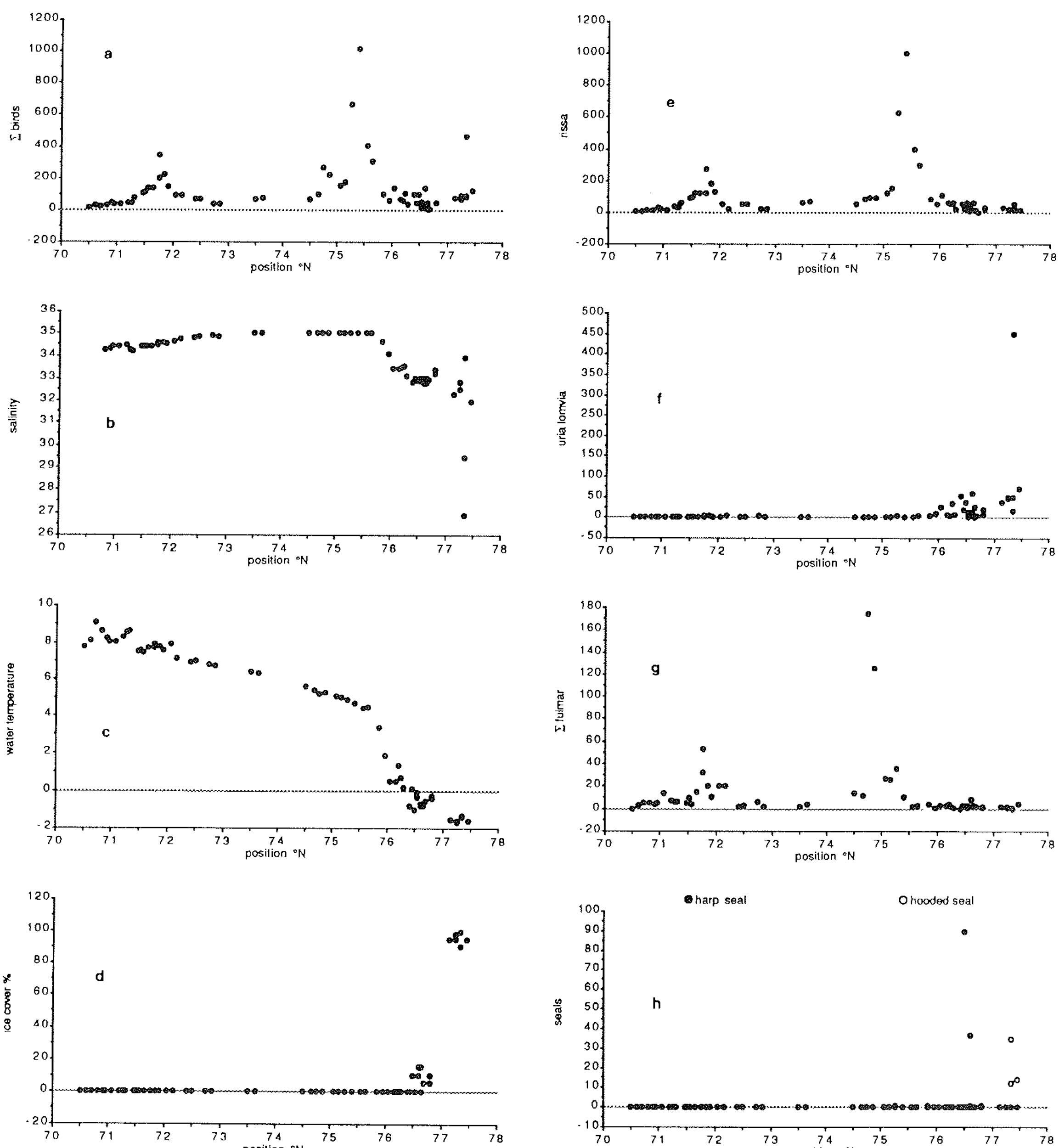


Fig. 6.5 - 1a - h: Distribution of birds and mammals along environmental gradients in the Barents Sea (June 21-25, 1991)

Results will be worked out under the form of different E-W and N-S transects. As an example, data of the very first S-N transect are shown (Figs. 6.5 - 1a-h: numbers per half hour). Numbers are very low in general, with the obvious exception of the frontal zones (between Norwegian coastal and Atlantic water, Atlantic and mixed frontal waters, and from frontal to polar water, also corresponding to the ice edge).

The two first fronts are characterized by high numbers of kittiwakes and some fulmars. The third zone showed numbers of alcids (Brünnich's guillemot) and seals: first, groups of harp seals *Phoca groenlandica* moving north to their summer feeding grounds, then hooded seals *Cystophora cristata* scattered on the ice; this was also a zone of high density of Polar Bears.

7. Geology / Sedimentology

(H. Grobe & O. Iacurto)

Sediment cores

The evolution of the North Atlantic and Arctic Ocean margins during the last million years is dominated by the onset of cold climates and subsequent cyclic glacial-interglacial events. The sedimentary record on the continental margins consequently offers unique possibilities to contribute to the reconstruction of the Quaternary glacial history of the Arctic. Insights can be gained into the mechanisms of cryospheric development in response to climatic changes with their effects on the sedimentary environment.

One of the main objectives of the geological programme was to investigate the mechanisms of the most recent glacial-interglacial changes in the sedimentary environment around Svalbard. During glacials, Svalbard and the Barents Sea were covered by a huge ice sheet which disappeared with the glacial terminations. The history of this ice sheet can best be reconstructed from sediments deposited on the continental margins of the Svalbard archipelago. The investigations are part of the ESF-initiated project Late Cenozoic Evolution of the Polar North Atlantic Margins (PONAM) and are integrated into the Global Change core project Past Global Changes (PAGES).

During the Quaternary glacial maxima the Eurasian shelves were covered by grounded ice, and the continental shelf break acted as a depocenter and prograded rapidly. The investigation of sediments on the outer shelf and, especially, the slope, which were sampled during this cruise, will provide information on the late Cenozoic history of the glaciation of the Svalbard region. Locations with lower sedimentation rates on the continental slope may provide information on the variations in size of the ice sheets, sea level changes and sea ice coverage. In addition, they will provide insights into primary productivity and bottom water formation, at least during the last climatic cycle. Areas of higher sedimentation rates in fjord depressions on the shelf will provide a high resolution record of the last 20,000 years including the Holocene deglaciation period.

During a great part of the cruise a sea floor survey using a swath sonar system and a sub-bottom sediment echo sounding system was carried out to support the marine geological and benthos investigations.
A gravity corer (1.5 t weight, 5 or 10 m in length) was used for obtaining the sediment cores. A total of 71.50 m cores with a mean length of 5.10 m were recovered from 14 sites. The uppermost disturbed section of the cores was completed on each station with a subcore, taken from the box corer which provides undisturbed surface samples.
Different sedimentological investigations will be carried out on the cores in the laboratory including analyses of organic carbon, carbonate, silica, grain size distribution, clay mineralogy and stable oxygen and carbon isotopes on the planktic foraminiferan *Neogloboquadrina pachyderma*.

Benthic Foraminifera

Micropaleontological sampling for the investigation of benthic foraminifera has been an important part of the marine geological activities. Sediment samples were collected at 38 locations by a vented box corer (50 x 50 cm surface). At some stations two boxes of the multigrab (11 x 19 cm each) were sampled. Immediately after coring, undisturbed surface sediment samples, within a defined area of 412 cm^2 were taken to a depth of 1-2 cm. These were preserved in methanol, to which rose bengal was added as dye. The staining distinguishes between dead and alive foraminifera. Additionally, at some stations the uppermost 15 cm of two subcores of the multicorer (10 cm Ø) or four subcores of the minicorer (6 cm Ø), which was used in combination with the CTD, were cut into 8 slices of 1 cm thickness (0-1, 1-2, 2-3, 3-4, 4-5, 7-8, 10-11, 14-15 cm) and treated as described above.

Onshore investigations of the foraminiferan fauna will focus on the distribution of the recent benthic assemblages, on the transition of an assemblage from live via dead to fossil state and on quantitative estimates of small-scale patchiness. The grouping of assemblages and the correlation with environmental parameters such as the temperature and salinity of bottom water and characteristics of the surface sediment will be done by multivariate statistical methods.

Investigations of foraminiferan assemblages together with stable isotope data on selected cores will provide information about paleoceanographic changes during the most recent climatic cycles.

Surface sediments

In the Barents Sea, extensive marine geological work has been done by Norwegean research institutes (a. o. Bjørlykke et al., 1978; Elverhoi et al., 1988, 1989; Vorren et al., 1988). Today, the shelf acts mainly as a large depocenter for the mineral and organic sediment load of the large rivers, and to some extent also of glaciers and marine production. In the central Barents Sea, late Quaternary sediments overlie the Mesozoic and upper Palaeozoic bedrock. These sediments consist of till and glaciomarine deposits with relatively uniform mineralogical and geochemical composition downcore and are generally less than 10 m thick. Lateral variations have been recorded which may reflect variations in the underlying bedrock.

The present day sedimentary environment is characterized by sediment reworking, with additional sediment supply from sea ice and minor amounts from icebergs. Accumulation rates from the late Holocene ranges from a few cm/kyr up to 20 cm/kyr. The underlying late Weichselian sediments were deposited during the last glacial maximum and by the waning glaciers at its termination.

During this cruise leg, the geological investigations concerning the surface sediment distribution in the Barents Sea as well as on the continental slope were designed in one part to provide sedimentological background information also for the biological research on the pelago-benthic coupling. In addition, the accompanying sedimentological parameters are crucial to the interpretation of the foraminiferan fauna. Surface sediment samples of 20 cm^3 of the uppermost 1 cm were therefore taken at all stations from the box corer for the investigation of organic carbon, carbonate and grain size distribution in Bremerhaven.

Additional samples from the surface as well as from greater depths (slightly consolidated), taken with the box corers, will be analysed in Italy for:
- grain size composition (by Coulter Counter and other techniques);
- mineralogical composition (by X-ray diffraction);
- grain morphology, size and texture (by scanning electron microscopy and dispersive energy);
- aminoacids of carbonate fossils (by chemical methods).

These techniques are regarded particularly useful in erecting and supporting hypotheses about potential sources of Barents Sea sediments and, may-be, also transportation routes.

8. Weather conditions during ARK VIII/2

(E. Roed)

According to the summer season, calm weather without rapid cyclonic developments prevailed during the cruise leg. As could be expected, the atmospheric pressure level was considerably above that in winter. The horizontal pressure differences mostly remained weak.
There was only one day with wind forces of 7-8 Beaufort and gusts up to 9 Bft. At other times we observed daily means of about 3-4 Bft on the average. Moreover, the wind was almost not felt as swell when sea ice was present. Nevertheless, some phenomena were different from the climatological mean conditions and are described below.

Compared with other summer cruises to the Arctic, but also with the preceding cruise leg and the last decade of this leg, a cyclonic phase lasting for four weeks was most striking. During this phase there was no Arctic high present along the central polar region, even the Greenland high was missing. Higher pressures were only recorded at the New Sibirian Islands and above the Laptev and Kara Seas.
Fig. 8 - 1A shows the time series of the daily means of atmospheric pressure in the research area (the ship´s movements may be disregarded in this connection). The pressure level persisted quite low until the midst of July, when a strong and extensive Arctic anticyclone was built up from the Kara Sea across Greenland up to Baffin Bay with its centre in the Svalbard region.
The cyclonic regime was maintained partly by quasi-stationary cyclones, partly by vortices moving along rather unusual trajectories which, occasionally, also touched our operational area. A low was frequently found centred near the pole covering the sea ice zone with extended cloud formations. Clouds and cloud motions provided some information on the atmospheric circulation and allowed to localize the centres of the lows as well as the fronts (satellite images).
The first minimum of the pressure graph (Fig. 8 - 1A, June 27 and 28) was caused by a small low which moved from Danmarkshavn across the Fram Strait to Spitsbergen and from there to the New Sibirian Islands. The second minimum (July 1-3) was due to another low, which passed with a speed of 30 knots from the area north of Thule across the Fram Strait to the Barents Sea shortly after the first event. The last low of this cruise leg (the mimimum in the curve from July 12-13) migrated from Franz Josef Land across the operational

area of "Polarstern" to the North Pole. With a pronounced rise of the air pressure by 35 hPa, the cyclonic weather period ended after July 13/14.

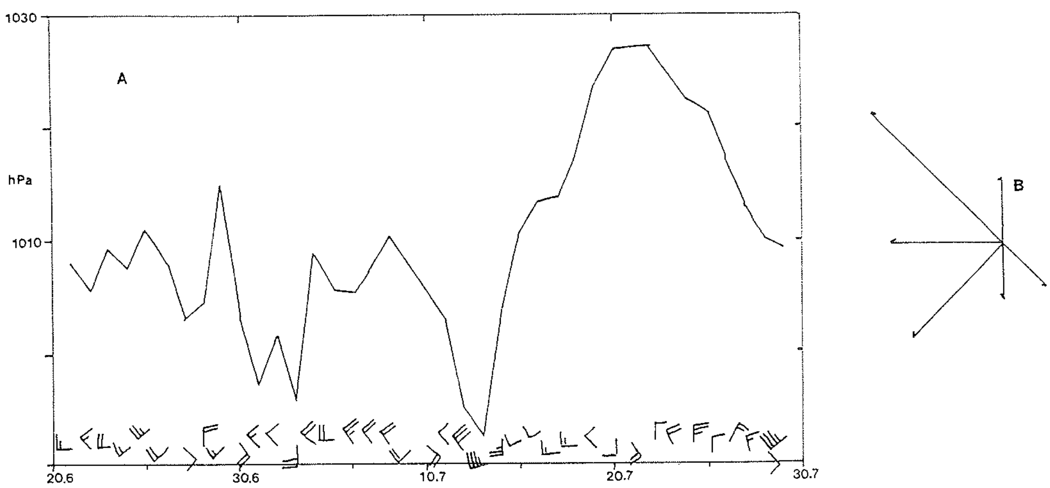


Fig. 8 - 1: Weather variations during ARK VIII/2:
A. Pressure graph (June 20 - July 29) with wind directions and intensities (below);
B. Rhumb-card indicating frequencies of main wind directions

During the cyclonic phase, inversions neither at the surface nor at the top of the boundary layer were formed, as shown by the radiosounding graph from July 7, which is typical for this period (Fig. 8 - 2). The "temp" of the 22nd of July, however, shows the characteristic stable thermal stratification during an anticyclonic regime.
The strong inversion is the prerequisite for the production and the southward outflow of Arctic air masses. (To some extent this may be compared with the formation of cold bottom water in oceanography).

It is striking that during the persistance of the low atmospheric pressure situation nearly no wind directions from the northeastern quadrant were observed, while the westerly component was predominant. Accordingly, there was no protrusion of polar air to the south. The wind arrows shown in Fig. 8 - 1A and the rhumb-card of Fig. 8 - 1B reveal the wind conditions during the cruise. After the formation of the Arctic high the northerlies were by far dominating.
During the long-lasting pressure anomaly an exceptional hot spell occupied first Asian Russia, then central Europe and finally the Iberian peninsula. After the formation of the Arctic high, low pressure areas in European and Asian Russia

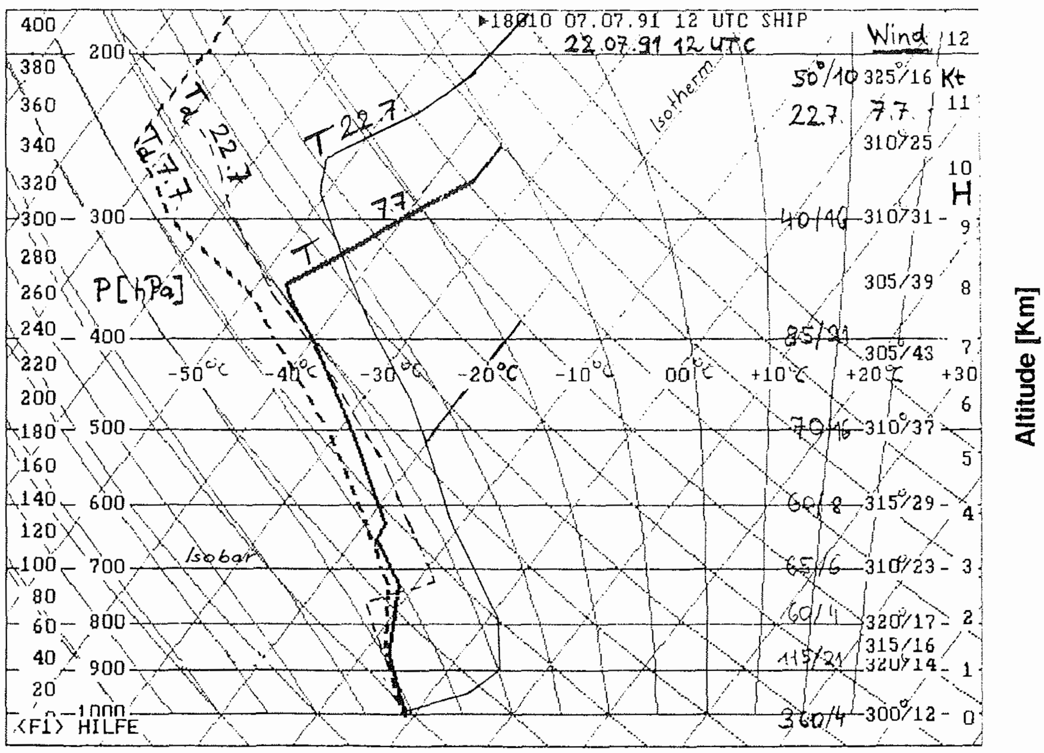


Fig. 8 - 2: Radiosounding graph of July 7, with graph of June 22 inserted
(T = temperature, T_d = dew point temperature)

as well as in Scandinavia caused monsoon-like approaches of polar marine air masses to the continent.

This relationship shows how closely the weather in temperate latitudes may be coupled with these long-periodic pressure oscillations in the polar region. This holds true even for the tropical zone, as was observed during the cruise ANT IX/4 back from the Antarctic: A strong Arctic high pressure cell together with a northward shifted subtropical high allowed polar air masses directly to advance to the equator !

Finally, polar low developments will be commented, which could several times be seen on the satellite images (Fig. 8 - 3). These mesoscale vortices indicate the importance of individual eddy motion for the dynamics of the atmosphere. Incidentally they are also found in areas, where a high pressure cell is indicated at the surface. Such a polar low above the Barents Sea happened to develop within a triangle of 100 nm side length, made up by three vessels. These vessels reported a closed circulation with wind speeds only up to 12 knots (it is to mention, however, that in such sub-synoptic eddies wind speeds even of Beaufort 8 may sometimes be found).

Details of the weather observations during ARK VIII/2 are given in the Annex (A 2).

Fig. 8 - 3: Small polar low above the Barents Sea
(arrow in weather satellite image: mesoscale cloud vortex)

9. References

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10. ANNEX

10.1 Station List

10.2 Weather Data

10.3 Cooperative Work in the Barents Sea

10.4 Participants

10.1 Station List ARK VIII/2

Stat. No. 19/	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology (No.)	Others/ Details
037	21.6.	14.52 15.35	72°00.1´ 71°59.8	25°03.9 25°02.7	258 261	x	-	-	
Central Barents Sea:									
038	22.6.	13.38 14.22	76°09.5 76°09.4	34°03.1 34°02.8	307 305	x	-	-	
039	22.6.	15.54 16.36	76°19.7 76°19.7	34°27.5 34°28.2	287 271	x	-	-	
040	22.6. 23.6.	18.25 23.12	76°36.8 76°34.3	34°50.5 34°41.5	195 208	x	x	2111	GSN, OFOS, VA
041	24.6.	08.06 12.43	77°27.2 77°27.0	33°03.0 33°05.9	156 147	x	x	2112	Ice
042	24.6.	14.07 16.44	77°22.2 77°21.2	33°17.8 33°17.8	144 145	-	-	-	AGT, OFOS
043	25.6.	06.05 07.05	76°48.3 76°48.0	34°11.0 34°10.5	139 137	x	x	-	
044	25.6.	09.31 11.15	76°29.9 76°29.7	34°50.0 34°51.4	227 229	x	x	-	
045	25.6.	14.10 20.24	75°59.7 75°59.0	34°49.6 34°41.3	250 250	x	x	2113	GSN, OFOS
Storfjord area:									
046	26.6.	11.08 11.40	76°28.1 76°28.3	22.15.5 22°15.3	241 240	x	-	-	
047	26.6.	12.40 13.12	76°30.9 76°30.9	21°45.2 21°45.7	265 265	x	(x)	-	
048	26.6.	15.57 17.11	76°39.9 76°40.13	20°04.6 20°07.7	194 188	x	-	-	VA
049	26.6.	19.32 20.55	76°37.8 76°37.85	18°16.0 18°14.42	219 221	x	-	-	VA
050	27.6.	06.15 12.32	77°33.9 77°32.8	19°06.2 19°03.5	199 178	x	-	2114	AGT, OFOS, Fish traps

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank- ton	Benthos/ Geology	Others/ Details
051	27.6.	13.37 14.22	77°28.9 77°28.6	18°33.0 18°32.4	107 106	x	x	-	
052	27.6.	15.13 18.04	77°29.0 77°28.7	19°02,1 19°13.8	183 185	x	x	-	
053	27.6.	18.31 19.09	77°28.8 77°28.8	19°26.8 19°27.4	120 110	x	-	-	
054	27.6.	20.00 20.51	77°33.9 77°34.1	19°05.8 19°05.4	194 197	-	-	-	Fish trap recovered
055	28.6.	06.03 10.17	77°12.0 77°12.0	18°19.7 18°16.6	99 112	x	-	2115	AGT, OFOS
056	28.6.	11.07 11.47	77°12.0 77°12.2	18°40.3 18°39.5	100 100	x	x	-	
057	28.6.	12.24 13.39	77°12.1 77°11.8	18°59.7 18°59.7	143 142	x	x	-	
058	28.6.	14.15 16.35	77°11.9 77°15.8	19°19.7 19°24.5	177 169	x	x	-	
059	28.6.	17.12 17.43	77°12,2 77°12.1	19°38.8 19°38.8	149 149	x	-	-	
060	28.6.	18.22 18.32	77°12.0 77°12.0	20°00.1 20°00.3	140 139	x	-	-	
061	28.6.	19.06 19.13	77°12.0 77°11.9	20°19.5 20°19.8	120 123	x	-	-	
062	28.6.	23.01 23.25	76°34.9 76°35.1	20°38.4 20°37.8	123 130	x	-	-	
063	29.6.	00.08 00.41	76°35.0 76°35.5	20°18.0 20°18.5	177 177	x	-	-	
064	29.6.	01.23 02.28	76°35.1 76°35.2	19°56.7 19°56.3	216 217	x	x	-	
065	29.6.	03.06 03.56	76°34.9 76°34.8	19°37.2 19°39.0	217 212	x	x	-	
066	29.6.	04.38 07.21	76°34.6 76°33.0	19°17.9 19°03.0	200 153	x	x	-	
067	29.6.	07.52 08.34	76°34.7 76°34.3	18°49.7 18°48.9	76	x	-	-	

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
068	29.6.	09.36 10.16	76°37.7 76°37.8	18°15.3 18°14.7	221 219	-	-	-	VA recovered
069	29.6.	13.06 14.02	76°37.8 76°38.7	19°09.1 19°08.0	172 156	-	-	-	VA
070	29.6.	18.18 23.20	75°59.3 76.00.1	17°10.1 17°09.6	328 323	x	x	2116	AGT, OFOS
071	29.6. 30.6.	23.53 00.24	76°03.1 76°03.4	17°05.3 17°06.6	323 316	x	-	-	
072	30.6.	01.03 01.30	76°07.0 76°07.2	17°00.1 17°01.1	315 298	x	-	-	
073	30.6.	02.07 02.35	76°11.0 76°11.3	16°55.0 16°56.4	283 292	x	-	-	
074	30.6.	03.10 03.35	76°15.1 76°15.3	16°50.1 16°51.9	219 221	x	(x)	-	
075	30.6.	04.10 04.41	76°18.8 76°19.4	16°43.6 16°45.9	104 97	x	-	-	
(Hornsund & Longyearbyen)									
Isfjordrenna:									
076	01.7.	19.22 21.39	78°15.2 78°15.0	10°49.4 10°44.6	353 347	x	x	-	AGT
Transect Kongsfjordrenna:									
077	02.7.	06.04 16.00	79°00.0 79°07.0	08°10.9 08°04.9	990 946	x	x	-	GSN, Fish traps
078	02.7. 03.7.	18.12 19.34	79°00.5 78°59.2	05°59.7 05°34.1	1811 2329	x	x	2117	AGT, OFOS, Sed. trap
079	03.7. 03.7.	21.19 23.48	79°01.9 79°01.4	06°42.9 06°34.6	1242 1314	x	x	2118	
080	04.7.	01.52 19.49	79°00.1 79°01.8	08°09.6 07°50.9	984 1180	x	x	2119	OFOS
081	04.7. 05.7.	21.07 06.40 10.23	79°01.6 79°04.2 79°02.1	08°35.5 08°46.2 09°09.5	297 245 175	 x	 x	 2120	Sed. trap
082	05.7.	02.45 21.30	79°01.0 79°01.6	10°44.6 10°45.6	334 333	x	x	2121	AGT, OFOS

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
Transect Yermak:									
083	06.7.	06.24	80°15.5	08°03.5	631	x	x	-	
		09.21	80°14.7	08°06.4	632				
084	06.7.	12.03	80°23.4	07°33.0	705	x	x	2122	AGT, Ice
		20.20	80°19.6	07°23.6	655				
085	06.7.	22.08	80°15.7	08°50.1	593	x	x	-	
		23.35	80°15.6	08°51.5	586				
086	07.7.	06.05	80°10.0	09°51.4	571	x	x	2123	AGT, OFOS
	08.7.	00.31	80°07.7	10°11.2	541				
087	08.7.	00.36	80°07.8	10°11.3	541	x	-	-	
		01.13	80°08.2	10°13.2	543				
088	08.7.	06.04	80°10.8	10°26.8	502	x	x	-	
		08.09	80°03.6	10°26.6	493				
089	08.7.	09.07	80°00.1	11°00.1	250	x	-	-	
		09.35	80°00.1	11°00.5	242				
090	08.7.	10.07	79°58.2	11°12.1	169	x	x	2124	AGT, OFOS
		17.12	79°57.7	11°14.6	144				
North of Svalbard:									
091	08.7.	18.41	80°02.8	12°14.2	89	x	(x)	2125	
		19.20	80°02.8	12.15.3	93				
092	08.7.	20.27	80°00.9	13°00.1	195	x	-	-	
		20.50	80°00.8	13°00.4	193				
093	09.7.	08.39	80°48.1	18°37.3	103	x	(x)	2126	
		08.59	80°48.1	18°37.7	101				
094	09.7.	14.00	81°01.2	18°27.4	220	x	x	2127	OFOS, FTS
		20.12	81°02.5	18°33.7	221				ICE
Transect Seven Islands - Hinlopen Trough:									
095	10.7.	00.34	81°11.4	18°10.6	450	x	-	-	
		01.08	81°11.3	18°11.7	455				
096	10.7.	02.31	81°17.5	17°43.5	645	x	-	-	
		03.15	81°17.8	17°44.2	635				
097	10.7.	04.38	81°27.6	17°16.1	1484	x	-	-	
		05.48	81°27.8	17°17.0	1430				
098	10.7.	07.48	81°30.4	16°42.4	2579	x	x	2128	Ice
		14.45	81°32.1	16°40.6	2615				

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
099	10.7.	17.11 19.07	81°33.6 81°33.9	15°39.4 15°37.6	2697 2674	x	-	-	
100	11.7.	06.01 20.42	81°22.0 81°22.4	17°28.3 17°29.2	875 859	x	x	2129	AGT, OFOS, Ice, Fish traps
101	11.7. 12.7.	22.28 15.12	81°17.4 81°11.6	18°37.4 18°28.5	530 433	x	x	2130	AGT, OFOS, Ice, Sed. trap

Northeastern transect (slope to Nansen-Basin)

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
102	13.7.	10.33 12.30	80°58.5 80°57.5	27°05.9 27°17.1	108 84	x	-	2131	FTS
103	13.7.	17.02 17.28	80°55.6 80°55.3	29°28.0 29°27.9	340 342	x	-	-	
104	14.7.	09.00 17.51	81°26.6 81°26.8	31°29.3 31°39.3	266 250	x	x	2132	AGT, OFOS, Ice, Met. buoy
105	15.7.	06.26 20.13	81°25.9 81°24.7	30°46.8 31°00.5	395 218	x	x	2133	AGT,OFOS,Ice Sed. trap, VA
106	16.7.	06.29 08.17	81°25.3 81°25.1	31°10.0 30°54.0	217 276	x	-	-	Recovery Sed. trap
107	16.7.	08.58 10.18	81°25.6 81°25.2	30°28.6 30°57.3	362 261	-	-	x	GSN
108	16.7. 17.7.	13.30 20.09	81°40.8 81°37.4	29°48.2 30°31.3	2542 1914	x	x	2134	AGT, FTS, Ice, VA, Sed. trap
109	17.7.	21.20 23.09	81°41.8 81°41.9	30°29.5 30°30.1	2934 2942	x	-	2135	
110	18.7.	00.22 04.02	81°37.5 81°36.4	30°33.0 30°41.9	1930 1871	x	x	2136	
111	18.7.	04.26 09.37	81°34.7 81°34.3	30°46.6 30°45.8	1441 1351	x	x	2137	
112	18.7. 19.7.	10.39 12.52	81°32.1 81°33.0	30°35.6 31°08.7	995 864	x	x	2138	AGT, OFOS, Sed. trap, Fish traps
113	19.7.	13.38 14.47	81°30.5 81°30.8	30°54.4 30°56.3	748 756	x	x	2139	
114	19.7.	15.58 17.00	81°27.9 81°28.2	31°16.6 31°18.2	485 518	x	x	2140	
115	19.7.	17.54 18.54	81°25.0 81°24.8	30°58.8 30°01.2	237 217	x	x	2141	

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
Transect Renna NW Kvitøya:									
116	20.7.	06.10	80°50.9	30°38.1	107	x	x	2142	Ice, FTS
		09.12	80°50.3	30°38.5	109				
117	20.7.	11.10	80°48.7	30°07.2	195	x	-	2143	FTS
		14.46	80°50.0	30°06.2	191				
118	20.7.	16.36	80°46.0	29°40.8	341	x	-	-	
		16.50	80°46.0	29°41.3	330				
119	20.7.	18.11	80°44.8	29°28.4	495	x	x	2144	OFOS, Ice
	21.7.	07.46	80°45.8	29°31.8	459				
119A		09.48	80°41.9	29°09.7	540	-	-	-	AGT
	21.7	10.49	80°42.6	29°04.2	566				
120	21.7.	12.10	80°41.9	28°37.2	407	x	-	2145	
		12.37	80°42.0	28°36.7	399				
121	21.7.	13.02	80°41.9	28°33.6	300	x	x	2146	FTS
		15.41	80°42.8	28°32.6	164				
122	21.7.	16.00	80°42.9	28°27.6	50	x	-	-	
		16.07	80°42.9	28°27.6	51				
Barents Sea transect:									
123	22.7.	06.03	80°22.3	28°40.3	87	x	-	-	
		06.29	80°22.3	28°40.1	87				
124	22.7.	08.17	80°20.3	29°08.5	356	x	x	2147	FTS, Ice,
	23.7.	08.20	80°21.6	29°24.7	411				Sed. trap
125	23.7.	10.21	80°08.1	30°04.7	305	-	-	x	GSN
		11.48	80°12.4	29°54.0	271				
126	23.7.	12.50	80°06.0	29°37.9	354	x	x	2148	
		17.32	80°06.7	29°32.2	316				
127	23.7.	19.38	79°50.2	29°59.5	222	x	-	-	
		20.04	79°50.1	29°58.7	215				
128	23.7.	21.28	79°40.0	30°13.2	218	x	-	-	
		21.57	79°39.9	30°13.3	222				
129	23.7.	23.12	79°30.8	30°29.8	99	x	x	-	FTS
	24.7.	01.18	79°29.5	30°24.6	106				
130	24.7.	01.45	79°28.3	30°31.0	233	x	-	-	FTS
		02.40	79°28.0	30°28.9	249				

Stat. No.	Date 1991	Time (UTC)	Lat. N	Long. E	Depth (m)	CTD /RO	Plank-ton	Benthos/ Geology	Others/ Details
131	24.7.	03.08	79°26.8	30°30.2	330	x	x	x	FTS
		06.45	79°26.5	30°19.8	308				
132	24.7.	09.28	79°10.9	31°42.5	77	x	x	2149	FTS
		12.16	79°10.5	31°44.2	70				
133	24.7.	14.49	78°50.9	31°59.8	251	x	-	-	
		15.19	78°50.8	31°59.2	254				
134	24.7.	16.57	78°39.1	32°09.8	288	x	x	2150	AGT, OFOS
		23.22	78°38.4	32°07.3	288				
135	25.7.	06.03	78°19.0	32°33.8	244	x	-	-	
		06.41	78°18.9	32°33.7	245				
136	25.7.	09.05	77°59.5	32°54.6	139	x	x	2151	AGT, OFOS
		15.00	77°58.2	32°58.3	144				
137	25.7.	16.54	77°45.2	33°02.8	173	x	-	-	
		17.17	77°45.3	33°02.9	172				
138	25.7.	19.15	77°27.2	33°02.2	155	x	x	-	FTS
	25.7.	21.21	77°27.3	33°01.4	162				
139	25.7.	22.18	77°21.3	33°16.3	143	x	-	-	
		22.52	77°21.3	33°17.2	143				
140	26.7.	06.14	76°43.5	30°01.18	261	-	-	2152 (Nor 1)	
		06.25	76°43.6	30°00.8	261				
141	26.7.	10.31	76°55.9	33°01.6	149	x	-	-	AGT
		12.46	76°56.8	33°29.2	152				
142	26.7.	14.29	76°47.9	34°09.3	140	x	-	-	
		14.51	76°48.1	34°09.7	138				
143	26.7.	16.40	76°36.8	34°51.6	198	x	x	2153	VA
	27.7.	09.09	76°36.5	34°48.6	198				(Sed. trap)
144	27.7.	10.15	76°29.8	34°50.2	224	x	-	-	
		10.45	76°29.9	34°49.7	225				
145	27.7.	12.31	76°15.2	34°49.7	299	x	-	-	
		12.48	76°15.3	34°49.8	298				
146	27.7.	14.36	76°00.2	34°49.5	252	x	x	2154	
		16.19	75°59.9	34°50.9	253				
147	27.7.	20.06	75°39.7	32°05.9	322	-	-	2155 (Nor 2)	
		20.23	75°39.6	32°05.2	325				

Explanations Station List:

CTD/R0: Continuous vertical profiles of conductivity (salinity), temperature, pressure (depth) and fluorescence (only at depths less than 1000 m)
+ Rosette with 24 water bottles;
(in a few cases, CTD/RO was combined with the AWI sediment minicorer)

Plankton: Different plankton nets: mainly Bongo-, Fransz- and Multi-nets; in addition: Apstein/Hand-nets and Passelaigue-net (combined with light meter);

Benthos/Geology: Mainly large bottom grab (Großkastengreifer), multi-grab, multi-corer and gravity corer; trawls;
(AWI geology label no. is indicated)

Others/Details: AGT = Agassiz trawl; GSN = Otter trawl; OFOS = Ocean floor observation system (video + photo); FTS = Photo sledge; Sed. trap = Sediment trap; VA = Oceanographic mooring (3 with sediment traps); Ice = Ice research; Met. buoy = Meteorological Argos buoy for ice drift observations.

Locations: The first coordinates are - as a rule - those of the stopped vessel (e.g. for CTD work, not for trawl), the second coordinate is given for the end of all station work.

Depths: Corrected for ship´s draught (11 m)

10.2 Weather data (next 8 pages)

Provided by ship´s weather station (s. report E. Roed)

Bordwetterwarte FS Polarstern
Reise ARK VIII/2 vom 20.06. bis 30.07. 1991

TT MM JJ	UT	Lat	Lon	Wind	kt	V/km	Wetter	Druck	rF	Tl	Tw	See	Duenung		ICE	Fahrt
20.06.91	0	69.7N	19.0E	290	4	/	/	989.3	63	11.2	8.7	/	/	/	0	Station
20.06.91	3	69.7N	19.0E	200	7	/	/	988.5	58	11.9	8.1	/	/	/	0	Station
20.06.91	6	69.7N	19.0E	210	11	/	/	988.2	55	12.9	8.3	/	/	/	0	Station
20.06.91	9	69.7N	19.0E	200	17	/	/	989.1	54	13.6	8.2	/	/	/	0	Station
20.06.91	12	69.7N	19.0E	220	16	/	/	991.8	63	12.0	7.2	/	/	/	0	Station
20.06.91	15	69.7N	19.0E	270	12	/	/	995.6	80	9.5	7.8	/	/	/	0	Station
20.06.91	18	69.7N	19.0E	240	14	/	/	1000.1	83	8.8	8.5	/	/	/	0	Station
20.06.91	21	69.8N	19.3E	290	15	/	/	1003.2	83	8.2	7.7	/	/	/	0	NE 3kt
21.06.91	0	70.3N	20.6E	270	15	/	/	1004.5	82	7.8	7.6	/	/	/	0	NE 13kt
21.06.91	3	70.9N	22.0E	270	18	/	/	1005.7	87	7.4	8.7	/	/	/	0	NE 13kt
21.06.91	6	71.3N	23.0E	270	13	20.0	fast bedkt	1006.6	83	7.1	8.7	0.5m	/	/	0	NE 8kt
21.06.91	9	71.6N	24.0E	270	11	20.0	fast bedkt	1007.8	69	7.1	7.7	0.5m	/	/	0	NE 8kt
21.06.91	12	72.0N	25.0E	280	9	50.0	heiter	1008.5	70	6.9	7.4	0.0m	/	/	0	NE 8kt
21.06.91	15	72.0N	25.1E	270	6	50.0	heiter	1008.9	70	7.5	7.6	0.0m	/	/	0	E 3kt
21.06.91	18	72.0N	25.0E	130	3	20.0	fast bedkt	1008.3	68	6.9	7.7	0.0m	/	/	0	W 3kt
21.06.91	21	72.6N	26.2E	300	1	20.0	bedeckt	1007.9	73	6.0	6.7	0.0m	310	1.0m	0	NE 13kt
22.06.91	0	73.3N	27.6E	220	5	/	/	1006.8	73	5.4	6.5	/	/	/	0	NE 13kt
22.06.91	3	73.9N	28.9E	30	3	/	/	1006.5	71	4.9	6.1	/	/	/	0	NE 13kt
22.06.91	6	74.6N	30.3E	340	8	20.0	bedeckt	1006.2	71	3.4	5.4	0.0m	310	1.0m	0	NE 13kt
22.06.91	9	75.2N	31.8E	280	9	20.0	wolkig	1005.9	68	3.0	5.1	0.0m	310	1.0m	0	NE 13kt
22.06.91	12	75.8N	33.3E	280	12	20.0	fast bedkt	1005.5	82	2.0	3.2	0.5m	310	1.0m	0	NE 13kt
22.06.91	15	76.2N	34.2E	280	11	20.0	fast bedkt	1005.5	94	0.9	0.9	0.5m	260	0.5m	0	NE 8kt
22.06.91	18	76.6N	34.8E	290	10	20.0	bedeckt	1005.5	96	-0.4	-0.7	/	/	/	4	N 8kt
22.06.91	21	76.6N	34.9E	290	5	20.0	bedeckt	1006.4	97	-0.8	-0.6	/	/	/	4	E 3kt
23.06.91	0	76.6N	34.9E	310	5	/	/	1007.3	90	-0.6	-0.6	/	/	/	0	Station
23.06.91	3	76.6N	34.9E	280	7	/	/	1008.0	91	-0.2	-0.5	/	/	/	0	Station
23.06.91	6	76.6N	34.9E	270	15	50.0	heiter	1008.4	88	-0.1	-0.6	/	/	/	4	Station
23.06.91	9	76.6N	34.9E	270	15	50.0	heiter	1009.3	90	0.2	-0.7	0.5m	250	0.5m	3	Station
23.06.91	12	76.6N	34.7E	270	14	50.0	heiter	1010.0	86	0.6	-0.4	0.5m	250	0.5m	2	W 3kt
23.06.91	15	76.6N	34.8E	250	12	50.0	wolkenlos	1010.2	87	0.8	-0.4	0.5m	250	0.5m	2	E 3kt
23.06.91	18	76.6N	34.8E	230	13	50.0	wolkig	1009.7	92	0.8	-0.5	0.5m	250	0.5m	2	Station
23.06.91	21	76.6N	34.8E	240	15	20.0	fast bedkt	1009.5	91	0.8	-0.5	0.5m	250	0.5m	2	Station
24.06.91	0	76.6N	34.5E	240	17	/	/	1008.9	92	0.9	-0.6	/	/	/	0	NW 3kt
24.06.91	3	77.1N	33.8E	230	15	/	/	1007.4	90	0.6	-1.0	/	/	/	0	N 8kt
24.06.91	6	77.4N	33.2E	240	13	50.0	heiter	1006.8	92	0.6	-1.5	/	/	/	5	N 8kt
24.06.91	9	77.5N	33.1E	240	11	20.0	wolkig	1007.0	92	0.7	-1.4	/	/	/	5	NW 3kt
24.06.91	12	77.5N	33.1E	260	10	20.0	heiter	1007.2	92	0.8	-1.4	/	/	/	5	Station
24.06.91	15	77.4N	33.3E	260	10	50.0	wolkenlos	1007.7	94	0.4	-1.4	/	/	/	5	SE 3kt
24.06.91	18	77.3N	33.6E	280	9	0.2	Nebel	1008.1	98	-0.7	-1.4	/	/	/	5	SE 3kt
24.06.91	21	77.0N	34.0E	280	11	0.2	Nebel	1008.9	99	-0.6	-1.6	/	/	/	5	S 8kt
25.06.91	0	76.8N	34.3E	270	14	/	/	1009.6	99	-0.3	-0.4	/	/	/	0	SE 3kt
25.06.91	3	76.8N	34.4E	250	9	/	/	1010.0	99	0.2	-0.3	/	/	/	0	Station
25.06.91	6	76.8N	34.2E	240	13	10.0	bedeckt	1010.1	95	0.8	-0.1	/	/	/	4	W 3kt
25.06.91	9	76.6N	34.7E	240	18	0.2	Nebel	1010.9	98	1.1	-0.3	1.0m	/	/	2	SE 3kt
25.06.91	12	76.4N	34.8E	250	21	0.5	Nebel	1011.2	98	1.6	0.3	1.0m	240	1.0m	0	S 3kt

25.06.91	15	76.0N	34.7E	260	20	10.0	bedeckt	1012.4	93	3.0	1.5	1.0m	240	1.0m	0	S	8kt
25.06.91	18	76.0N	34.8E	240	18	20.0	bedeckt	1012.1	89	2.7	1.5	1.0m	240	1.0m	0	E	3kt
25.06.91	21	76.0N	34.4E	85	19	4.9	diesig	1012.4	89	3.1	1.5	1.0m	240	1.0m	0	W	3kt
26.06.91	0	76.1N	32.0E	230	18	/	/	1011.5	95	3.4	2.1	/	/	/	0	W	13kt
26.06.91	3	76.2N	29.6E	230	12	/	/	1010.9	93	2.9	2.2	/	/	/	0	W	13kt
26.06.91	6	76.3N	27.0E	220	13	0.2	Nebel	1009.8	96	2.2	1.9	0.5m	250	1.0m	0	W	13kt
26.06.91	9	76.4N	24.2E	210	13	0.2	Nebel	1008.9	96	1.3	0.4	0.5m	250	1.0m	0	W	13kt
26.06.91	12	76.5N	22.2E	210	12	10.0	fast bedkt	1008.0	96	2.4	2.0	0.5m	270	1.0m	0	W	8kt
26.06.91	15	76.5N	20.4E	240	9	20.0	bedeckt	1007.7	92	2.8	2.4	0.0m	270	1.0m	0	W	8kt
26.06.91	18	76.7N	19.6E	230	13	2.0	diesig	1007.0	95	1.7	3.8	0.5m	270	1.0m	0	NW	3kt
26.06.91	21	76.6N	18.3E	340	2	10.0	heiter	1005.9	75	3.4	1.8	0.0m	/	/	0	W	8kt
27.06.91	0	77.1N	18.6E	360	5	/	/	1005.3	83	2.0	0.5	/	/	/	0	N	8kt
27.06.91	3	77.5N	19.1E	120	7	/	/	1005.3	97	0.4	3.9	/	/	/	0	N	8kt
27.06.91	6	77.6N	19.1E	130	4	10.0	Nebel	1004.5	96	0.7	2.7	0.0m	140	0.5m	0	N	3kt
27.06.91	9	77.5N	19.1E	110	4	2.0	Nebel	1004.0	87	1.6	2.6	0.0m	140	0.5m	1	S	3kt
27.06.91	12	77.6N	19.1E	150	4	10.0	fast bedkt	1003.3	87	1.3	3.7	0.0m	/	/	0	N	3kt
27.06.91	15	77.5N	18.9E	140	4	10.0	bedeckt	1002.5	88	0.6	4.3	0.0m	/	/	0	SE	3kt
27.06.91	18	77.5N	19.2E	70	4	10.0	bedeckt	1001.8	95	0.2	4.6	0.0m	/	/	0	E	3kt
27.06.91	21	77.6N	19.1E	30	5	10.0	bedeckt	1001.1	92	0.7	2.8	0.0m	/	/	0	N	3kt
28.06.91	0	77.4N	18.7E	30	11	/	/	1000.6	85	1.6	3.9	/	/	/	0	SE	3kt
28.06.91	3	77.2N	18.3E	20	13	/	/	1000.6	80	1.7	0.4	/	/	/	0	SE	3kt
28.06.91	6	77.2N	18.3E	10	15	20.0	bedeckt	1001.2	77	0.7	0.1	0.5m	110	1.5m	3	Station	
28.06.91	9	77.2N	18.4E	20	17	20.0	bedeckt	1002.6	77	0.9	0.4	1.0m	110	1.5m	3	E	3kt
28.06.91	12	77.2N	18.7E	10	11	20.0	bedeckt	1004.3	73	1.5	2.4	0.5m	110	1.5m	3	E	3kt
28.06.91	15	77.2N	19.3E	360	9	20.0	bedeckt	1006.1	72	2.0	3.3	0.0m	120	1.5m	0	E	3kt
28.06.91	18	77.2N	19.7E	320	7	20.0	bedeckt	1008.1	70	2.1	3.1	0.0m	120	1.0m	0	E	3kt
28.06.91	21	76.9N	20.1E	220	3	20.0	bedeckt	1010.5	72	1.6	3.5	0.0m	120	1.0m	0	S	8kt
29.06.91	0	76.6N	20.3E	200	7	/	/	1012.1	77	1.7	2.5	/	/	/	0	S	8kt
29.06.91	3	76.6N	19.7E	180	13	/	/	1012.9	90	2.9	3.8	/	/	/	0	W	3kt
29.06.91	6	76.6N	19.3E	220	9	20.0	bedeckt	1014.3	85	3.6	3.7	0.0m	140	1.0m	0	W	3kt
29.06.91	9	76.6N	18.6E	210	14	4.0	diesig	1015.1	96	2.8	2.6	0.5m	140	1.0m	0	W	3kt
29.06.91	12	76.6N	18.5E	210	12	4.0	diesig	1015.7	96	2.6	3.2	0.5m	120	1.0m	0	W	3kt
29.06.91	15	76.5N	18.8E	210	18	20.0	fast bedkt	1015.8	97	3.4	4.1	1.0m	120	1.0m	0	SE	3kt
29.06.91	18	76.0N	17.3E	200	13	20.0	bedeckt	1015.8	88	5.4	5.7	0.5m	220	1.0m	0	SE	13kt
29.06.91	21	76.0N	17.2E	200	13	20.0	wolkig	1014.8	93	4.9	6.0	0.5m	220	1.0m	0	W	3kt
30.06.91	0	76.1N	17.1E	170	18	/	/	1012.7	95	5.0	6.1	/	/	/	0	NW	3kt
30.06.91	3	76.2N	16.9E	170	20	/	/	1010.4	87	5.0	3.9	/	/	/	0	N	3kt
30.06.91	6	76.3N	16.1E	150	19	10.0	bedeckt	1007.5	93	4.2	2.7	1.0m	200	1.5m	0	NW	3kt
30.06.91	9	76.7N	15.1E	120	22	0.2	Nebel	1004.6	97	2.4	2.9	1.0m	200	1.0m	0	NW	8kt
30.06.91	12	76.9N	14.7E	130	19	0.2	Nebel	1002.5	97	3.1	4.5	1.0m	200	1.0m	0	NW	3kt
30.06.91	15	77.0N	15.6E	90	10	20.0	bedeckt	1001.9	90	2.6	3.3	0.0m	230	1.0m	0	NE	3kt
30.06.91	18	77.0N	15.6E	90	6	4.0	diesig	1000.6	96	2.2	3.6	0.0m	230	1.0m	0	Station	
30.06.91	21	77.0N	15.6E	270	11	/	/	1000.3	88	2.8	3.2	/	/	/	0	Station	
01.07.91	0	77.0N	14.6E	310	9	/	/	1000.4	70	2.5	3.0	/	/	/	0	W	3kt
01.07.91	3	77.5N	12.9E	200	5	/	/	998.9	77	3.6	5.1	/	/	/	0	NW	13kt
01.07.91	6	78.0N	12.6E	140	12	20.0	bedeckt	998.0	82	2.7	3.6	0.5m	220	1.0m	0	N	8kt
01.07.91	9	78.3N	15.4E	260	6	20.0	wolkig	998.1	71	4.0	6.4	/	/	/	0	NE	13kt
01.07.91	12	78.2N	15.6E	320	7	20.0	fast bedkt	996.9	74	4.4	5.6	0.0m	/	/	0	SE	3kt
01.07.91	15	78.3N	15.5E	320	6	/	/	995.9	73	5.0	6.2	/	/	/	0	Station	

01.07.91	18	78.1N	12.2E	340	15	20.0	bedeckt	995.7	79	3.5	5.2	0.5m	220	0.0m	0	W	13kt
01.07.91	21	78.3N	10.7E	340	15	20.0	wolkig	997.1	85	4.5	6.2	0.5m	220	1.0m	0	W	8kt
02.07.91	0	78.5N	9.8E	290	12	/	/	998.5	84	2.8	6.4	/	/	/	0	NW	8kt
02.07.91	3	78.9N	8.4E	330	12	/	/	999.2	85	1.4	5.1	/	/	/	0	NW	8kt
02.07.91	6	79.0N	8.2E	330	11	20.0	bedeckt	1000.5	88	1.6	5.8	0.5m	/	/	0	NW	3kt
02.07.91	9	79.0N	8.2E	340	13	20.0	bedeckt	1001.8	91	2.0	5.9	0.5m	030	0.5m	0	Station	
02.07.91	12	79.1N	8.0E	330	9	20.0	bedeckt	1002.2	89	1.1	6.2	0.0m	030	0.5m	0	NW	3kt
02.07.91	15	79.2N	8.0E	290	7	20.0	bedeckt	1002.5	94	0.4	5.7	0.0m	030	0.5m	0	N	3kt
02.07.91	18	79.0N	6.0E	300	4	20.0	bedeckt	1002.5	86	1.1	4.6	0.0m	/		2	W	8kt
02.07.91	21	79.0N	5.9E	350	4	20.0	bedeckt	1002.5	86	0.7	5.1	0.0m	/	/	2	W	3kt
03.07.91	0	79.0N	5.9E	200	7	/	/	1002.1	77	1.5	4.5	/	/	/	0	Station	
03.07.91	3	79.0N	5.8E	190	16	/	/	1000.8	88	1.3	4.8	/	/	/	0	Station	
03.07.91	6	79.0N	5.7E	170	24	20.0	bedeckt	999.0	85	2.3	5.1	1.0m	/	/	2	W	3kt
03.07.91	9	79.0N	6.0E	160	30	20.0	bedeckt	996.3	82	3.3	5.1	1.5m	/	/	0	E	3kt
03.07.91	12	79.0N	6.1E	180	22	20.0	bedeckt	994.2	82	3.3	4.8	1.0m	170	1.5m	2	E	3kt
03.07.91	15	79.0N	5.9E	220	14	20.0	wolkig	993.4	79	2.5	5.4	0.5m	160	1.5m	2	W	3kt
03.07.91	18	79.0N	5.8E	250	9	20.0	bedeckt	994.0	89	0.3	5.3	0.0m	160	1.0m	2	W	3kt
03.07.91	21	79.0N	6.5E	10	8	20.0	bedeckt	996.3	84	1.5	3.4	0.0m	160	1.0m	2	E	3kt
04.07.91	0	79.0N	6.6E	360	23	/	/	1000.4	91	2.4	6.0	/	/	/	0	Station	
04.07.91	3	79.0N	8.2E	350	25	/	/	1003.4	93	0.9	6.0	/	/	/	0	E	8kt
04.07.91	6	79.0N	8.2E	330	18	20.0	bedeckt	1005.9	86	0.5	4.8	1.0m	150	1.5m	0	Station	
04.07.91	9	79.0N	8.3E	330	22	10.0	bedeckt	1008.2	77	0.0	6.2	1.0m	150	1.0m	0	E	3kt
04.07.91	12	79.1N	8.2E	310	14	10.0	fast bedkt	1010.2	75	0.0	5.1	0.5m	160	1.0m	0	NE	3kt
04.07.91	15	79.1N	8.0E	290	6	20.0	fast bedkt	1010.7	77	0.7	5.5	0.0m	010	1.0m	0	E	3kt
04.07.91	18	79.1N	8.0E	260	10	20.0	fast bedkt	1010.8	81	0.6	5.4	0.0m	010	0.5m	0	Station	
04.07.91	21	79.0N	8.6E	250	13	20.0	fast bedkt	1010.6	90	0.0	6.1	0.5m	/		0	E	3kt
05.07.91	0	79.0N	8.7E	240	6	/	/	1009.9	85	1.5	6.1	/	/	/	0	Station	
05.07.91	3	79.1N	8.7E	230	7	/	/	1008.8	84	2.6	5.5	/	/	/	0	Station	
05.07.91	6	79.1N	8.7E	250	13	20.0	Regen	1007.3	87	1.8	6.3	0.5m	250	1.0m	0	Station	
05.07.91	9	79.0N	9.1E	230	17	0.1	Regen	1006.2	91	2.1	5.8	1.0m	250	1.0m	0	SE	3kt
05.07.91	12	79.0N	10.3E	240	17	10.0	Regen	1005.6	90	1.9	5.3	1.0m	250	1.0m	0	E	3kt
05.07.91	15	79.0N	10.8E	280	14	10.0	Regen	1004.6	87	1.7	5.3	0.5m	250	1.0m	0	E	3kt
05.07.91	18	79.0N	10.8E	290	11	10.0	bedeckt	1005.2	86	1.6	5.0	0.0m	250	1.0m	0	Station	
05.07.91	21	79.0N	10.8E	280	8	10.0	bedeckt	1005.5	85	2.5	4.7	0.0m	250	0.5m	0	Station	
06.07.91	0	79.3N	9.3E	310	16	/	/	1005.9	88	0.6	4.7	/	/	/	0	NW	8kt
06.07.91	3	79.8N	8.5E	290	16	/	/	1005.6	96	-0.1	-0.2	/	/	/	0	N	8kt
06.07.91	6	80.3N	8.0E	290	15	4.0	Schneefall	1005.2	94	-0.1	0.3	/	/	/	4	N	8kt
06.07.91	9	80.2N	8.1E	280	17	4.0	Schneefall	1005.5	96	-0.6	0.7	/	/	/	4	SE	3kt
06.07.91	12	80.4N	7.6E	290	17	10.0	bedeckt	1005.3	96	-0.1	-0.6	/	/	/	4	NW	3kt
06.07.91	15	80.4N	7.5E	290	17	20.0	bedeckt	1005.7	93	0.0	-0.7	/	/	/	4	W	3kt
06.07.91	18	80.4N	7.5E	300	17	20.0	bedeckt	1006.1	93	-0.3	-0.9	/	/	/	4	Station	
06.07.91	21	80.3N	7.7E	300	11	20.0	Nebel	1006.3	92	0.7	-0.6	/	/	/	0	SE	3kt
07.07.91	0	80.2N	9.0E	290	12	/	/	1006.4	98	-1.0	-0.1	/	/	/	0	E	3kt
07.07.91	3	80.2N	9.9E	300	11	/	/	1006.3	98	-0.7	1.3	/	/	/	0	SE	3kt
07.07.91	6	80.2N	9.9E	300	12	1.0	Schneefall	1006.3	97	-1.0	0.4	/	/	/	4	Station	
07.07.91	9	80.2N	9.9E	290	10	10.0	Schneefall	1006.8	96	0.2	0.6	/	/	/	4	Station	
07.07.91	12	80.2N	9.9E	300	11	10.0	Schneefall	1007.3	85	-0.2	1.9	/	/	/	4	Station	
07.07.91	15	80.1N	10.0E	300	12	20.0	bedeckt	1008.0	96	-0.6	1.6	/	/	/	4	SE	3kt
07.07.91	18	80.2N	9.9E	310	13	10.0	bedeckt	1008.7	93	-0.8	1.4	/	/	/	4	Station	

07.07.91	21	80.2N	9.8E	300	12	20.0	Schneefall	1009.1	92	-0.6	-0.6	/	/	/	4	W	3kt
08.07.91	0	80.1N	10.2E	300	17	/	/	1009.1	92	-0.8	1.6	/	/	/	0	SE	3kt
08.07.91	3	80.1N	10.5E	300	19	/	/	1008.9	93	-0.6	3.0	/	/	/	0	E	3kt
08.07.91	6	80.1N	10.4E	300	16	20.0	Schneefall	1008.9	92	-0.8	2.0	/	/	/	4	SE	3kt
08.07.91	9	80.0N	10.9E	320	14	20.0	Schneefall	1009.6	92	-0.1	4.0	0.5m	/	/	1	SE	3kt
08.07.91	12	80.0N	11.2E	330	15	20.0	bedeckt	1010.3	89	-0.8	4.1	0.5m	/	/	1	E	3kt
08.07.91	15	80.0N	11.4E	340	16	4.0	Schneefall	1010.8	92	-0.5	3.0	0.5m	/	/	2	E	3kt
08.07.91	18	80.0N	11.7E	320	14	20.0	fast bedkt	1011.1	84	-0.1	2.9	/	/	/	3	E	3kt
08.07.91	21	80.0N	13.0E	290	14	20.0	Schneefall	1010.9	90	-1.1	2.8	/	/	/	3	E	3kt
09.07.91	0	80.1N	15.6E	290	13	/	/	1010.2	92	-0.6	0.4	/	/	/	0	E	8kt
09.07.91	3	80.6N	16.6E	270	12	/	/	1009.2	94	-0.9	0.6	/	/	/	0	N	8kt
09.07.91	6	80.7N	17.8E	230	9	2.0	Schneefall	1008.2	95	0.7	-1.4	/	/	/	5	NE	3kt
09.07.91	9	80.8N	18.6E	240	14	2.0	Schneefall	1008.0	98	-0.3	-1.3	/	/	/	5	NE	3kt
09.07.91	12	80.9N	18.7E	210	13	10.0	Schneefall	1007.8	96	0.3	-1.3	/	/	/	5	N	3kt
09.07.91	15	81.0N	18.5E	190	15	10.0	fast bedkt	1007.7	94	-0.1	-1.2	/	/	/	5	NW	3kt
09.07.91	18	81.0N	18.5E	170	13	20.0	bedeckt	1007.7	91	0.1	-1.2	/	/	/	5	Station	
09.07.91	21	81.1N	18.6E	160	13	20.0	bedeckt	1007.7	83	0.5	-1.3	/	/	/	5	Station	
10.07.91	0	81.2N	18.6E	140	11	/	/	1007.5	77	1.2	-1.4	/	/	/	0	N	3kt
10.07.91	3	81.3N	17.7E	140	13	/	/	1007.0	84	-0.8	-0.7	/	/	/	0	NW	3kt
10.07.91	6	81.5N	17.3E	120	15	20.0	fast bedkt	1006.3	87	-1.5	-1.3	/	/	/	5	NW	3kt
10.07.91	9	81.5N	16.7E	120	13	20.0	fast bedkt	1006.1	86	-0.6	-1.3	/	/	/	5	W	3kt
10.07.91	12	81.5N	16.7E	110	14	20.0	fast bedkt	1005.8	88	-0.3	-1.2	/	/	/	5	Station	
10.07.91	15	81.5N	16.6E	120	12	4.0	Schneefall	1005.4	93	-0.1	-1.2	/	/	/	5	Station	
10.07.91	18	81.6N	15.6E	120	13	1.0	Schneefall	1004.9	96	-0.8	-1.2	/	/	/	5	W	3kt
10.07.91	21	81.5N	16.1E	110	15	10.0	Schneefall	1004.7	94	-0.5	-1.2	/	/	/	5	SE	3kt
11.07.91	0	81.5N	16.5E	110	14	/	/	1005.0	97	-0.6	-1.5	/	/	/	0	E	3kt
11.07.91	3	81.4N	17.7E	100	8	/	/	1005.5	97	-0.5	-1.4	/	/	/	0	SE	3kt
11.07.91	6	81.4N	17.5E	270	6	0.2	Nebel	1006.0	96	-1.1	-1.3	/	/	/	5	W	3kt
11.07.91	9	81.4N	17.4E	300	3	20.0	Schneefall	1006.5	95	-0.4	-1.3	/	/	/	5	W	3kt
11.07.91	12	81.4N	17.3E	310	5	10.0	bedeckt	1006.7	98	-0.4	-1.4	/	/	/	5	W	3kt
11.07.91	15	81.4N	17.4E	320	7	2.0	Schneefall	1006.7	95	-1.1	-1.2	/	/	/	5	W	3kt
11.07.91	18	81.4N	17.5E	30	3	4.0	Schneefall	1006.3	97	0.3	-1.4	/	/	/	5	E	3kt
11.07.91	21	81.4N	17.6E	70	8	4.0	Schneefall	1006.0	96	-1.0	-1.3	/	/	/	5	E	3kt
12.07.91	0	81.3N	18.6E	40	10	/	/	1005.6	95	-2.3	-0.3	/	/	/	0	SE	3kt
12.07.91	3	81.3N	18.6E	350	12	/	/	1004.2	92	-3.6	0.4	/	/	/	0	Station	
12.07.91	6	81.3N	18.7E	310	18	2.0	Schneefall	1001.1	93	-2.6	0.0	/	/	/	4	E	3kt
12.07.91	9	81.3N	18.8E	300	24	4.0	Schneefall	997.3	95	-1.4	0.1	/	/	/	4	E	3kt
12.07.91	12	81.2N	18.7E	310	27	1.0	Schneefall	994.1	94	-1.5	-0.4	/	/	/	4	SE	3kt
12.07.91	15	81.2N	18.5E	300	33	0.5	Schneefall	991.8	92	-1.8	-0.3	1.0m	/	/	3	W	3kt
12.07.91	18	81.3N	20.7E	300	25	10.0	bedeckt	989.1	90	-0.8	-1.2	1.0m	/	/	2	E	8kt
12.07.91	21	81.1N	22.8E	280	24	4.0	diesig	987.9	91	-1.1	-1.4	/	/	/	5	SE	8kt
13.07.91	0	80.9N	23.1E	270	26	/	/	988.3	88	-1.6	-1.3	/	/	/	0	S	3kt
13.07.91	3	81.0N	24.2E	270	28	/	/	987.3	93	-1.4	-1.3	/	/	/	0	E	3kt
13.07.91	6	81.0N	25.6E	270	27	10.0	bedeckt	988.1	90	-0.7	-1.2	/	/	/	5	E	3kt
13.07.91	9	81.0N	26.4E	270	27	2.0	diesig	989.0	92	-0.4	-1.2	/	/	/	5	E	3kt
13.07.91	12	81.0N	27.2E	260	35	4.0	diesig	991.4	90	-0.1	-1.2	/	/	/	5	E	3kt
13.07.91	15	80.9N	28.5E	260	31	10.0	bedeckt	994.2	97	0.5	-1.2	/	/	/	5	E	3kt
13.07.91	18	81.0N	29.6E	240	29	20.0	bedeckt	996.7	76	1.2	-1.4	/	/	/	5	E	3kt
13.07.91	21	81.4N	30.4E	230	32	20.0	wolkig	997.8	67	0.7	-1.4	/	/	/	4	N	8kt

14.07.91	0	81.5N	32.6E	220	28	/ /		1000.0	69	0.3	-1.0	/	/	/	0	NE	8kt
14.07.91	3	81.4N	31.5E	200	23	/ /		1001.1	77	-0.3	-0.9	/	/	/	0	SE	3kt
14.07.91	6	81.4N	31.6E	200	16	20.0	heiter	1002.3	79	-0.2	-1.4	0.5m	/	/	3	E	3kt
14.07.91	9	81.4N	31.5E	190	16	20.0	wolkig	1003.5	92	0.4	-0.8	0.5m	/	/	4	W	3kt
14.07.91	12	81.5N	31.6E	180	18	50.0	heiter	1004.4	92	0.0	-0.8	0.5m	/	/	4	NE	3kt
14.07.91	15	81.4N	31.7E	180	18	50.0	wolkig	1004.5	84	-0.2	-0.8	0.5m	/	/	3	SE	3kt
14.07.91	18	81.4N	31.6E	170	17	20.0	fast bedkt	1004.6	85	0.9	-1.2	0.5m	/	/	3	E	3kt
14.07.91	21	81.4N	30.2E	190	12	20.0	bedeckt	1003.8	94	0.2	-1.3	/	/	/	4	SE	3kt
15.07.91	0	81.4N	30.5E	210	10	/ /		1004.5	97	-0.4	-1.3	/	/	/	0	NE	3kt
15.07.91	3	81.4N	30.7E	250	10	/ /		1006.0	96	0.7	-1.0	/	/	/	0	Station	
15.07.91	6	81.4N	30.8E	250	6	2.0	Nebel	1007.8	96	-1.1	-1.0	/	/	/	4	E	3kt
15.07.91	9	81.4N	30.8E	240	7	50.0	heiter	1009.8	75	-0.1	-0.6	/	/	/	4	Station	
15.07.91	12	81.4N	30.8E	240	8	20.0	heiter	1011.2	75	0.4	-0.4	/	/	/	4	Station	
15.07.91	15	81.4N	30.9E	270	4	1.0	Nebel	1011.7	95	-0.4	-0.5	/	/	/	4	E	3kt
15.07.91	18	81.4N	31.0E	240	3	0.5	Nebel	1011.8	94	-1.9	-0.8	/	/	/	4	E	3kt
15.07.91	21	81.4N	30.7E	330	3	0.5	Nebel	1012.2	94	-2.0	-1.2	/	/	/	4	W	3kt
16.07.91	0	81.4N	30.8E	300	6	/ /		1012.8	94	-2.6	-0.6	/	/	/	0	Station	
16.07.91	3	81.4N	30.8E	290	5	/ /		1012.9	95	-1.6	-0.6	/	/	/	0	Station	
16.07.91	6	81.4N	30.9E	290	5	20.0	bedeckt	1013.5	97	-0.4	-0.9	/	/	/	4	E	3kt
16.07.91	9	81.4N	30.5E	200	2	20.0	bedeckt	1013.7	99	0.8	-1.6	/	/	/	4	W	3kt
16.07.91	12	81.5N	29.4E	190	7	20.0	bedeckt	1013.7	98	-0.1	-1.5	/	/	/	4	W	3kt
16.07.91	15	81.7N	29.8E	200	10	10.0	Schneefall	1013.1	98	-0.5	-1.5	/	/	/	4	N	3kt
16.07.91	18	81.7N	29.9E	220	10	1.0	diesig	1012.7	91	-0.5	-1.5	/	/	/	4	E	3kt
16.07.91	21	81.7N	29.9E	220	9	20.0	bedeckt	1012.2	96	0.2	-1.5	/	/	/	4	Station	
17.07.91	0	81.7N	30.0E	270	10	/ /		1012.0	96	-0.6	-1.1	/	/	/	0	Station	
17.07.91	3	81.7N	30.1E	280	9	/ /		1012.3	96	-0.7	-0.8	/	/	/	0	Station	
17.07.91	6	81.7N	30.2E	300	11	20.0	fast bedkt	1012.1	96	-0.4	-0.8	/	/	/	4	N	3kt
17.07.91	9	81.7N	30.2E	300	10	20.0	bedeckt	1012.8	94	-0.6	-1.4	/	/	/	4	N	3kt
17.07.91	12	81.6N	30.2E	280	7	10.0	Nebel	1013.7	96	-0.1	-1.3	/	/	/	4	S	3kt
17.07.91	15	81.6N	30.3E	280	9	4.0	Nebel	1014.5	96	-1.0	-0.9	/	/	/	4	SE	3kt
17.07.91	18	81.6N	30.4E	260	9	10.0	Regen	1014.8	97	-0.9	-1.2	/	/	/	4	W	3kt
17.07.91	21	81.7N	30.4E	250	10	10.0	bedeckt	1014.9	96	-0.4	-1.7	/	/	/	4	N	3kt
18.07.91	0	81.6N	30.5E	260	11	/ /		1015.2	95	-0.5	-1.6	/	/	/	0	Station	
18.07.91	3	81.6N	30.6E	280	12	/ /		1015.0	95	-0.3	-1.5	/	/	/	0	Station	
18.07.91	6	81.6N	30.7E	290	13	20.0	bedeckt	1015.6	95	-0.4	-1.5	/	/	/	4	E	3kt
18.07.91	9	81.6N	30.8E	290	11	0.5	Nebel	1016.7	97	-0.6	-1.5	/	/	/	4	E	3kt
18.07.91	12	81.5N	30.7E	280	7	0.2	Nebel	1017.9	98	-0.5	-1.7	/	/	/	4	S	3kt
18.07.91	15	81.5N	30.6E	300	7	0.5	Nebel	1018.7	97	-1.4	-1.2	/	/	/	4	W	3kt
18.07.91	18	81.5N	30.7E	280	5	0.5	Nebel	1019.1	97	-1.1	-1.1	/	/	/	4	E	3kt
18.07.91	21	81.5N	30.9E	270	6	0.5	Nebel	1019.8	96	-1.5	-1.1	/	/	/	4	E	3kt
19.07.91	0	81.5N	30.9E	270	5	/ /		1020.4	97	-0.6	-1.0	/	/	/	0	Station	
19.07.91	3	81.6N	30.9E	320	4	/ /		1020.8	96	-1.0	-1.1	/	/	/	0	Station	
19.07.91	6	81.5N	31.0E	300	2	1.0	Nebel	1021.4	96	-0.8	-0.9	/	/	/	4	SE	3kt
19.07.91	9	81.5N	31.1E	280	5	4.0	diesig	1022.4	96	-1.4	-1.3	/	/	/	4	E	3kt
19.07.91	12	81.5N	31.1E	280	4	0.2	Nebel	1023.7	96	-2.0	-1.2	/	/	/	4	Station	
19.07.91	15	81.5N	31.0E	290	3	0.2	Nebel	1024.2	96	-2.4	-0.9	/	/	/	4	W	3kt
19.07.91	18	81.4N	31.0E	300	3	0.2	Nebel	1024.7	94	-3.0	-0.5	/	/	/	4	S	3kt
19.07.91	21	81.2N	31.0E	250	4	0.2	Nebel	1025.3	94	-2.9	-1.2	/	/	/	4	S	3kt
20.07.91	0	80.9N	30.9E	50	4	/ /		1025.9	96	-1.4	-1.6	/	/	/	0	S	3kt

20.07.91	3	80.8N	30.5E	270	4		/ /	1025.9	96	-1.0	-1.5	/	/	/	0	SE	3kt
20.07.91	6	80.8N	30.6E	200	3	2.0	diesig	1026.2	97	-0.7	-1.4	/	/	/	4	W	3kt
20.07.91	9	80.8N	30.6E	140	3	10.0	Nieseln	1026.7	97	0.2	-1.6	/	/	/	4	Station	
20.07.91	12	80.8N	30.1E	210	4	4.0	Nebel	1027.2	97	-0.6	-1.4	/	/	/	5	W	3kt
20.07.91	15	80.8N	30.1E	50	2	20.0	wolkig	1027.1	94	-0.5	-1.4	/	/	/	5	Station	
20.07.91	18	80.7N	29.5E	140	5	10.0	Nieseln	1027.1	91	-1.2	-1.5	/	/	/	5	SE	3kt
20.07.91	21	80.7N	29.5E	160	5	20.0	bedeckt	1027.3	90	-1.1	-1.5	/	/	/	5	Station	
21.07.91	0	80.7N	29.5E	130	6		/ /	1027.4	94	-1.9	-1.6	/	/	/	0	Station	
21.07.91	3	80.8N	29.5E	160	7		/ /	1027.0	94	-1.9	-1.6	/	/	/	0	Station	
21.07.91	6	80.5N	30.2E	140	4	4.0	Schneefall	1027.0	94	-1.6	-1.6	/	/	/	5	SE	3kt
21.07.91	9	80.7N	29.3E	150	5	4.0	Schneefall	1027.0	89	-1.6	-1.3	/	/	/	5	NW	3kt
21.07.91	12	80.7N	28.6E	160	6	10.0	bedeckt	1027.3	93	-1.5	-1.6	/	/	/	5	W	3kt
21.07.91	15	80.7N	28.5E	160	4	0.2	Nebel	1027.2	94	-1.4	-1.5	/	/	/	5	E	3kt
21.07.91	18	80.6N	28.7E	150	4	0.5	Nebel	1027.2	93	-2.4	-1.6	/	/	/	5	S	3kt
21.07.91	21	80.4N	28.8E	100	5	0.5	Nebel	1027.2	92	-3.3	-1.4	/	/	/	5	S	3kt
22.07.91	0	80.4N	28.8E	140	4		/ /	1027.4	92	-3.4	-1.4	/	/	/	0	Station	
22.07.91	3	80.4N	28.7E	10	2		/ /	1027.0	92	-3.2	-1.6	/	/	/	0	Station	
22.07.91	6	80.4N	28.7E	20	6	0.5	Schneefall	1027.0	91	-4.0	-1.4	/	/	/	5	Station	
22.07.91	9	80.3N	29.2E	10	4	0.5	Schneefall	1027.2	91	-3.2	-1.4	/	/	/	5	E	3kt
22.07.91	12	80.3N	29.3E	350	4	0.5	Nebel	1027.0	92	-2.9	-1.4	/	/	/	5	E	3kt
22.07.91	15	80.3N	29.1E	10	4	0.2	Nebel	1027.0	94	-2.1	-1.4	/	/	/	5	W	3kt
22.07.91	18	80.3N	29.3E	10	6	0.2	Nebel	1026.6	95	-1.8	1.6	0.0m	/	/	3	Station	
22.07.91	21	80.4N	29.2E	360	3	20.0	heiter	1026.5	94	-2.2	-1.5	/	/	/	5	W	3kt
23.07.91	0	80.4N	29.3E	30	5		/ /	1026.2	93	-2.2	-0.8	/	/	/	0	Station	
23.07.91	3	80.3N	29.3E	340	4		/ /	1025.6	94	-1.4	-0.6	/	/	/	0	Station	
23.07.91	6	80.4N	29.3E	330	7	50.0	heiter	1025.2	98	1.3	-1.0	/	/	/	5	Station	
23.07.91	9	80.3N	29.7E	320	8	50.0	heiter	1025.0	94	1.0	1.0	0.0m	/	/	1	SE	3kt
23.07.91	12	80.2N	29.9E	330	14	50.0	heiter	1024.6	88	0.2	1.3	0.5m	/	/	1	S	3kt
23.07.91	15	80.1N	29.6E	330	15	50.0	heiter	1024.0	90	0.4	1.8	0.5m	/	/	1	SE	3kt
23.07.91	18	80.1N	29.6E	330	15	50.0	wolkig	1023.8	89	0.7	1.6	0.5m	/	/	1	Station	
23.07.91	21	79.7N	30.2E	340	17	50.0	fast bedkt	1023.3	86	1.3	0.1	0.5m	/	/	3	S	8kt
24.07.91	0	79.5N	30.5E	340	20		/ /	1022.8	90	0.5	0.2	/	/	/	0	S	3kt
24.07.91	3	79.4N	30.5E	350	23		/ /	1022.0	85	1.7	0.6	/	/	/	0	S	3kt
24.07.91	6	79.4N	30.4E	330	21	20.0	bedeckt	1021.9	84	1.5	0.9	0.5m	/	/	3	W	3kt
24.07.91	9	79.2N	31.5E	330	16	20.0	bedeckt	1021.9	85	1.0	-0.9	0.5m	/	/	3	SE	3kt
24.07.91	12	79.2N	31.7E	350	16	20.0	Regen	1022.4	91	0.5	-0.9	0.5m	/	/	4	E	3kt
24.07.91	15	78.8N	32.0E	360	12	4.0	diesig	1022.7	96	-0.4	0.0	0.5m	/	/	3	S	3kt
24.07.91	18	78.7N	32.1E	30	11	20.0	bedeckt	1023.0	97	-0.3	0.7	0.0m	/	/	4	S	3kt
24.07.91	21	78.7N	32.1E	40	7		/ /	1023.1	98	-0.3	0.6	/	/	/	0	Station	
25.07.91	0	78.6N	32.2E	340	1		/ /	1023.1	97	-0.4	0.5	/	/	/	0	S	3kt
25.07.91	3	78.3N	32.6E	310	2		/ /	1022.7	98	0.7	2.0	/	/	/	0	S	3kt
25.07.91	6	78.3N	32.6E	310	4	20.0	bedeckt	1022.2	90	1.1	2.1	0.0m	/	/	2	Station	
25.07.91	9	78.0N	32.9E	280	5	20.0	bedeckt	1021.9	94	1.0	1.1	0.0m	/	/	0	S	8kt
25.07.91	12	78.0N	33.0E	330	7	20.0	bedeckt	1021.4	93	1.2	1.1	0.0m	/	/	0	E	3kt
25.07.91	15	78.0N	33.0E	340	10	20.0	bedeckt	1021.1	90	0.8	1.0	0.0m	030	0.5m	0	Station	
25.07.91	18	77.7N	33.1E	350	6	20.0	bedeckt	1020.5	94	0.8	1.0	0.0m	030	0.5m	2	S	8kt
25.07.91	21	77.5N	33.0E	360	9	20.0	bedeckt	1019.6	97	0.6	0.1	0.0m	/		2	S	3kt
26.07.91	0	77.3N	32.8E	350	7		/ /	1019.0	98	0.1	-1.0	/	/	/	0	S	3kt
26.07.91	3	76.9N	31.1E	20	10		/ /	1018.5	97	1.1	3.3	/	/	/	0	SE	8kt

26.07.91	6	76.7N	30.0E	40	11	20.0	bedeckt	1017.6	88	2.2	4.3	0.0m	/	/	0	SE	8kt
26.07.91	9	76.9N	32.1E	30	8	0.2	Nebel	1017.3	97	1.2	2.2	0.0m	/	/	0	E	8kt
26.07.91	12	76.9N	33.5E	360	10	10.0	Nebel	1017.0	96	0.3	2.1	0.0m	320	0.5m	0	E	8kt
26.07.91	15	76.8N	34.2E	360	9	0.5	Nebel	1016.6	97	-0.4	2.6	0.0m	320	0.5m	0	SE	3kt
26.07.91	18	76.6N	34.9E	10	9	0.5	Nebel	1015.9	98	-0.1	3.4	0.0m	/		0	SE	3kt
26.07.91	21	76.6N	34.8E	20	7	4.0	diesig	1015.5	99	0.8	3.4	0.0m	/		0	W	3kt
27.07.91	0	76.6N	34.8E	10	9	/	/	1015.4	97	-0.9	3.3	/	/	/	0	Station	
27.07.91	3	76.6N	34.8E	20	7	/	/	1015.1	97	-1.1	3.7	/	/	/	0	Station	
27.07.91	6	76.6N	34.9E	10	6	0.2	Nebel	1014.5	97	-0.3	3.2	0.0m	/		0	W	3kt
27.07.91	9	76.6N	34.8E	340	6	0.2	Nebel	1014.0	97	-0.3	3.2	0.0m	/		0	W	3kt
27.07.91	12	76.3N	34.8E	330	11	0.5	Nebel	1013.3	98	0.1	3.7	0.0m	/		0	S	3kt
27.07.91	15	76.0N	34.8E	320	14	0.5	Nebel	1012.3	99	0.8	4.2	0.5m	340	0.5m	0	S	8kt
27.07.91	18	75.9N	33.7E	310	15	0.5	Nebel	1011.4	99	1.2	5.6	0.5m	340	0.5m	0	SE	8kt
27.07.91	21	75.6N	31.9E	310	13	0.5	Nebel	1011.4	98	2.7	6.3	0.5m	340	0.5m	0	SE	8kt
28.07.91	0	75.3N	31.2E	310	11	/	/	1011.3	83	3.3	6.6	/	/	/	0	SE	8kt
28.07.91	3	75.0N	30.4E	300	16	/	/	1010.9	83	3.1	7.1	/	/	/	0	SE	8kt
28.07.91	6	74.7N	29.7E	310	9	20.0	fast bedkt	1010.8	78	4.1	7.5	0.0m	340	0.5m	0	SE	8kt
28.07.91	9	74.4N	28.9E	310	2	20.0	fast bedkt	1011.2	77	4.6	7.7	0.0m	340	0.5m	0	SE	8kt
28.07.91	12	74.0N	28.1E	150	6	20.0	bedeckt	1010.9	76	6.7	8.0	0.0m	340	0.5m	0	SE	8kt
28.07.91	15	73.6N	27.2E	130	7	50.0	wolkig	1010.4	77	7.9	8.7	0.0m	340	0.5m	0	SE	8kt
28.07.91	18	73.2N	26.3E	180	8	50.0	heiter	1009.5	70	8.7	9.2	0.0m	340	0.5m	0	SE	8kt
28.07.91	21	72.8N	25.4E	160	16	0.2	Nebel	1007.7	96	8.6	9.1	0.5m	/		0	SE	8kt
29.07.91	0	72.4N	24.5E	160	17	/	/	1005.8	96	9.5	8.9	/	/	/	0	SE	8kt
29.07.91	3	72.0N	23.8E	250	27	/	/	1006.9	86	9.8	10.0	/	/	/	0	SE	8kt
29.07.91	6	71.6N	23.0E	240	23	10.0	fast bedkt	1007.8	90	10.2	10.1	1.0m	250	1.5m	0	SE	8kt
29.07.91	9	71.4N	22.5E	240	28	10.0	bedeckt	1008.9	90	10.5	10.2	2.0m	250	1.5m	0	SE	3kt
29.07.91	12	71.2N	22.2E	230	36	4.0	Schauer	1009.2	97	10.3	10.0	2.5m	/	/	0	SE	3kt
29.07.91	15	70.9N	21.7E	230	33	20.0	fast bedkt	1009.9	86	10.8	10.7	3.5m	/	/	0	SE	3kt
29.07.91	18	70.7N	21.3E	240	36	10.0	bedeckt	1010.3	90	10.6	10.2	3.5m	/	/	0	SE	3kt
29.07.91	21	70.5N	20.8E	250	33	/	/	1012.2	97	10.2	9.7	/	/	/	0	SE	3kt

Bedeutung der Abkürzungen

TT,MM,JJ,UT	Tag, Monat, Jahr, Zeit/UTC
Lat,Lon	Breite, Laenge
Wind kt	Windrichtung, -geschwindigkeit in kt
V/km	Sichtweite in km
Wetter	Bedeckung bzw. signifikantes Wetter (Regen, Schnee usw.)
rF	relative Feuchte in %
Tl, Tw	Temperatur Luft bzw. Wasser
See	Höhe der Windsee in m
Duenung	Richtung und Höhe der Dünung
ICE	Ci des ICE-Codes
	0 kein Meereis im Blickfeld
	1 Schiff befindet sich in einer > 1 nm breiten offenen Rinne bzw. im Festeis, dessen Grenzen außerhalb des Blickfeldes liegen
	2 Eisbedeckung < 3/10, offenes Wasser oder lockeres Treibeis
	3 lockeres Treibeis 4/10 bis 6/10
	4 dichtes Treibeis 7/10 bis 8/10
	5 sehr dichtes Treibeis 9/10 oder mehr, aber kleiner 10/10
	6 Streifen und kleine Treibeisfelder mit offenem Wasser
	7 Streifen und kleine Treibeisfelder von dichtem/sehr dichtem Treibeis
	8 Festeis mit offenem Wasser oder lockeres Treibeis seewärts der Eisgrenze
	9 Festeis mit dichtem Treibeis seewärts der Eisgrenze
	/ keine Angaben wegen Dunkelheit oder schlechter Sicht
Fahrt	Kurs und Fahrt des Schiffes in 5kt-Stufen.

Explanations of Abbreviations:

TT,MM,JJ,UT	Day, Month, Year, Time/UTC
Lat, Lon	Latitude, Longitude
Wind kt	Wind direction, speed in knots
V/km	Range of visibility in km
Wetter	Cloudiness (bedeckt = 100 % cloudy, fast bedkt = almost 100 % cloudy, wolkig = cloudy, heiter = clear) or other significant weather (Regen = rain, Nieseln = drizzle, Schneefall = snowfall, Nebel = fog, diesig = hazy)
rF	Relative humidity
Tl, Tw	Temperature of air, of water
See	Wave hight in m
Duenung	Direction and hight of swell
ICE	Ci of Ice code
Fahrt	Course and speed of the ship in steps of 5 knots

10.3 Cooperative Work in the Barents Sea

Macrofauna investigations along a transect towards the eastern Barents Sea (Novaya Zemlya)

(Ingrid Kröncke, AWI)

Area of investigation:

From June 21st until July 4th, 1991 a cruise parallel to the EPOS II study on RV "Polarstern" was carried out with the Russian RV "Dalnie Zelentsy" from the Murmansk Marine Biological Institute into the eastern Barents Sea. 23 stations were sampled along a transect from a position north of North Cape towards a location west of Novaya Zemlya and from there northward up to the marginal pack ice zone (Fig. 10.3 - 1).
Water depths in the eastern Barents Sea varied between 250 and 300 m. West of Novaya Zemlya we measured depths between 260 m at the southern and 120 m at the northernmost stations.
The sediments were muds or muddy fine sands.

Methods:

On every station a CTD probe of AWI was run by the oceanographer K. Latarius. Parallel to her measurements the Russian colleagues used Nansen water samplers for the oceanographic investigations.
The macrofauna was sampled with a 0.2 m^2 "Oceanus" grab at 13 stations (large dots Fig. 10.3 - 1). 5 replicates were taken, 3 of them for AWI and 2 for MMBI benthos studies. The macrofauna samples were washed over 0.5 mm screens and preserved in 5 % formaline. In addition, one dredge was run per station to sample larger epifauna. A representative sample was preserved in 5 % formaline as well.

First results (on board):

The macrofauna of the area of investigation appeared to be of a high species richness; biomass was high, too. The communities were dominated by tube-building polychaetes (Maldanidae), followed by echinoderms, molluscs and sipunculids. The fauna seemed to represent about equal shares of Boreal and Arctic species.
Water temperatures of the transect between stations 1 and 17 as measured by Murmansk oceanographers and by K. Latarius (AWI) are indicated in Fig. 10.3 - 2.

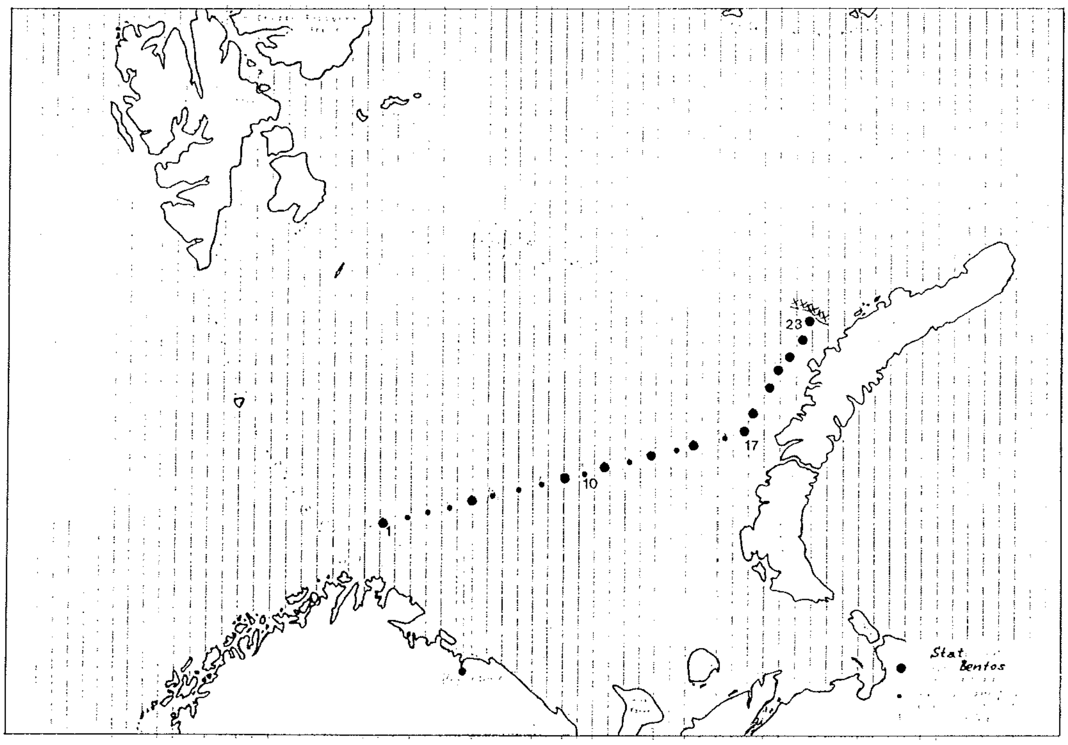

Fig. 10.3 - 1: Location of sampling stations (1-23) of the Murmansk RV "Dalnie Zelentsy" (June 21 - July 4, 1991); map provided by MMBI

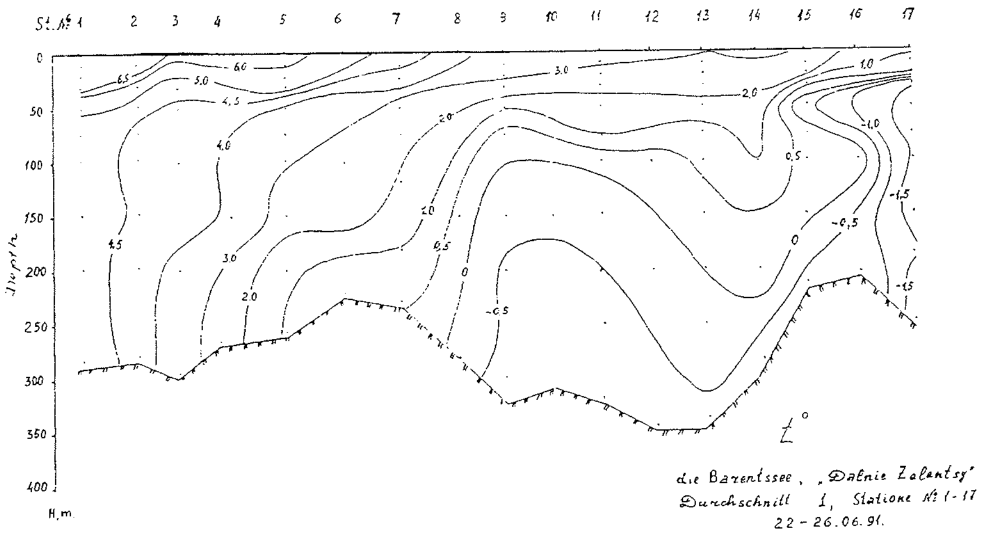

Fig. 10.3 - 2: Section of the eastern Barents Sea (Stations 1-17) showing water temperatures measured between June 21 and 30, 1991; graph provided by MMBI

10.4 Participants

Participating Institutions:

Belgium:

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France

COM	Centre d'Océanologie de Marseille, Université d'Aix-Marseille 2, Centre d'Océanologie de Marseille, Campus de Luminy, Case 901 F - 13288 Marseille

Germany

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AW-W	Forschungsstelle für Wirbeltierforschung der Akademie der Wissenschaften (of the former DDR) Alfred-Kowalke-Strasse 17 D (O) - 1136 Berlin
IFMH	Institut für Meereskunde der Universität Hamburg Troplowitzstraße 7 D - 2000 Hamburg 54
IPÖ	Institut für Polarökologie der Universität Kiel Olshausenstaße 40 D - 2300 Kiel
RF	Reedereigemeinschaft Forschungsschiffahrt August-Bebel-Allee 1 D - 2800 Bremen 41

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IBMV	Instituto di Biologia del Mare Consiglio Nazionale delle Ricerche Castello, 1364 I - 30122 Venezia
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Turkey

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United Kingdom

SPRI	Scott Polar Research Institute, University of Cambridge Lensfield Road GB - Cambridge CB2 1ER, England
US-O	Department of Oceanography, University of Southampton, GB - Southampton 209 5NH, England

U.S.A.

WHOI	Woods Hole Oceanographic Institution, Biology Department Woods Hole, MA 02543, USA

U.S.S.R./Russia

MMBI	Murmansk Marine Biological Institute, USSR Academy of Sciences Vladimirskaya, 17 Murmansk - 183 023, Russia
ZIL	Zoological Institute Leningrad/St. Petersburg, USSR Academy of Sciences Leningrad/St. Petersburg - 199 164, Russia

Scientific Staff:

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Duman, Muhammed	UI-M
Fransz, H. George	NIOZ
Gerberding, Holger	WHOI/ UGö-M
Gisselson, Lars-Ake	UG-M
Gonzales, Humberto	AWI
Graeve, Martin	AWI
Grobe, Hannes	AWI
Gutt, Julian	AWI
Hall, Per	UG-C
Harms, Ingo	IFMH / (AWI)
Hempel, Gotthilf (20.6.-1.7.)	AWI
Hoffmann, Hilmar	RF
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Iacurto, Olindo	ENEA
Inall, Mark	SPRI
Jannasch, Holger W.	WHOI
Joiris, Claude	VUB
Kendall, Mike A.	PML
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Mathieu, Thierry	UL-E
Matishov, Dmitry G.	MMBI
Meyer, Ute	AWI
Neyelov, Alexey V.	ZIL
Nöthig, Eva-Maria	AWI
Opalinski, Krzysztof	IOS-PAN
Owrid, Georgina	US-O
Parker, Paul	SPRI
Passelaigue, Françoise	COM
Petrov, Vladimir S.	MMBI
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Rachor, Eike	AWI
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Socal, Giorgio	IBMV
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Timofeev, Sergey F.	MMBI
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Wiktor, Josef	IOS-PAN
Roed, E.	SWA
Ochsenhirt, Mr.	SWA

Transferred to the Murmansk RV "Dalnie Zelentsy":

Kröncke, Ingrid	AWI
Latarius, Katrin	AWI
Tahon, Jaques	VUB

Ship´s Crew:

Master	Suhrmeyer, Lothar
Ch. Mate	Götting, Hans
Naut. Offc.	Varding, Ingo
Naut. Offc.	Fuellbrunn, Willi
Naut. Offc.	Grundmann, Uwe
Doctor	Aschoff, Horst
Rdo. Offc.	Geiger, Horst
Rdo. Offc.	Wanger, Karl-Heinz
Ch. Eng.	Müller, Klaus
2. Eng.	Erreth Monostory, Gy
2. Eng.	Fengler, Rolf R.
2. Eng.	Schuster, Eckbert
Electronician	Elvers, Heinrich
Electron.	Lembke, Udo
Electron.	Muhle, Helmut
Electron.	Pabst, Helmar E.
Electrician	Schuster, Georg
Boatswain	Hopp, Wolfgang
SBM	Zulauf, Reinhard
Carpenter	Marowsky, Klaus
A.B.	Iglesias Bermudes, Bal
	Soage Curra, Jose
	Abreu Dios, Jose
	Pousada Martinez, Sat
	Gil Iglesias, Luiz
	Garcia, Martinez
Storekeeper	Schierl, Franz
Motormen	Carstens, Erwin
	Dufner, Gustav
	Husung, Udo
	Wittfloh, Willi
	Reitz, Marcel
	Heger, Olaf

Ship´s crew, ctd.

1. Steward	Vollmeyer, Helmut
Cook	Kubicka, Egon
Cook Mate	Dutsch, Michael
Cook Mate	Hueneke, Heino
2. Steward	Yang, Chien-Chang
2. Steward	Yu, Chung-Leung
2. Steward	Tu, Jian-Min
Stewardess	Hoppe, Martha
Stewardess	Hopp, Agnes
Stewardess	Rothmann, Tanja
Stewardess	Droese, Katja
SN	Varding, Isi