Scientific Cruise Report of the Joint Russian-German Kara-Sea Expedition of RV "Akademik Boris Petrov" in 1999

Wissenschaftlicher Fahrtbericht über die russisch-deutsche Karasee-Expedition von 1999 mit FS „Akademik Boris Petrov"

Edited by
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with contributions of the participants

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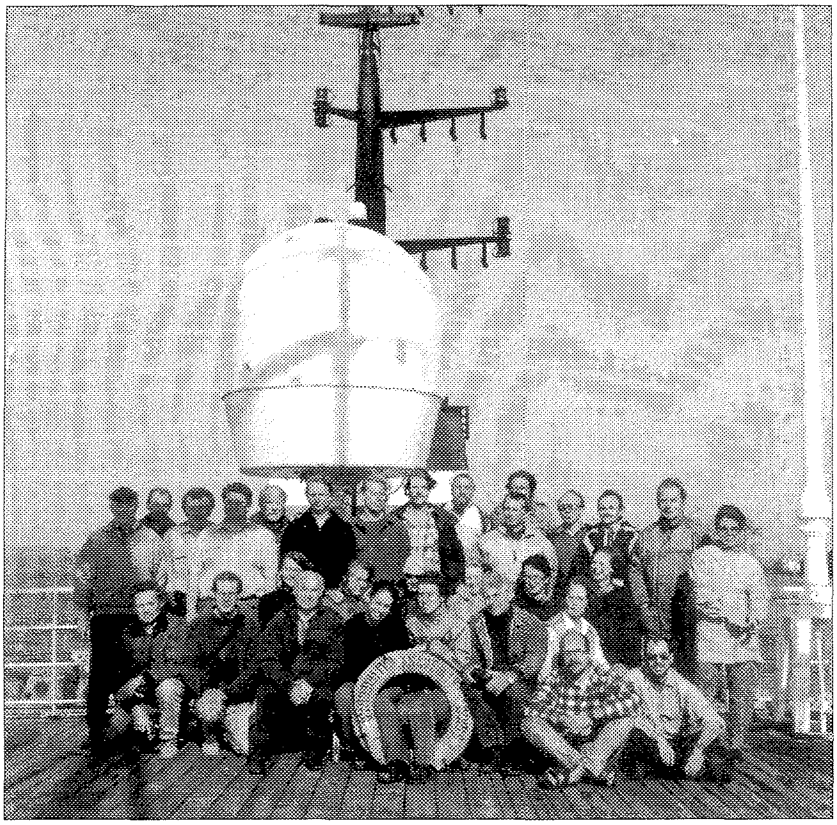
Shipboard Scientific Party of the "Akademik Boris Petrov" Expedition 1999



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Second row (sitting, left to right): Alexandr Borisov, Matthias Kraus, Vladimir Sukhoruk, Nina Lau, Daniela Unger, Oleg Stepanets, Luydmila Kodina
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Content

1 Introduction

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Within the framework of the joint Russian - German pilot project on "The Nature of Continental Run-Off from the Siberian Rivers and its Behavior in the "Kara Sea Area" and the cooperation agreement between the V.I.Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences (GEOKHI RAS) (Coordinator Academician E. M. Galimov) and the Alfred Wegener Institute for Polar and Marine Research, Germany (AWI) (Coordinator Professor Dr. D. K. Fütterer), a second pilot expedition with RV "Akademik Boris Petrov" was carried out in the Ob and Yenisei estuaries and adjacent inner Kara Sea in August-September 1999 (Fig. 2-1). This expedition is based on the results of the first Kara Sea expedition in 1997 (Matthiessen and Stepanets, 1998; Matthiessen et al., 1999). Overall goal of this joint research project is the understanding of oceanographical, biological, geochemical and geological processes related to the freshwater and sediment input by the Siberian rivers Ob and Yenisei and its impact on the present and past environments of the inner Kara Sea.

During the expedition, an extensive sampling program was carried out on a total of 39 stations (Fig. 2-2). Furthermore, two sediment traps were successfully deployed north of the Ob and Yenesei estuaries at 74°30´N, 74°E and 74°N, 80°E, respectively, to measure the saisonal variability of particle flux over one year.

The scientific program of the expedition covered a wide range of objectives:

(1) to characterize the supply of the rivers Ob and Yenisei with respect to their dissolved and suspension load, to identify processes modifying the river supply in the estuaries and the inner shelf sea, and finally to analyse the dispersal and deposition of the riverine suspendes matter in the Kara Sea;

(2) to study the response of the planktic and benthic biota on variations in the river supply along the salinity gradient from the estuaries to the inner shelf;

(3) to study the geochemistry of dissolved and particulate organic matter and hydrocarbon gases in the water column and the sediments;

(4) to study the dispersal and distribution pattern of contaminants;

(5) to reconstruct temporal and spatial changes in the late Weichselian and Holocene paleoenvironment along transects from the estuaries of the rivers Ob and Yenisei towards the open Kara Sea; and

(6) to calculate total sediment and organic carbon budgets for the Ob and Yenisei estuaries and the inner Kara Sea.

The research institutes involved in this expedition are from the Russian side the Vernadsky Institute of Geochemistry and Analytical Chemistry (GEOKHI) Moscow, the Shirshov Institute of Oceanology (IORAS), Kaliningrad, the Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry (IGEM) Moscow, and the Murmansk Marine Biological Institute (MMBI), and from the German side the Alfred Wegener Institute for Polar and Marine Research (AWI) Bremerhaven, the Research Center for Marine Geosciences (GEOMAR) Kiel, and the Institute for Biogeochemistry and Marine Chemistry (IFBM) Hamburg.

The success of our expedition is mainly based on the excellent cooperation between crew and scientists. We would like to thank captain Victor Kondratev and his crew for their untiring and able support during work onboard RV "Akademik Boris Petrov".

This report presents the scientific program and initial results of the expedition and outlines future research to be performed on the material obtained during the expedition.

The financial support by the Ministry for Education, Science, Research, and Technology (BMBF) is gratefully acknowledged.

2 Itinerary

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RV "Akademik Boris Petrov" left Kaliningrad late in the night of August 06, 1999, heading for the German port of Kiel, where the equipment of the German scientists was loaded. On August 10, 16.30h local time, we left Kiel, onboard 36 crew members and 32 Russian and German scientists, ahead of us 1675 nautical miles (nm) to Murmansk. After sailing though the Baltic Sea, Kattegat and Skagerak and passing along the western coast of Norway, we arrived at Murmansk on August 16 (Fig. 2-1). After a port call of four days we left Murmansk on August 21, heading towards northeast. On August 24, we met the Russian nuclear icebreaker "Arktika" at the packice margin northeast of Novaya Zemlya at 76°10´N, 71°E. With the support of the icebreaker we continued towards the south, passing through packice fields between 76°10´N, 71°E and 75°30´N, 73°50´E. Around midnight August 24, we reached the northwestern corner of our study area (Fig. 2-1).

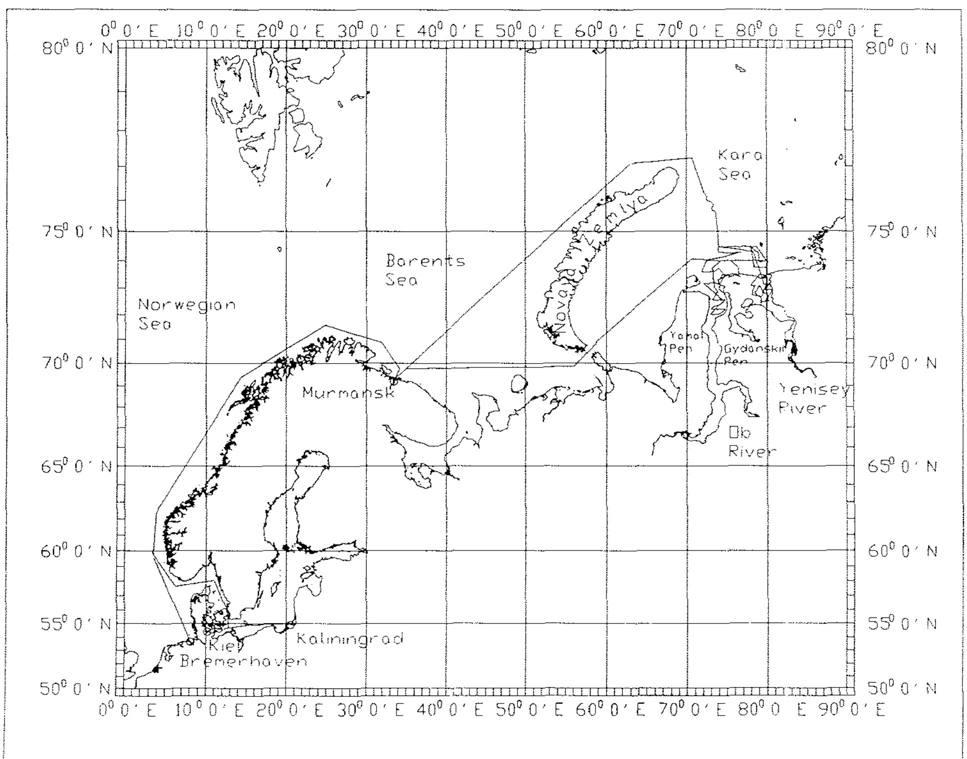

Fig. 2-1
Cruise track of the Kara Sea Expedition 1999 with RV "Akademik Boris Petrov"

At all main stations (Fig. 2-2), the work program generally included (i) hydrographical measurements by means of CTD, (ii) water, plankton, and suspended matter sampling using Rosette, larger volume sampler (Batomat) and plankton nets, and (iii) sediment and benthos sampling using large box corer, multicorer, gravity corer, and benthos dredge. At some additional stations, only CTD measurements were performed (Fig. 2-2). During transit, the sediment profiler was runnig continously to obtain information about the seafloor topography as well as the thickness and structure of the upper (Holocene?) sedimentary cover.

During the first two days, two sediment traps were successfully deployed north of the Ob and Yenesei estuaries at 74°30'N, 74°E (Station BP99-01) and 74°N, 80°E (Station BP99-03) (Fig. 2-2), respectively, and a sampling program of the water column and the sediments was performed. From August 26 to 28, a north-south transect in the Yenisei along 80°E longitude was sampled for biological, geochemical and geological studies. All stations were carefully selected based on sediment-profiling results. At station BP99-04, the longest sediment core of 7.95 m in length was recovered. At Station BP99-06 (72°17'N, 80°02'E), the southernmost station of the Yenisei transect, lowest salinity of 2.5 ‰ was measured by CTD.

During the next days, we worked in the northeastern part of our study area. On August 29, we recovered and re-deployed the Yenisei sediment trap. After having finished all sampling work, RV "Akademik Boris Petrov" headed westwards and reached 74°N/74°E on August 30. Bad weather conditions with strong northerly winds and high waves prevented any station work. Thus, we decided to steam towards the south into the Ob estuary. Until September 03, we completed an intensive biological, geochemical, and geological sampling program in the Ob area between 72°N and 74°30'N, where all gears were run successfully. In the southernmost part of the transect, a detailled salinity measurement program was performed. As result, the freshwater endmember with a salinity of 0.6 ‰ could be sampled.

On September 03, we had to stop our station work due to too strong southerly winds and high waves. We dropped anchor directly north of Vilkitsky Island (73°30'N, 76°30'E). Next day RV "Akademik Boris Petrov" headed towards the southeast, and we continued sediment-profiling and biological, geochemical, and geological station work in the channel north, west and south of Sibirjakov Island on September 04 and 05. During the next two days we completed our profiling and sampling program in the Yenisei.

During the night of September 06/07 RV "Akademik Boris Petrov" left the Yenisei area and steamed towards the NW corner of our study area. In the morning of September 07 we recovered and re-deployment the Ob sediment trap. On September 07 and 08, we carried out the last three main stations on a profile along 74°18'N latitude, where again all sampling gears were used.

On September 08, 13.00h ship time (= Moscow time) we have finished our station program in the study area and started steaming towards the southwest. Due to ice-free conditions in the southern Kara Sea we could use the southern route through Kara Strait. We passed Kara Strait on September 10, 04.00 - 06.00h ship time. On September 12, we arrived at Murmansk. We left

Murmansk during the night of September 21/22 and arrived in Bremerhaven in the morning of September 27, 1999.

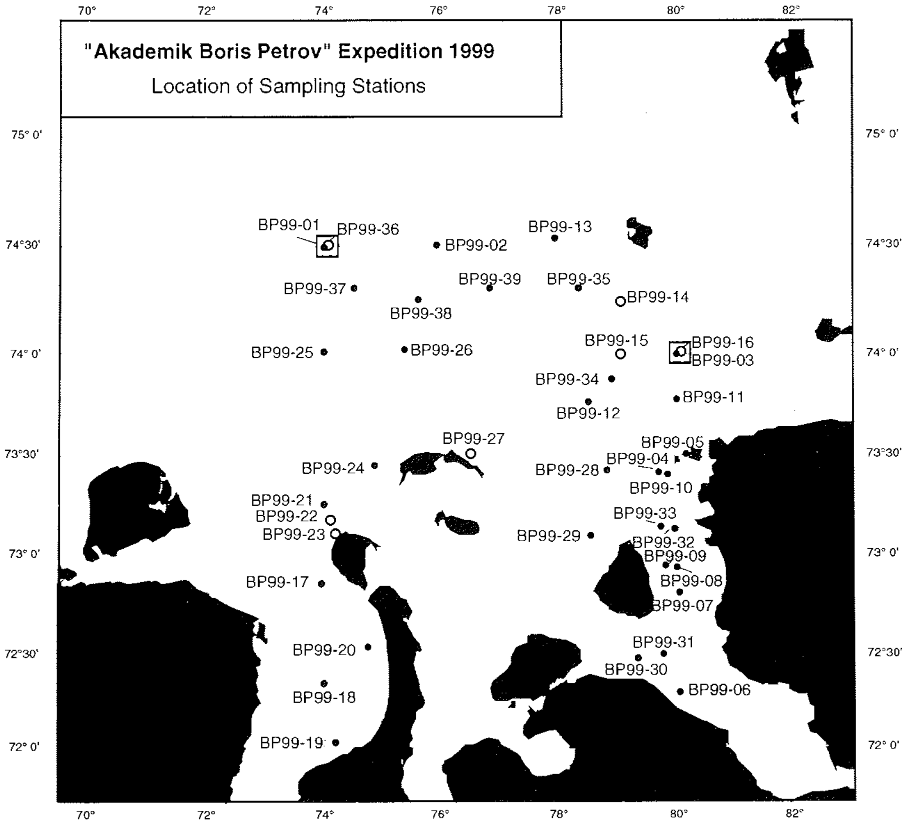

Fig. 2-2:
Location of sampling stations
Solid dots indicate main stations and sediment stations, open dots indicate stations where only CTD measurements were performed. The large open squares mark the two stations where the sediment traps were deployed.

3 Meteorological Data and Ice Conditions

R. Stein

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven

During the RV "Akademik Boris Petrov" Kara Sea Expedition 1999, the meteorological data was taken at each station from the bord computer screen. Water temperature, air temperature as well as wind speed and direction are listed in Table 3-1.

Table 3-1:
Water temperature (°C), air temperature (°C), wind speed (m/s) and wind direction (Deg) at stations BP99-01 to BP99-39.

Station Nr.	Date	Time (GMT)	Latitude (° N)	Longitude (° E)	T-Water (°C)	T-Air (°C)	Wind (m/s)	Wind Dir. (Deg)
BP99-01	24.08.1999	19:00	74° 29.82´	73° 59.62`	3,9	2,8	2	53
BP99-02	25.08.1999	11:37	74° 30.04`	75° 55.63`	4,1	4	6,4	137
BP99-03	26.08.1999	02:00	73° 59.88`	80° 00.56`	3,65	-	12,4	129
BP99-04	26.08.1999	16:30	73° 24.89`	79° 40.48`				
BP99-05	26.08.1999	21:06	73° 30.10`	80° 00.66`	4,80	5,5	12	83
BP99-06	27.08.1999	04:30	72° 17.14`	80° 01.88`	6,7	7,5	13,6	154
BP99-07	27.08.1999	09:22	72° 47.97`	80° 02.74`	7	6,8	10,7	150
BP99-08	27.08.1999	14:45	72° 55.77`	79° 59.38`	5,9	7,1	7,2	140
BP99-09	27.08.1999	20:30	72° 55.94`	79° 46.61`				
BP99-10	28.08.1999	04:30	73° 23.32`	79° 50.50`				
BP99-11	28.08.1999	10:25	73° 46.37`	79° 59.22`	5,1	3,1	4	5
BP99-12	28.08.1999	17:45	73° 45.56`	78° 28.81`	4,5	3,4	5,3	306
BP99-13	29.08.1999	01:38	74° 29.84`	78° 00.00`	4,4	1,9	4,9	348
BP99-14	29.08.1999	11:48	74° 15.05'	79° 00.93'	3,3	1,8	7	345
BP99-15	29.08.1999	13:32	73° 59.88'	78° 59.61'	3,5	1,6	7,4	345
BP99-16	29.08.1999	11:54	74° 00.14`	80° 02.00`				
BP99-17	30.08.1999	11:45	72° 51.44`	76° 56.44`	3,6	2,6	10,7	303
BP99-18	31.08.1999	04:00	72° 19.98`	74° 00.00`	4	2,5	7,9	307
BP99-19	31.08.1999	16:05	72° 11.34`	74° 11.15`	4	2,5	4,5	7
BP99-20	01.09.1999	05:41	72° 30.81`	74° 43.90`	3,9	2,8	6,2	296
BP99-21	02.09.1999	02:06	73° 14.79`	74° 02.01`	3,5	3,8	9,2	243
BP99-22	02.09.1999	07:30	73° 11.09`	74° 04.91`				
BP99-23	02.09.1999	08:25	73° 06.59`	74° 10.13`				
BP99-24	02.09.1999	11:24	73° 26.03`	74° 52.26`		4,2	6	264
BP99-25	03.09.1999	02:10	74° 00.06`	73° 59.76`	3,4	2,9	8,6	218
BP99-26	03.09.1999	14:24	74° 00.33`	75° 21.62`	3,1	5,3	14,3	198
BP99-27	03.09.1999	21:36	73° 30.00`	76° 28.75`				
BP99-28	04.09.1999	09:08	73° 25.40`	78° 48.73`	3,2	3,6	6,6	213
BP99-29	04.09.1999	17:24	73° 05.52`	78° 30.79`	3,4	4,9	7,5	186
BP99-30	05.09.1999	02:56	72° 27.45`	79° 17.95`	5,5	5,2	11,8	135
BP99-31	05.09.1999	11:38	72° 29.16`	79° 45.66`	5,8	6,3	9,4	150
BP99-32	06.09.1999	01:45	73° 08.07`	79° 57.24`	5,3	4,5	7,8	243
BP99-33	06.09.1999	10:52	73° 08.05`	74°43.02`	5,3	5,9	4,8	214
BP99-34	06.09.1999							
BP99-35	06.09.1999	18:25	74° 18.05`	78°20.04`	2,9	3,5	8,1	149
BP99-36	07.09.1999	05:09	74° 29.87`	73°59.16`	2,6	3,1	7,6	121
BP99-37	07.09.1999	09:12	74° 18.03`	74°20.05`	2,9	2,6	2,5	239
BP99-38	07.09.1999	15:05	74° 15.00`	75°36.34`	3,1	3	6,2	18
BP99-39	08.09.1999	20:52	74° 17.92`	76°49.88`	2,9	3,8	5,8	50

During most of the times, southwesterly, southerly to southeasterly winds with speeds of about 5 to 9 m/s prevailed. On September 03, maximum wind speed of almost 15 m/s was reached. Due to this strong wind and high waves, station work at Station BP99-26 had to be stopped before finishing the station. During the following night wind speed even more increased. Between August 28 to 31, wind direction changed to northerly winds with wind speeds of 4 to 10 m/s.

Due to too heavy ice conditions in the Kara Strait area, we had to use the route north around Novaya Zemlya to reach our study area. On August 28, we met the Russian nuclear icebreaker "Arktika" at the packice margin near 76°10´N, 71°E. With the support of the icebreaker a packice field with an ice coverage of about 40-60 % was passed in the area between 76°10´N, 71°E and 75°30´N, 73°50´E.

During the entire working time in the Kara Sea, our study area was completely ice-free, with one exception: On August 25, during transit from station BP99-02 to station BP99-03, we had to change our course due to a small packice field in the northeastern corner of our study area.

4.1 Brief characteristics and results from measurements of hydrophysical structures of waters in the estuaries of Ob and Yenisei

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Introduction and scientific goal

Within the world ocean the Arctic Basin is the largest influenced by continental river run-off. Especially strongly affected by continental run-off is the Kara Sea, annually gaining about 1300 km^3 of river water. During summer, fresh waters from the rivers Ob (ca. 450 km^3) and Yenisei (ca. 600 km^3) cover a wide area of appr. 600,000 km^2 within the limits of the 25 ‰ isoline (Fig. 4-1). Due to poor vertical mixing with the underlying denser sea water the river water spread out as a thin surface layer, forming the so-called "fresh water plume". Depending on the capacity of river run-off and on meteorological conditions three types of distribution of river waters are possible: (a) a western type of flow direction to northern Novaya Zemlya, (b) a central type with waters spread out fan-shaped to the north, and (c) an eastern type with a flow direction to the north-east along the Siberian coast.

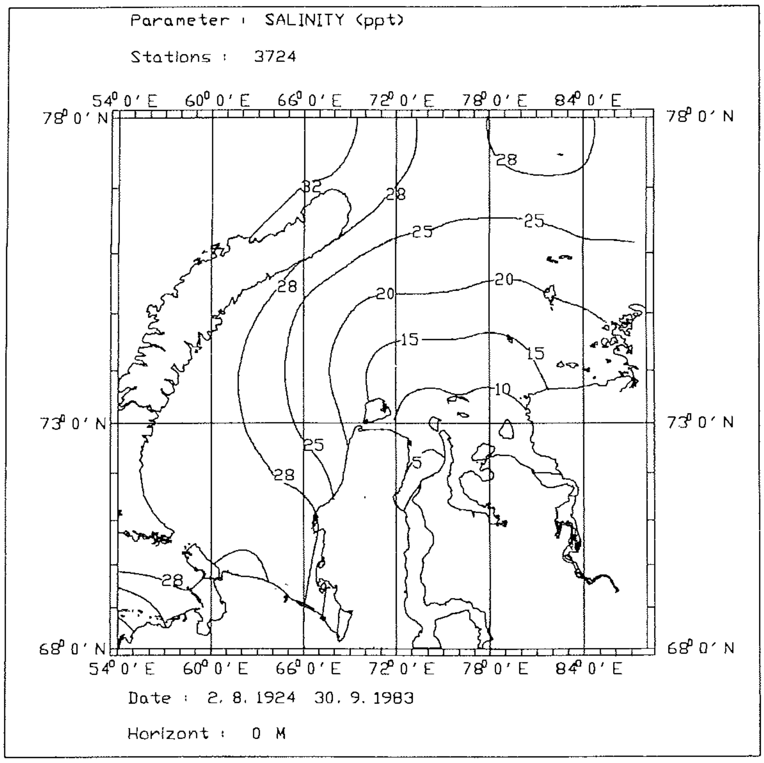


Fig. 4-1
Sea surface salinity from a climatological database (see text for explanation).

The Ob and Yenisei region in the Kara Sea shows strong seasonal and interannual variability in both salinity and temperature. Figures 4-1 and 4-2 display the salinity and temperature at sea surface in August and September based on a total of 3724 stations during the period 1924 to 1983, selected from the database "Hydrology of World Ocean" of the Centre of the Oceanographic Data Federal Hydrometeorological Service of Russia. These data were averaged on a spherical trapezoid grid with a resolution of 1° latitude and 2° longitude. The salinity field (Fig. 1) allows the precise identification of the fresh water plume (< 25 ‰) with an average horizontal salinity gradient of ca. 0.05 ‰/km. In a similar way this structure is characterized by the temperature field (Fig. 2). Variability of salinity and temperature is largest at the edge of the eastuaries of Ob and Yenisei.

The main purpose of hydrophysical research during the expedition of RV "Akademik Boris Petrov" 1999 was the identification and localization of frontal zones. In addition, the vertical profiles of temperature and salinity allowed the selection of horizons in the water column for geochemical sampling.

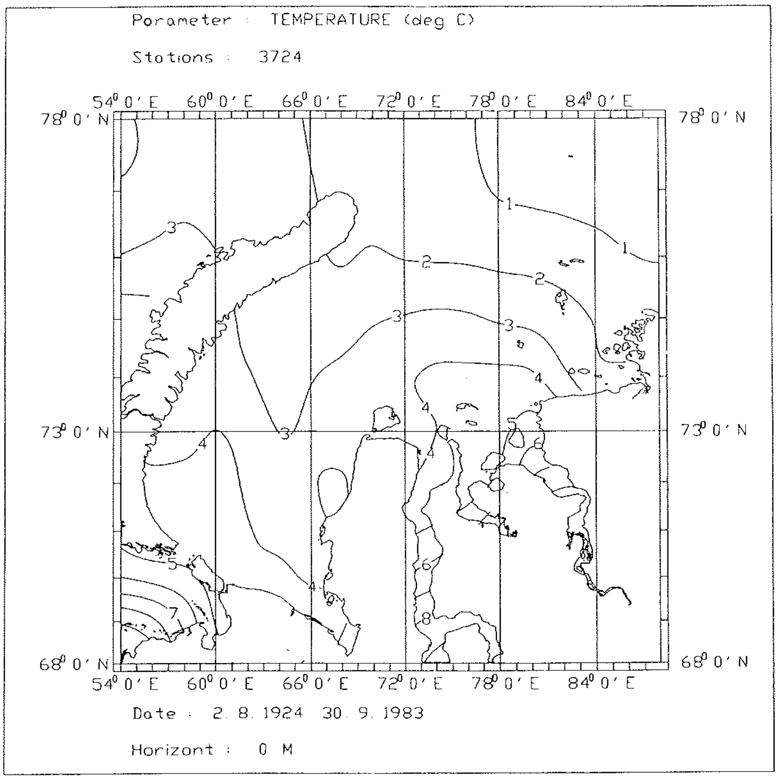


Fig. 4-2
Sea surface temperature from a climatological database.

Working program

To obtain vertical salinity and temperature profiles of the water column and for the subsequent sampling of selected horizons we used a rosette sampler equipped with 24 bathometers and a CTD-set "MARK-3b" of "EG&G, OCEAN PRODUCTS" for measurements of conductivity, temperature and pressure. The accuracy of temperature measurements in the range from -32°C to +32°C is ±0.005°C, the accuracy of conductivity measurements in the range from 1 to 65 mmho is ±0.005 mmho, and the accuracy of pressure measurements in the range from 0 to 320 db is 0.1 db. The measuring device was calibrated in May 1998 on a calibration standard at the Sewastopol Scientific and Technological Institution. The equipment worked without malfunctions. During the expedition temperature and salinity values were verified by means of a hand-held conductivity meter WTW-LF330/SET at some stations.

From August 24 to September 8, 1999, hydrophysical profiling was carried out at 37 stations on three meridional sections at 74°, 79.5°, and 80°E and two longitudinal sections at 73.5° and 74.5°N (Fig. 4-3). Water samples were taken at 31 stations. For this purpose the number of CTD-casts at each station varied between 1 and 5.

Preliminary results

Based on the T/S-profiles the stations can be divided into three groups:

1. South of 73°N, stations in the mouths of the rivers Ob and Yenisei (Fig. 4-3) have a more or less distinctive two-layer structure with a practically absent intermediate layer. Best examples for this two-layer structure are the profiles at stations 18 and 31, located in the central flow of Ob and Yenisei, respectively. There, the salinity difference between sea surface and bottom approximates 25 ‰. We should mention, that this pattern varies strongly even in a small distance off the central flow of Yenisei at station 30 (Fig. 4-3) where the surface to bottom difference in salinity amounts to just 7.5 ‰. Apparently the much greater current speed in the central flow (st. 31) suppresses vertical mixing of water masses with different salinity. The absolute salinity values in the upper layer at station 31 (4.5 ‰) located in the central flow are much lower than at station 30 (5.5 ‰) where Yenisei bay water from the northwest mixes with Yenisei river water from the southeast. In contrary the salinity values at the bottom are much higher at station 31 (31 ‰) than at station 30 (13 ‰), where the shallow bottom topography (<10 m) near the river bank blocks the influence of water from the open Kara sea and reduces its effect on salinity. This explanation also holds true for temperature. The vertical temperature difference in the central river flow at station 31 (-7.2°C) is much higher than at station 30 (-1.7°C).

Vertical variability is low in the shallow area between the mouths of Ob and Yenisei. For example the difference between sea surface and bottom does not exceed 0.6 ‰ in salinity and 0.1 °C in temperature at stations 29 and 27.

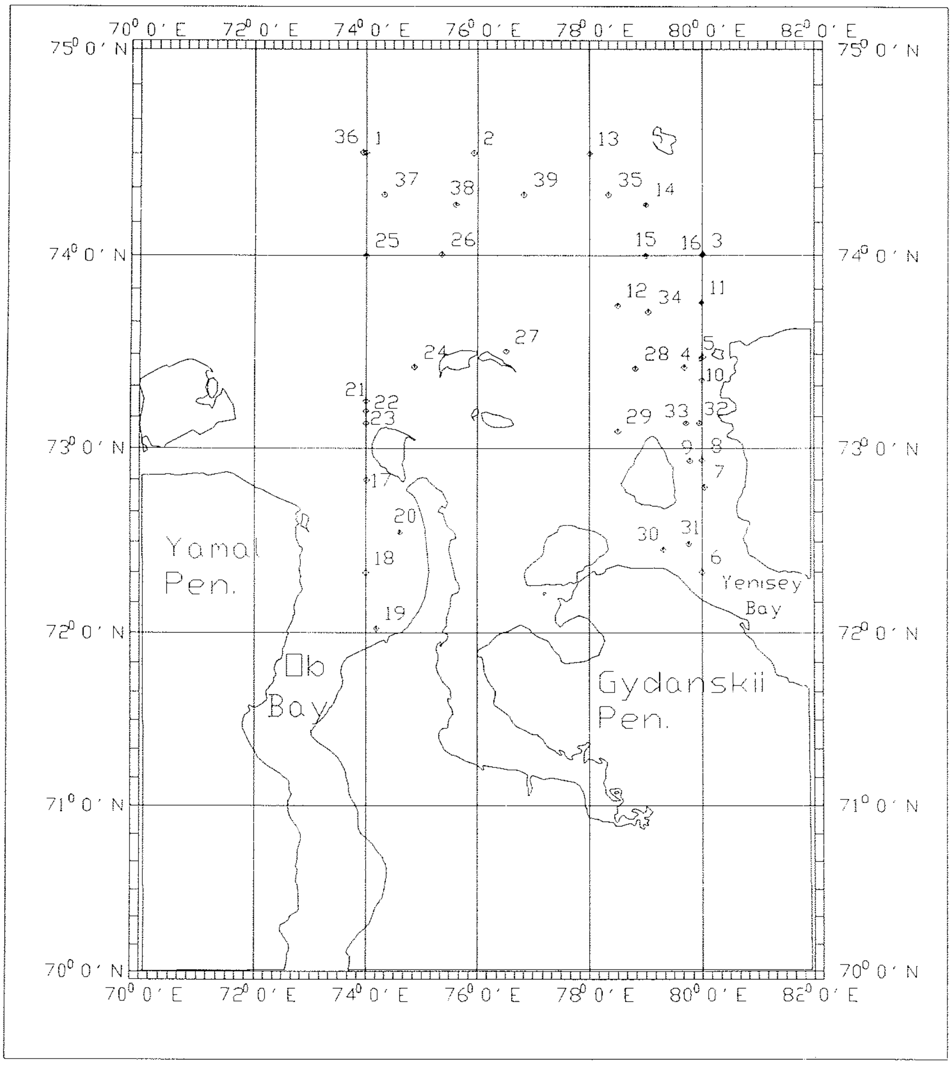


Fig. 4-3
Hydrophysical stations on the 32nd cruise of RV "Akademik Boris Petrov".

2. Stations north of 73.5 °N (Fig. 4-3) reveal a more complex stratification. The salinity profile is more or less similar in character at all stations. The surface layer is rather thin and ranges from 12 m in the south (st. 4) to 7 m in the north (st. 13). Salinity values in this upper layer are low and range from 6 ‰ at station 4 to 8 ‰ at station 13. Further down follows a thin, approximately 1 to 2 m thick layer with a sharp salinity gradient, followed by a layer of slowly increasing salinity which extends to the bottom. There the salinity is about 32 ‰ and practically identical at all stations.

The temperature profiles are a bit more complex in character as there are inverse layers. The absolute values of temperature in the surface layer range from 2.5°C to 5.5°C at all considered stations. The temperature of the bottom layer is generally negative between -1.1 and -1.6 °C. Warm or cold laminae show the thermal instability of the water column and demonstrate that at low temperatures the density depends basicly on salinity.

3. Profiles received in the frontal zone of the Ob (st. 21, 22, 23; Fig. 4-3) are characterized by a rather monotonous change of temperature and salinity with depth (vertical gradients of appr. -2.8°C/m and 1.4 ‰/m). The presence of alternated layers in the whole water column indicates momentary intermixing processes of marine and river waters.

The pattern of sea surface salinity allows to identify the distribution of river waters. Figure 4-4 shows isolines of salinity in 3 m water depth prepared from data of the 1999 expedition. This map should be considered as a very rough one because of the small number of measurements and the time shift between the stations. Two solitary lenses with lowered salinity in the center of the area and a weak frontal zone in the southern part of the area (salinity gradient 0.02 ‰/km), however, can be distinguished. A comparison of Figure 4-4 with the same area in Figure 4-1 shows significant differences. In 1999 surface salinities of approx. 9 ‰ were observed at 74 °N, whereas the climatological database gives salinity values in the order of 12 ‰ at the same latitude. Probably, the delayed ice break-up in 1999 served as a fresh water source, i.e., our measurements were conducted during high discharge of river waters. The small-scale solitary fresh water plumes may result from distinct changes in the river discharge together with temporary variability of wind conditions, which could cause the separation of small-scale short-lived fresh water plumes.

The study of meridional and parallel sections (Figs. 4-5 to 4-9) shows that all stations of the 1999 expedition were located within the core of the fresh water plume. The salinity of the surface layer did not exceed 11 ‰, the salinity of the bottom layer did not drop below 23 ‰. The temperature of the surface layer was not < 3°C and did not exceed -1°C at the bottom. The absence of longitudinal variations in the thickness of the upper homogeneous layer (Figs. 4-5 and 4-6) allows the conclusion that in 1999 the fan-shaped central type of distribution of river waters was realized.

The Yenisei sections (Figs. 4-7 and 4-8) reveal no precisely expressed frontal zone. A significant shallowing of salinity and temperature isolines is obviously at 74°N. This feature is more pronounced west of the central river flow (Fig. 4-8).

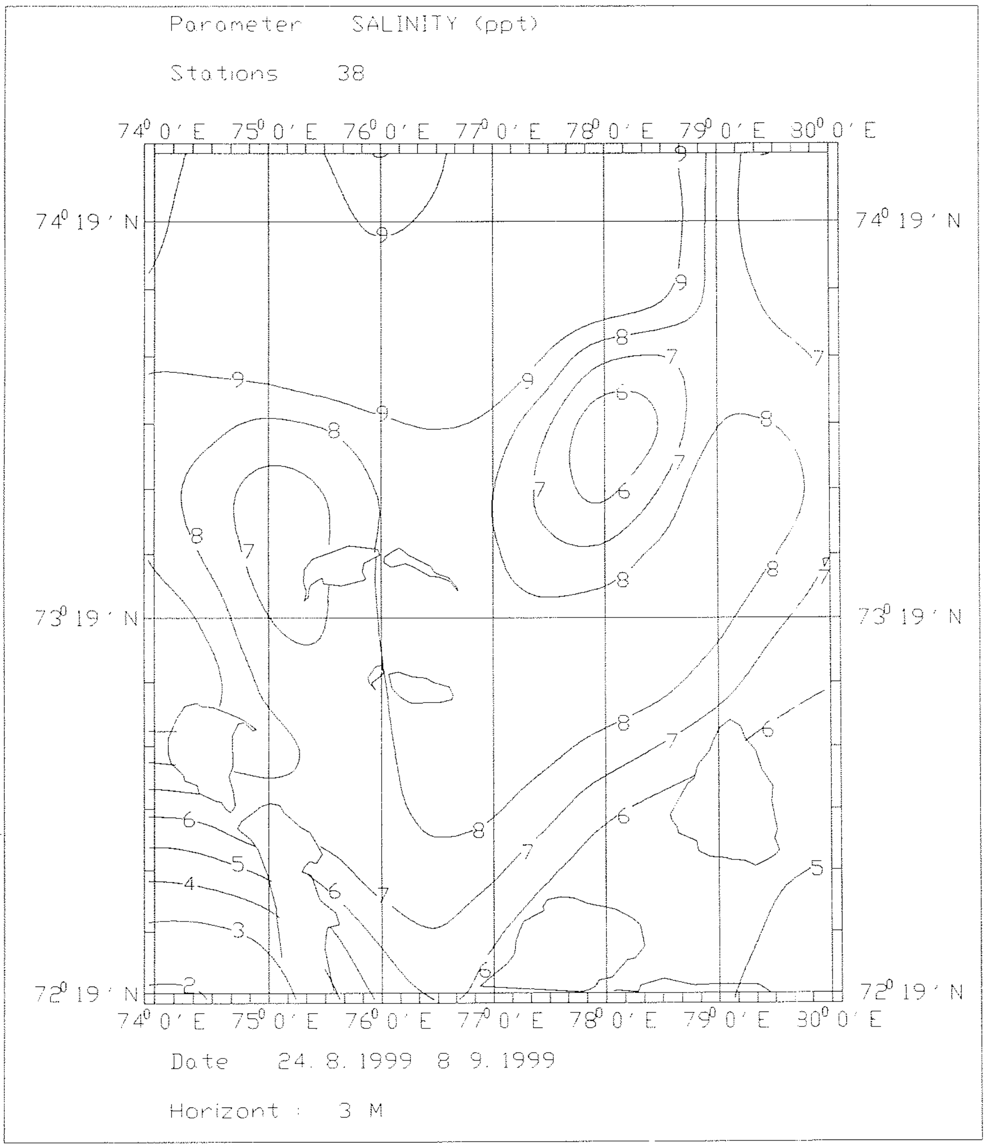
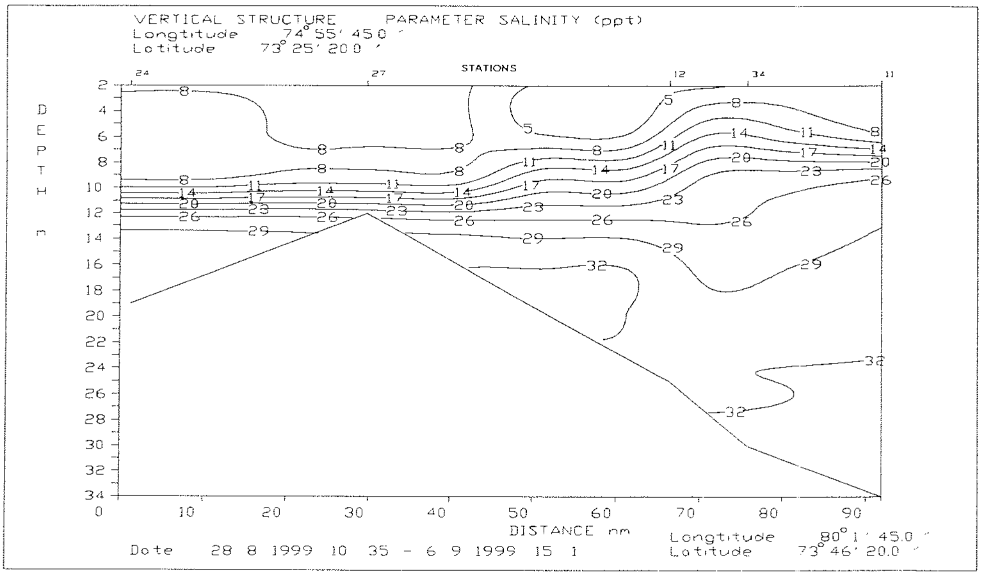
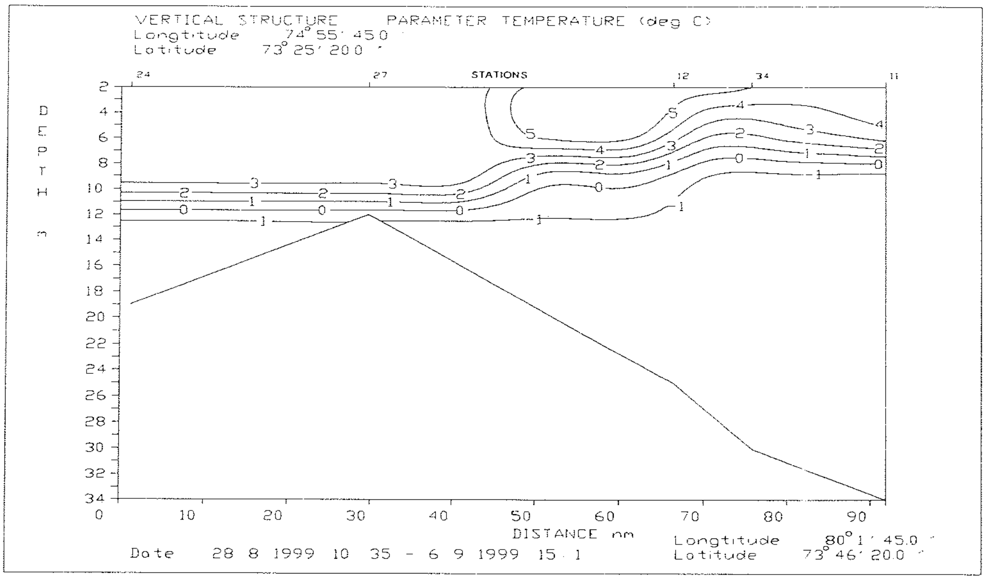


Fig. 4-4
Salinity in 3 m water depth, measured on the 32nd cruise of RV "Akademik Boris Petrov".

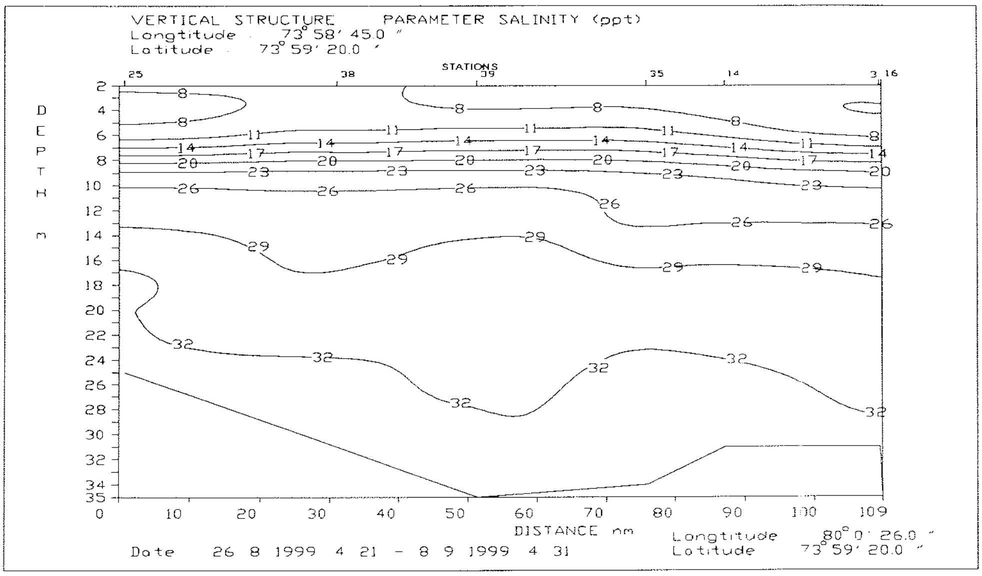


a)

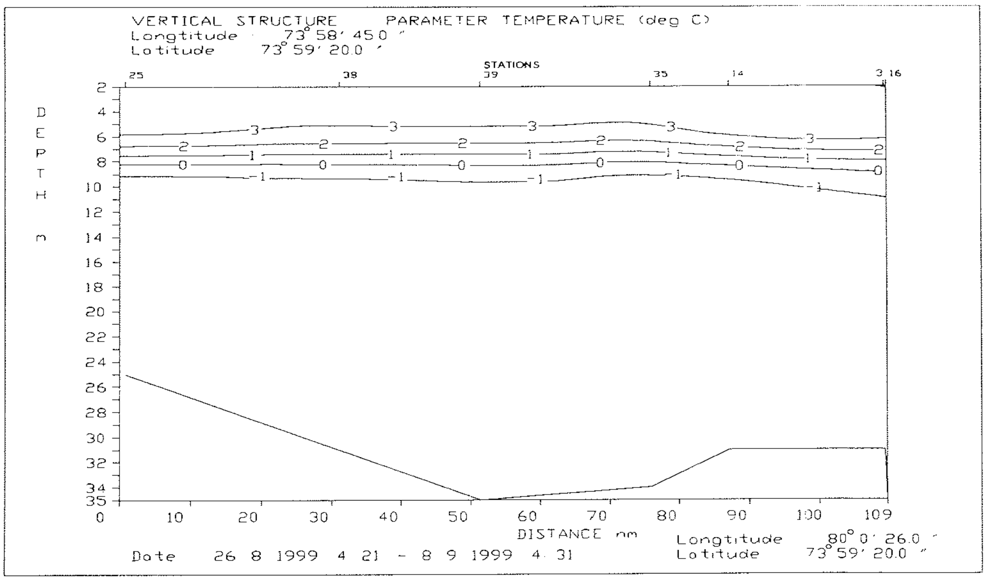


b)

Fig. 4-5
Vertical distribution of salinity (a) and temperature (b) on the southern longitudinal section (73.5° N).

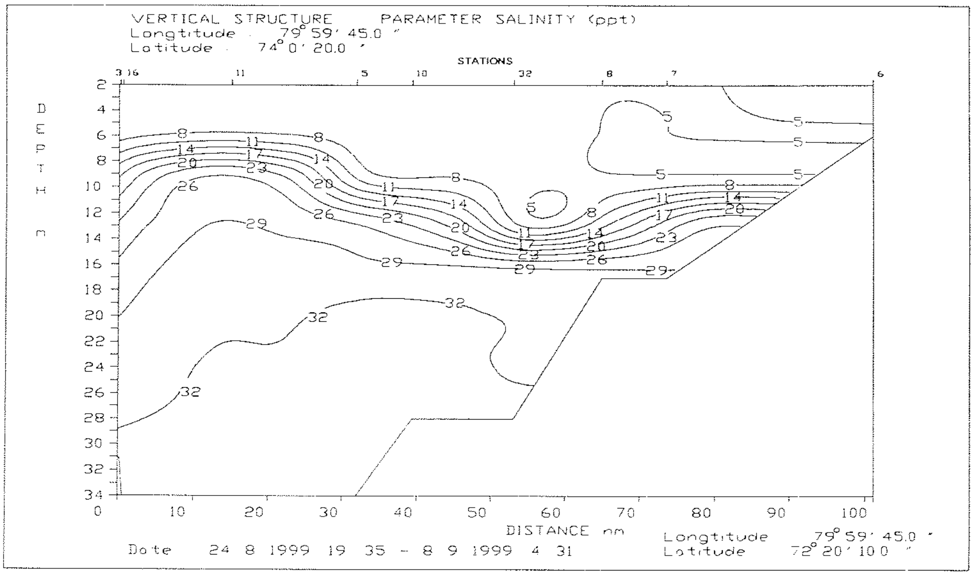


a)

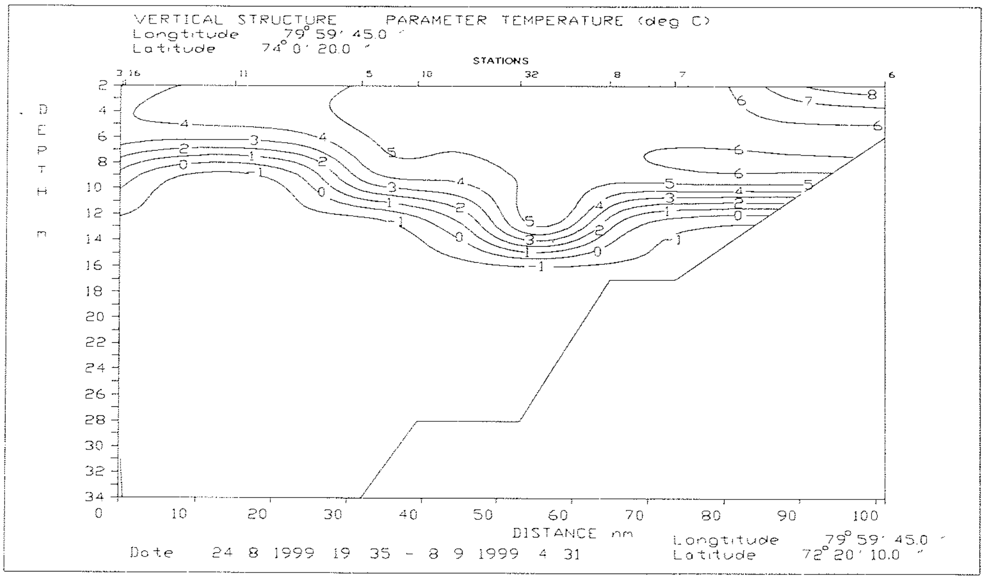


b)

Fig. 4-6
Vertical distribution of salinity (a) and temperature (b) on the northern longitudinal section (74.5° N).

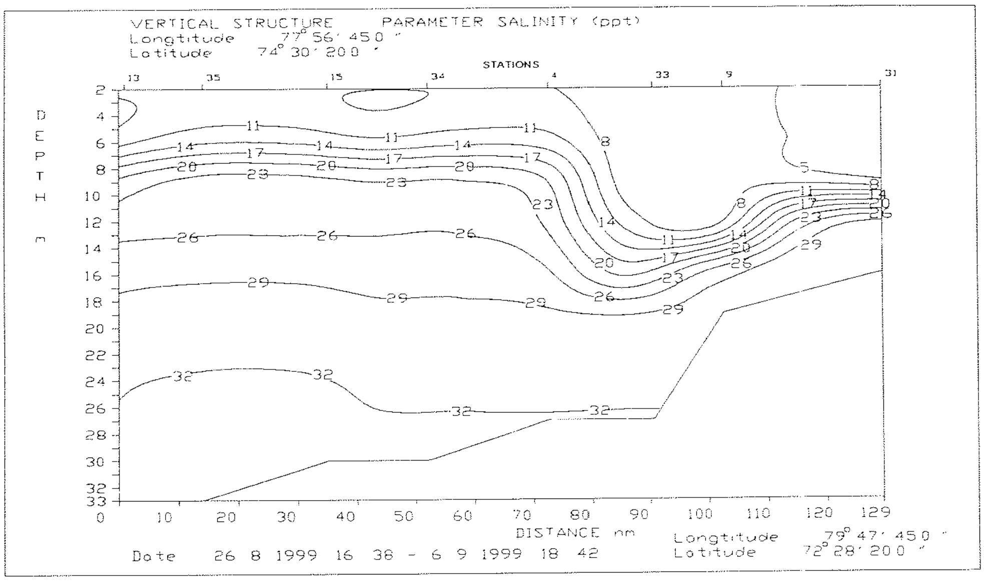


a)

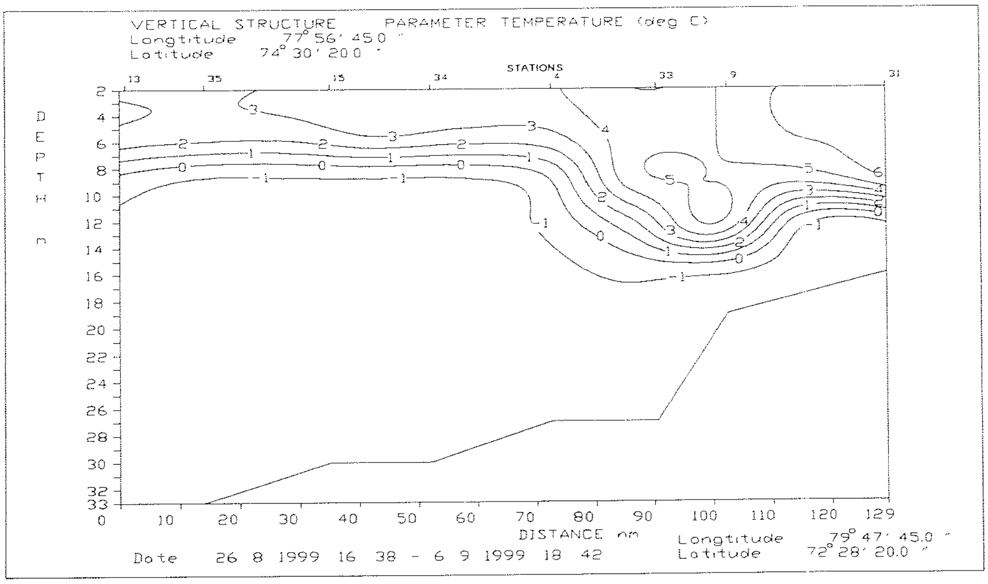


b)

Fig. 4-7
Vertical distribution of salinity (a) and temperature (b) on a meridional section (Yenisei, eastern section).

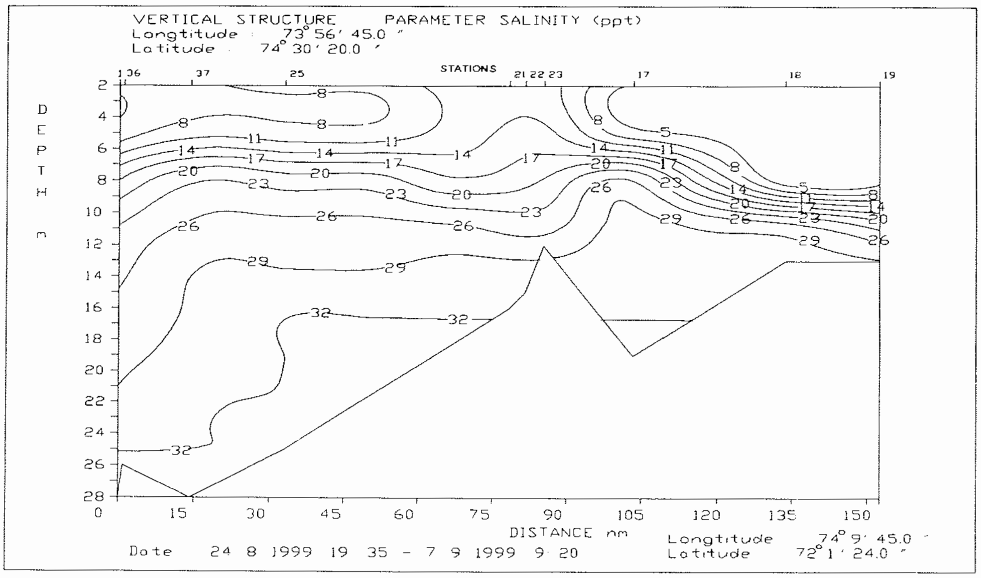


a)

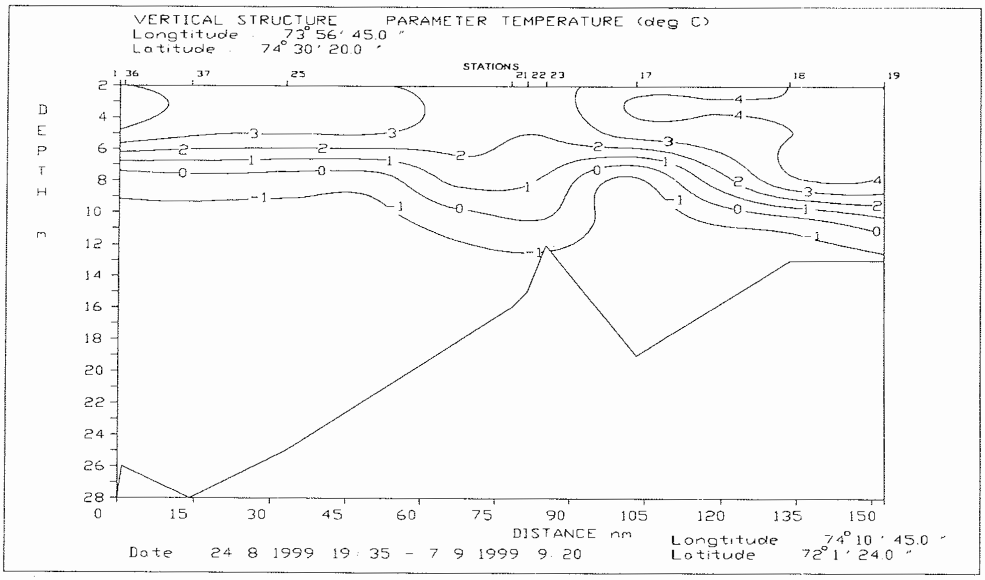


b)

Fig. 4-8
Vertical distribution of salinity (a) and temperature (b) on a meridional section (Yenisei, western section).



a)



b)

Fig. 4-9
Vertical distribution of salinity (a) and temperature (b) on a meridional section (Ob).

At this latitude a frontal zone will probably be formed when the fresh water flow is reduced. The basic features of salinity and temperature distribution in the Ob section (Fig. 4-9) resemble that of the Yenisei section. A frontal zone at 73°N is distinctly present with maximum horizontal gradients of 0.07 ‰/km in salinity and -0.02 °C/km in temperature. The presence of the frontal zones may be tied to the bottom configuration.

T/S-analysis of the data shows that the water masses of the investigated area result from mixing of two water types: deep and intermediate waters of the Kara Sea (S > 20 ‰, T < -0.5 °C) and low saline, relatively warm river waters from Ob and Yenisei (S < 4 ‰, T > 6 °C). Waters with intermediate T/S-values represent a combination of these two water masses, making a further classification of different water types impossible.

4.2 Distribution of surface salinity in the southern Kara Sea, Russia

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[2]Institute for Biogeochemistry and Marine Chemistry, University of Hamburg

Introduction

The two rivers Ob and Yenisei contribute about 35% to the annual river run-off into the Arctic Ocean. This huge freshwater discharge has a dominant influence on the oceanography of the Kara Sea. In order to better understand the hydrological conditions in the study area (Fig.4-10) we conducted a survey of surface salinity, roughly between 72° and 76° N and 70° E and 80° E with the majority of the data points to the south of 74° 30´ N. This survey increased the resolution of salinity measurements taken at the main hydrological stations (see Chapter 4.1).

Samples were taken with a bucket from the side of the ship. Salinity was determined by measuring conductivity using a field instrument (WTW LF 330, conductivity meter). Measurements were carried out in the period between August 22 and September 8, 1999, during which hydrological conditions changed partly due to the decreasing freshwater discharge coming from the two rivers.

Results and discussion

Salinity data are presented as discrete data points (Fig. 4-10) rather than isohalines to account for the strong temporal variations observed during the investigation period (16 days).

The general pattern for the distribution of surface salinity was as expected for an estuarine system with low salinity close to the river mouths and increasing salinity with increasing distance from the shore (Fig. 4-10). The lowest salinity in the study area was observed at 72° 20´ N in the Yenisei estuary (2.6 ‰) and at 72° N in the Ob estuary (0.6 ‰), respectively. The highest surface salinity was detected at approximately 76° N with a value of 21.5‰ (Fig. 4-10).

Overall the observed surface salinity agrees well with long-term mean surface salinity data reported by Burenkov and Vasil'kov (1995). The salinity in the study area was significantly lower around August 25 than in early September (Fig. 4-10). This can best be seen in areas that were surveyed at two different times, like the area at about 74° 30´ N, where the salinity doubled during the first and the second survey. The 5 ‰ isohaline moved almost 2° latitudes southward (74° 30 N – 72° 40´ N) during the sampling period. The 10‰ isohaline was located around 73° 30´ N, consistent with the data from Burenkov and Vasil'kov (1995). In the Ob plume lower salinity values extended further north than in the Yenisei plume (Fig. 4-10). The Ob plume extended approximately along the 74° E longitude reflecting a central pattern as described by Burenkov and Vasil'kov (1995). The strong variation in surface salinity is a result of changing freshwater discharge from the rivers, freezing and melting processes, as well as changing weather conditions. The dominant process in this area, however, is probably the changing discharge, since 60 % of the annual river run-off is discharged within the two summer months June and July.

In conclusion these data are consistent with data from the literature and confirm that Arctic river water extends far to the north having a great influence on the physical, chemical, and biological oceanography of the Kara Sea.

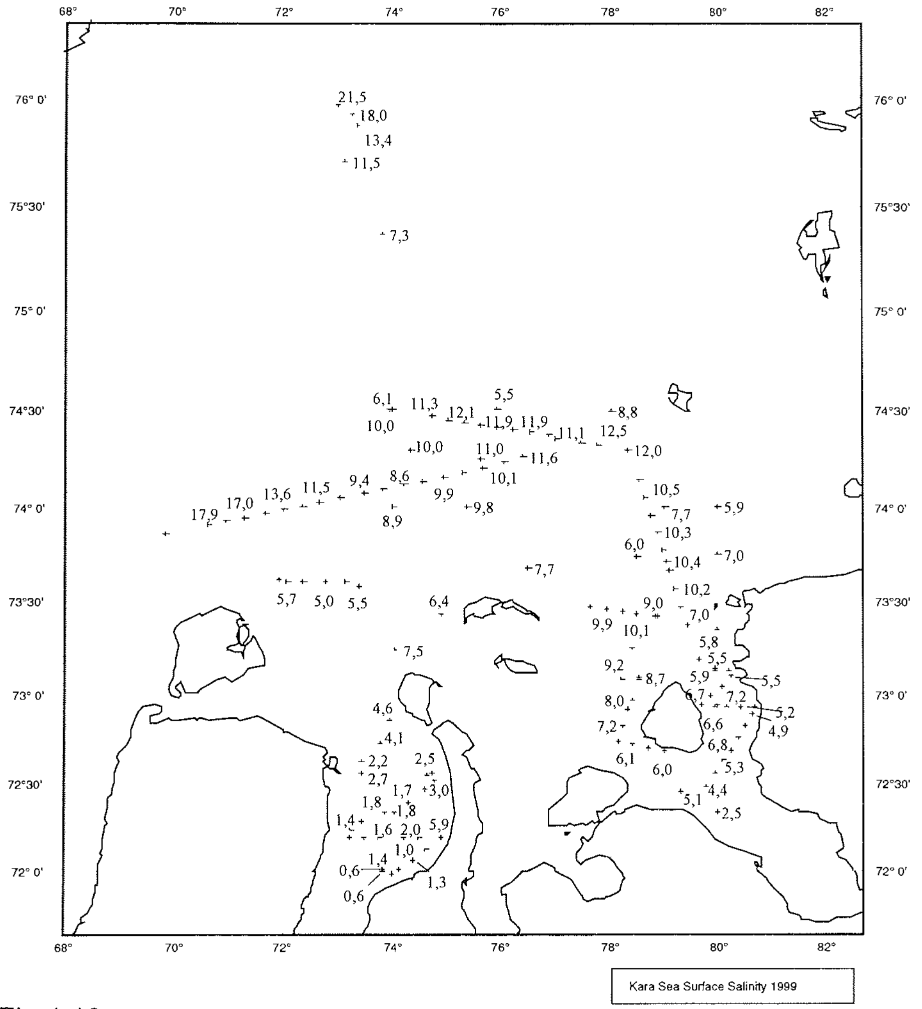

Fig 4-10
Surface water salinity measured during the "Akademik Boris Petrov" Expedition 1999

4.3 Sea water hydrochemistry and nutrients

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The basic hydrochemical water parameters belong to the significant characteristics of marine environments. Concentration and dynamics of the nutrients - dissolved inorganic carbon, phosphates, silicate, and mineral nitrogen compounds - might be effective for the study of biogeochemical activity of organic matter in sea water. At the same time the content and distribution pattern of nutrients affect the biological processes in the water area.

About 80 samples of sea water were taken with Rosette sampler through the vertical profile of the water column on three horizons: surface (2-3m), thermo-pycnocline, and subbottom water (about 2m above the bottom) at 26 stations grouped into two meridional transects along the Ob and Yenisei estuaries up to 74°30' N, and three latitudinal transects within the working area. Six subbottom water samples were taken from the multicorer. In total about 90 water samples were taken, including the fresh water (S = 0,6 ‰) sample at the southernmost station in the Ob transect and the surface water of maximum salinity S = 12,5 ‰ in the northernmost station of the Yenisei transect. Marine water of high salinity (S >31 ‰) was sampled on the subbottom horizons at most stations of the Yenisei transect situated north of 73 °0' N and at some stations of the Ob transect north of 74° N.

Marine water of high salinity invades the Yenisei farther to the south than the Ob. The phenomenon is well supported with hydrochemical data and spatial distribution pattern of phytoplankton.

In total, about 650 hydrochemical measurements were performed onboard "Akademik Boris Petrov". The data of the main hydrochemical parameters of three water horizons along the Ob river - Kara sea transect and Yenisei - Kara Sea transect are listed in Table 4-1. Examples of the distribution pattern of some hydrochemical parameters of surface water are presented in Figures 4-11 to 4-13.

Hydrochemical water parameters in the Kara sea are characterized by pronounced spatial and seasonal variability related to the special features of the hydrology regime which is determined first of all by river discharge, and secondly by water exchange with adjacent basins, ice regime and wind direction and strength.

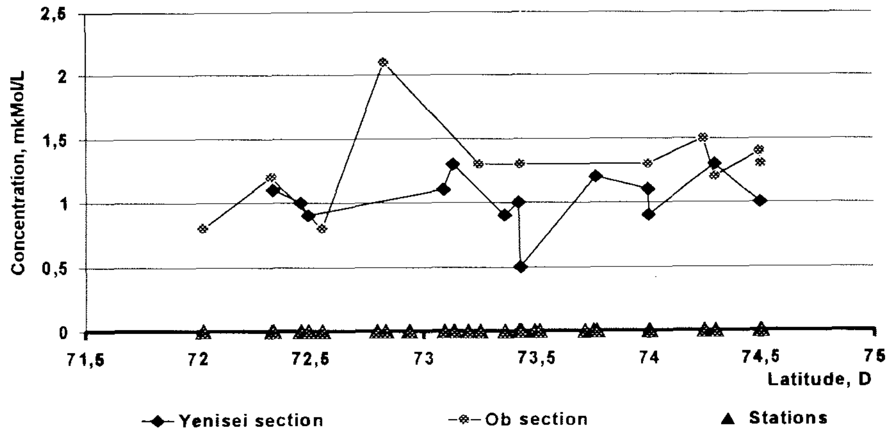

Fig. 4-11
Total alkalinity distribution pattern in surface water along Ob - Kara Sea and Yenisei - Kara Sea transects.

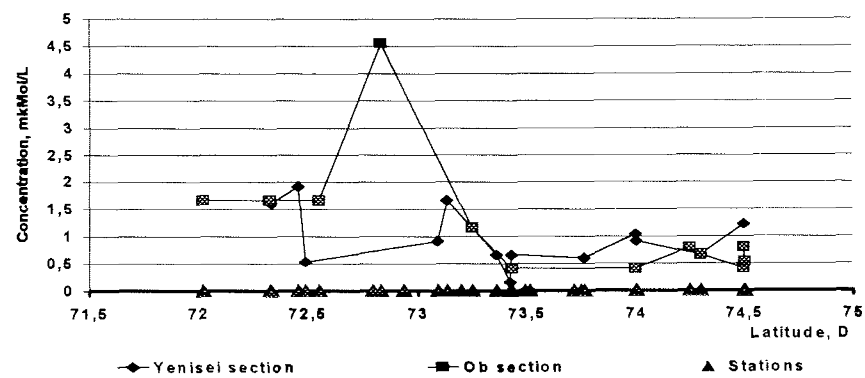

Fig. 4-12
Total phosphate distribution pattern in surface water along Ob - Kara Sea and Yenisei - Kara Sea transects.

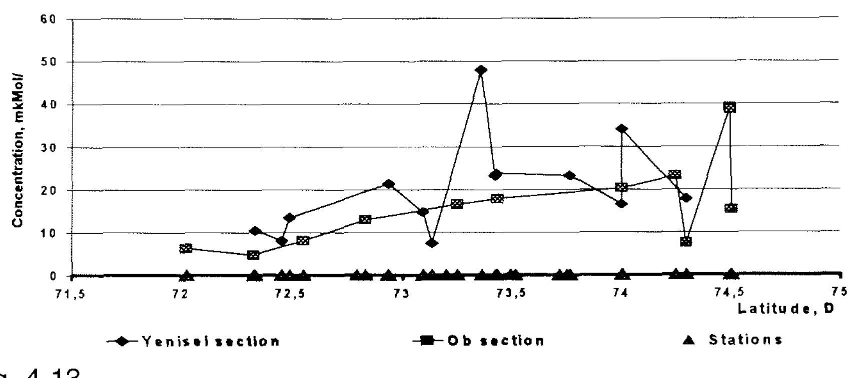

Fig. 4-13
Silicium distribution pattern in surface water along Ob - Kara Sea and Yenisei - Kara Sea transects.

Table 4-1
Concentration ofsea water nutrient elements

Stat.	Depth (m)	Sea water nutrient elements concentration, mkMol/L						pH (NBS)	AlkT, g-eq/L
		phosphate [PO4''' - P]	total phosphate	total organic phosphate	nitrite [NO2'' - N]	nitrate [NO3''' - N]	silicium [SiO3'' - Si]		
1	1,5	0,41	0,41	<0,1	<0,02	0,04	39,15	–	1,4
	6	0,53	0,53	<0,1	0,09	0,23	38,57	–	1,6
	24	0,66	0,78	0,13	<0,02	0,13	14,38	–	2,4
2	3	0,31	0,80	0,49	0,08	0,03	38,57	–	1,3
	7	0,16	2,29	2,13	0,12	<0,02	51,25	–	1,6
	12	0,34	0,66	0,31	<0,02	0,15	28,43	–	2,3
	27,5	0,28	1,29	1,00	<0,02	0,57	18,99	–	2,6
3	3	0,60	0,91	0,31	0,09	<0,02	33,97	–	0,9
	9	0,16	0,53	0,38	0,07	<0,02	25,90	–	1,2
	27	0,53	0,72	0,19	0,03	0,25	18,99	–	2,4
4	3	0,16	0,66	0,50	0,18	<0,02	23,59	–	0,5
	12	0,53	0,72	0,19	0,23	<0,02	33,97	–	1,2
4	18	0,34	0,60	0,25	0,02	0,22	28,20	–	2,4
	27	0,34	0,72	0,38	<0,02	0,33	24,75	–	2,3
6	2	1,60	1,60	<0,1	0,43	<0,02	10,49	–	1,1
8	2	0,78	–	<0,1	0,15	0,08	21,35	7,702	0,9
	12	0,78	–	<0,1	0,03	0,06	12,91	7,804	1,5
	15	0,41	–	<0,1	0,07	<0,02	29,80	7,75	0,9
10	3	0,66	0,66	<0,1	<0,02	0,02	47,90	7,55	1,2
	10	0,53	0,53	<0,1	<0,02	<0,02	46,09	7,54	1,2
	25	1,81	1,85	<0,1	0,11	<0,02	37,04	7,46	2,5

Table 4-1
Cont. 1

Stat.	Depth (m)	Sea water nutrient elements concentration, mkMol/L						pH (NBS)	AlkT, g-eq/L
		phosphate [PO4''' - P]	total phosphate	total organic phosphate	nitrite [NO2'' - N]	nitrate [NO3''' - N]	silicium [SiO3'' - Si]		
11	3	0,03	0,60	0,57	<0,02	0,25	23,16	7,88	1
	7	0,03	0,28	0,25	<0,02	<0,02	28,59	7,78	1,1
	12	0,03	0,63	0,60	<0,02	<0,02	20,15	7,8	2,2
	36	1,03	1,54	0,50	<0,02	0,06	14,72	7,67	2,5
13	2	0,41	1,22	0,82	<0,02	<0,02	21,96	7,63	1,1
13	8	0,41	1,41	1,00	<0,02	<0,02	31,61	7,61	1,4
	15	0,78	1,16	0,38	0,07	<0,02	26,78	7,66	2
	32	1,54	2,23	0,69	0,21	<0,02	22,56	7,53	2,3
15	4	0,60	1,03	0,44	0,11	<0,02	16,53	7,7	1,4
	9	0,72	1,03	0,31	0,11	<0,02	35,84	7,48	1,6
	28	1,29	1,41	0,13	0,15	<0,02	3,43	7,53	2,2
17	2	4,55	4,55	<0,1	<0,02	<0,02	12,91	7,57	2,1
	7	1,91	2,29	0,38	<0,02	<0,02	16,53	7,41	1,8
	16	4,43	4,55	0,13	<0,02	<0,02	24,37	7,52	2,3
18	2	1,22	1,66	0,44	0,36	<0,02	4,76	7,55	1,2
	9	1,22	1,54	0,31	0,32	<0,02	5,24	7,43	0,7
	12	0,91	1,07	0,16	0,03	0,32	28,72	7,33	1,9
19	3	1,66	1,66	<0,1	<0,02	0,08	6,27	7,6	0,8
	10	1,66	1,66	<0,1	<0,02	0,08	9,89	7,7	0,8
19	12	0,91	0,91	<0,1	1,42	<0,02	27,99	7,22	1,9

Table 4-1
Cont. 2

Stat.	Depth (m)	Sea water nutrient elements concentration, mkMol/L						pH (NBS)	AlkT, g-eq/L
		phosphate [PO4''' - P]	total phosphate	total organic phosphate	nitrite [NO2'' - N]	nitrate [NO3''' - N]	silicium [SiO3'' - Si]		
20	3	1,41	1,66	0,25	<0,02	0,06	8,08	7,58	0,8
	6	2,67	2,79	0,13	0,03	0,36	28,59	7,58	2,1
	12	3,80	4,30	0,50	0,03	0,21	29,80	_	2,2
	15	1,79	1,73	<0,1	0,03	0,13	12,60	7,42	0,9
21	3	0,78	1,16	0,38	<0,02	0,04	16,53	7,74	1,3
	10	2,92	2,92	<0,1	0,03	0,65	24,97	7,27	1,9
	15	4,05	4,05	<0,1	0,03	0,29	27,99	7,39	2,2
24	3	0,16	0,41	0,25	0,28	<0,02	17,73	7,78	1,3
	12	0,41	0,66	0,25	0,03	0,71	27,39	7,55	1,6
	19	3,55	3,55	<0,1	0,28	<0,02	39,46	7,48	2,2
25	2	0,28	0,41	0,13	<0,02	<0,02	20,15	7,75	1,3
	9	0,28	0,41	0,13	<0,02	0,17	31,61	7,62	1,4
	15	2,29	2,29	<0,1	0,49	0,05	38,25	7,55	2,3
25	24	0,66	0,66	<0,1	<0,02	0,38	6,31	_	2,3
28	2	0,16	0,16	<0,1	0,03	0,21	23,16	7,69	1
	9	0,28	0,28	<0,1	0,03	0,08	32,22	7,5	1,1
	21	3,80	3,80	<0,1	0,70	0,42	51,53	8,18	2,2
29	2	0,53	0,91	0,38	0,07	<0,02	14,72	7,8	1,1
	10	0,53	0,91	0,38	0,07	<0,02	14,72	7,79	1,1
	15	4,30	4,30	<0,1	1,25	<0,02	38,85	7,73	2,1
30	2	1,16	1,91	0,75	0,03	0,46	8,08	7,68	1
	11	1,03	1,54	0,50	0,03	0,67	6,87	7,63	1,1

Table 4-1
Cont. 3

Stat.	Depth (m)	Sea water nutrient elements concentration, mkMol/L						pH (NBS)	AlkT, g-eq/L
		phosphate [PO4''' - P]	total phosphate	total organic phosphate	nitrite [NO2'' - N]	nitrate [NO3''' - N]	silicium [SiO3'' - Si]		
31	3	0,53	0,53	<0,1	0,03	<0,02	13,51	7,73	0,9
	11	1,16	1,16	<0,1	0,03	0,25	21,96	7,67	1,8
	16	2,42	3,67	1,26	0,03	<0,02	38,25	7,56	2,1
32	2,5	0,41	1,66	1,26	<0,02	0,50	7,47	7,73	1,3
	16	1,41	2,29	0,88	0,32	1,68	19,54	7,65	1,4
32	25	1,79	2,42	0,63	0,30	<0,02	20,75	7,44	2,1
35	3	0,28	0,66	0,38	0,03	1,55	17,73	7,9	1,3
	8,5	0,66	0,78	0,13	0,07	2,44	23,77	7,88	1,7
	32,5	1,41	1,41	<0,1	0,11	0,29	20,15	7,69	2,2
36	3	0,03	0,53	0,50	<0,02	0,57	15,32	7,96	1,3
	7	0,66	0,91	0,25	0,03	0,42	14,11	7,69	1,9
	28,5	1,16	1,16	<0,1	0,13	<0,02	5,06	7,74	2,2
37	3	0,34	0,66	0,31	<0,02	0,38	7,47	7,85	1,2
	8	0,66	0,91	0,25	0,07	0,34	12,30	7,78	1,5
	29	1,54	1,54	<0,1	0,20	0,08	15,32	7,72	2,1
38	2,5	0,03	0,78	0,75	0,03	0,34	23,16	7,82	1,5
	9	0,28	0,91	0,63	0,03	0,50	18,34	7,83	1,9
	29,5	1,16	1,66	0,50	0,24	0,42	21,35	7,74	2,2
1 MUC	0 - 5 sm	1,61	_	_	0,28	_	25,32	_	2,4
1 MUC	10 - 15 sm	1,29	_	_	0,15	_	12,19	_	2,8
	20 - 25 sm	0,96	_	_	0,11	_	18,41	_	2,8
2 MUC	0 - 5 sm	1,03	_	_	0,18	_	22,44	_	2,3
	10 - 15 sm	1,22	_	_	0,13	_	20,14	_	2,5
	20 - 25 sm	1,16	_	_	0,11	_	17,83	_	2,5

5 Sediment Trap Investigations in the Kara Sea

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[2]Alfred Wegener Institute, Bremerhaven, Germany

Introduction

Sediment traps are a powerful tool for the investigation of the vertical particle flux in the ocean which links surface ocean processes with the sea floor. The drawdown of biogenic material from the surface layer to the deep sea and sediments plays a major role in the global biogeochemical cycles of elements such as carbon, nitrogen and silica. The study of the particle flux in the ocean considerably improved our knowledge of the pathways of organic material and is critical for the interpretation of the sedimentary record. Particle flux studies have been carried out in various locations of the world oceans (Lampitt & Antia, 1997 for an overview). Observations in the Arctic Ocean especially over longer periods are scarce due to logistical problems arising from the ice cover in this region. Available data, however, show a wide range of flux rates from only a few mg $m^{-2} d^{-1}$ day in permanently ice-covered regions (Hargrave et al., 1993) up to > 300 mg $m^{-2} d^{-1}$ under the influence of ice-rafted material near the ice edge (Hebbeln & Wefer, 1991). Available data were obtained mainly from deep sea settings. As the vast continental shelves of the Arctic Ocean represent huge depositional environments with relatively high primary production (Subba Rao & Platt, 1984) and act as source areas of sedimentary material to the deep Arctic Ocean, it is crucial to understand the sedimentation processes in these regions.

The Kara Sea forms part of the Eurasian continental margin and receives about one third of the freshwater and more than half of the sediments delivered to the Arctic Ocean via rivers (Pavlov & Pfirman, 1995). Thus, it is a suitable region for studying complex fluvial-induced continent-ocean processes in the Arctic.

Within the first phase of the joint Russian-German pilot study numerous informations on the oceanographic, biological and sedimentological characteristics have been obtained (Matthiessen and Stepanets, 1998; Matthiessen et al., 1999). Due to the strong seasonal variations of environmental parameters such as river runoff (Fig. 5-1), ice-coverage and insolation, it became obvious, however, that an annual record of the particle flux and its seasonally changing composition is necessary to better understand the sedimentary record (Matthiessen & Boucsein, 1999; Boucsein et al., 1999). After the deployment of single cup sediment traps during the cruise of RV "Akademik Boris Petrov" in 1997 it was now possible to deploy two systems with time series sediment traps during the 1999 expedition. This experiment will enable us for the first time to investigate an almost complete annual cycle of particle flux at two locations of the Kara Sea shelf area.

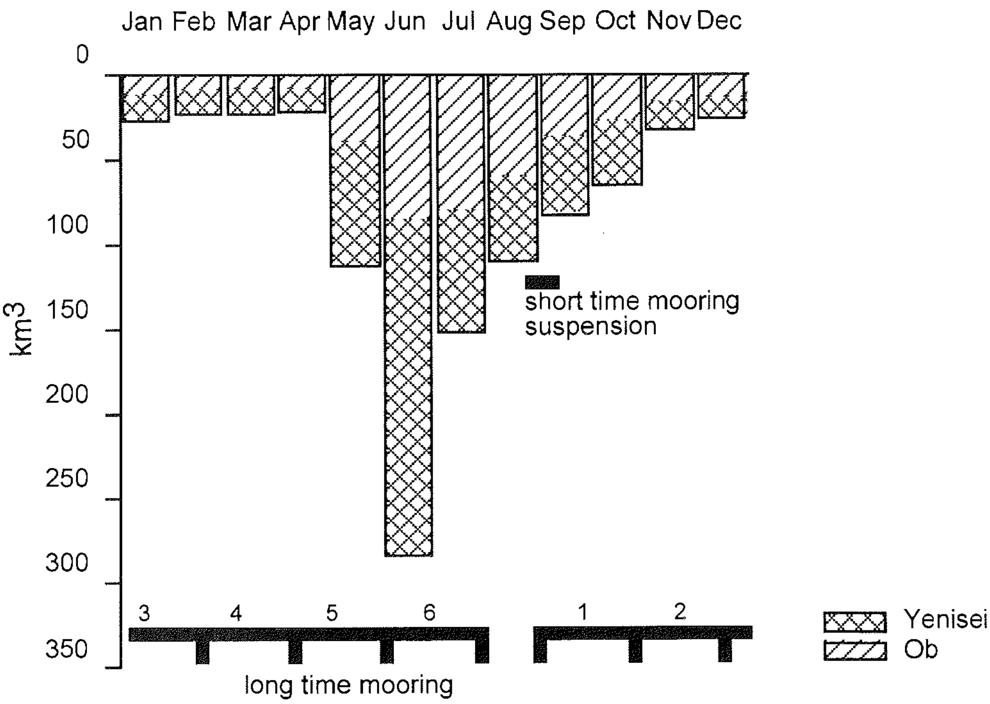

Fig 5-1
Seasonal variability of annual discharge of rivers Ob and Yenisei (Data from Global Runoff Data Centre, Koblenz, Germany) and sampling intervals of short-time moorings and long-time moorings.

Deployment of sediment traps

Within the first days of the working program two sediment trap moorings were deployed north of the Yenisei and Ob estuaries (cf., Fig. 2-2) in order to collect material sinking out of the surface mixed layer to the sea floor. The traps employed in this study were especially designed to be used in shallow shelf waters (Table 5-1, Fig. 5-2). Both systems consist of anchor weight, acoustic release, floating spheres and one multiple sediment trap (Fig. 5-3). The moorings were combined in such a manner that the traps were located approximately 7 m above the sea floor within the high salinity bottom water. In order to avoid degradation and diffusion processes within the cups, $HgCl_2$ and NaCl were added to the cupwater prior to deployment (Table 5-1).

Both sediment traps worked properly and collected sinking particles for the period of 4 (Yenisei) and 12 days (Ob), respectively (Table 5-2). The obtained samples were sealed immediately after recovery and stored cool. Determination of total particle flux, analysis of phytoplankton composition and Corg and total nitrogen contents will be conducted in the home laboratories. Further analysis might be restricted by the low quantity of material obtained during this short-time investigation.

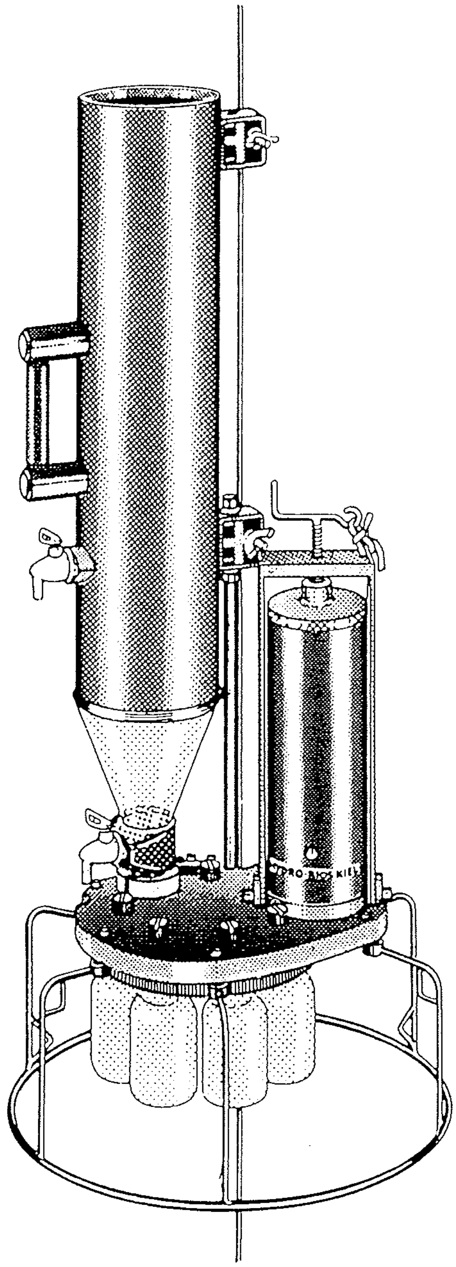

Fig. 5-2
Hydro-Bios Multi-Sediment Trap MST 6

Table 5-1
Technical information about mooring systems

OB RIVER 02

Trap	Hydro-Bios Multi Sediment Trap MST 6, AWI S.N. 37989
Trap Frame	Hydro-Bios Multi Sediment Trap MST 6, AWI S.N. 37988 Energy Source: 2 Lithium Cells 3V, 123 A Armed: Amon/Unger/Neumann
Acoustic Release	Benthos Model 865-A-DB/13, S.N. 769 Energy Source: Lithium Cells for 5-Year-Deployment Receive Frequency 11kHz = Code 3 Enable Code = B Release Code = D Armed: Unger/Neumann/Amon
Cupwater	Filtrated Sea Water ca. 3,3 g $HgCl_2$ / L ca. 35 g NaCl / L

YENISEI RIVER 02

Trap	Hydro-Bios Multi Sediment Trap MST 6, AWI S.N. 37988
Trap Frame	Hydro-Bios Multi Sediment Trap MST 6, AWI S.N. 37989 Energy Source: 2 Lithium Cells 3V, 123 A Armed: Amon/Neumann/Unger
Acoustic Release	Benthos Model 865-A-DB/13, S.N. 772 Energy Source: Lithium Cells for 5-Year-Deployment Receive Frequency 10kHz = Code 1 Enable Code = B Release Code = D Armed: Unger/Neumann/Köhler
Cupwater	Filtrated Sea Water ca. 3,3 g $HgCl_2$ / L ca. 35 g NaCl / L

Table 5-2
Details of short-time mooring systems

	YENISEI RIVER 01	OB RIVER 01
Period of Deployment	26.08. – 29.08.99	24.08. – 07.09.99
Time of Recovery	20.55 Moscow Time	09.30 Moscow Time
Position	Lat. 74° 00' 08 N Long. 79° 58' 63 E	Lat. 74° 29' 94 N Long. 74° 59' 65 E
Water Depth	30.2 m	26 m
Trap Depth	22 mbs	18 mbs
Sampling Intervals	24 hours **1**: 26.8.99, 19.35h – 27.8.99, 19.35h **2**: 27.8.99, 19.35h – 28.8.99, 19.35h **3**: 28.8.99, 19.35h – 29.8.99, 19.35h **4**: 29.8.99, 19.35h – 30.8.99, 19.35h **5**: 30.8.99, 19.35h – 31.9.99, 19.35h **6**: 31.6.99, 19.35h – 01.9.99, 19.35h	48 hours **1**: 25.8.99, 03.55h – 27.8.99, 03.55h **2**: 27.8.99, 03.55h – 29.8.99, 03.55h **3**: 29.8.99, 03.55h – 31.8.99, 03.55h **4**: 31.8.99, 03.55h – 02.9.99, 03.55h **5**: 02.9.99, 03.55h – 04.9.99, 03.55h **6**: 04.9.99, 03.55h – 06.9.99, 03.55h
Rotation	according to program recovered on cup 4	according to program recovered on open hole
Remarks	During first interval sediment sampling at the same station. Loss of material from cup 4 during recovery can not be excluded.	Sediment trap and floating balls got entangled during recovery. Trap was damaged: Holding rod and fixation plate (see manual) were broken.

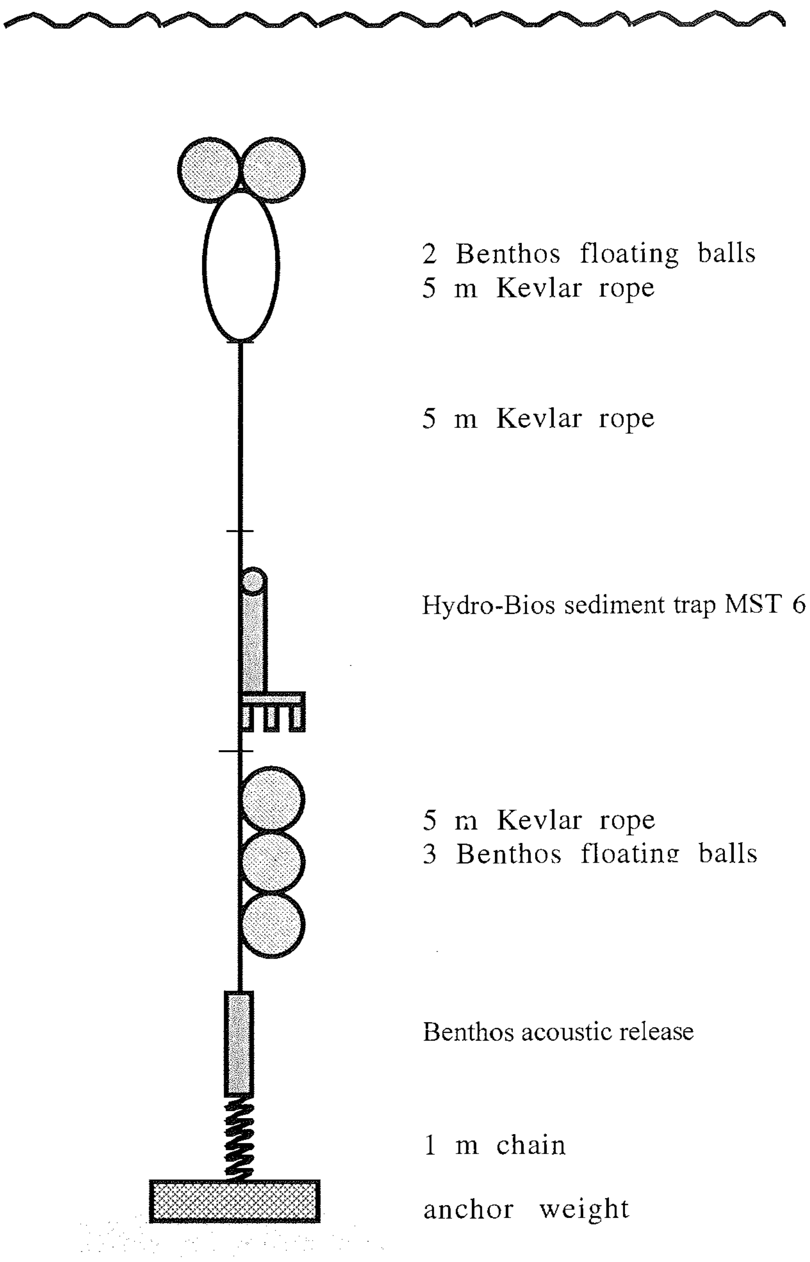

Fig. 5-3
Scheme of the sediment trap moorings

After recovery both moorings were redeployed at approximately the former positions (Table 5-3). They were programmed to collect sinking particles in intervals of 55 (Yenisei) and 54 (Ob) days, respectively. Additionally to the above mentioned analyses, much more detailed studies will be performed after recovery of the sediment traps in 2000. The sediment trap material will be split and jointly studied according to the agreement between the Vernadsky Institute and AWI and within the framework of the joint Kara Sea project by scientists from the Vernadsky Institute, AWI, and the Institute of Biogeochemistry and Marine Chemistry (IFBM). The studies to be performed at AWI include biological investigations (e.g., plankton composition and biomass), organic geochemical studies (e.g., specific biomarkers such as *n*-alkanes, fatty acids, steroids), sedimentological investigations (quantification and characterisation of sediment flux; clay minerals) as well as micropaleontological studies (dinoflagellates, pollen, spores etc.). Determinations of POC, PON, biogenic opal as well as amino acid, amino sugars, and carbohydrates will be performed at the IFBM. The other investigations (for example, radionuclides, stable carbon isotopes, etc.) will be performed at the Vernadsky Institute.

Table 5-3
Details of long-time mooring systems

	YENISEI RIVER 02	OB RIVER 02
Date of Deployment	29.08.1999	07.09.1999
Position	Lat. 74° 00' 284 N Long. 80° 00' 723 E	Lat. Lat. 74° 00' 284 N Long. 80° 00' 723 E
Water Depth	31.1 m	30.5 m
Trap Depth	23 mbs	22.4 mbs
Sampling Intervals	55 days (rotation at 00.50) **1**: 30.08.1999–24.10.1999 **2**: 24.10.1999–18.12.1999 **3**: 18.12.1999–11.02.2000 **4**: 11.02.2000–06.04.2000 **5**: 06.04.2000–31.05.2000 **6**: 31.05.2000–25.07.2000	54 days (rotation at 12.20) **1**: 07.09.1999–31.10.1999 **2**: 31.10.1999–24.12.1999 **3**: 24.12.1999–16.02.2000 **4**: 16.02.2000–10.04.2000 **5**: 10.04.2000–03.06.2000 **6**: 03.05.2000–27.07.2000

First results

The results of a first visual inspection of the composition of the samples obtained from short-time moorings are summarized in Table 5-4. The faecal pellets intercepted in the traps were mainly produced by Larvacea with only minor contribution of copepod pellets. It is likely that most of the zooplankton individuals entered the trap cups actively/alive while descending in the water column and died after contact with the poisened cup water. Thus they do not contribute to the vertical particle flux and it appears that faecal pellets were the main vehicles of material transfer to the sea floor during the investigated period. The massive occurrence of Larvacea at the Ob station might be connected to the supply of large amounts of fluvial algal matter (mainly Chlorophycea) on which the Larvacea possibly feed. In contrast to this the material delivered by the Yenisei river seemed to be of lower nutritional value due to the high content of lithogenic clastics.

Table 5-4
Composition of samples obtained from short-time moorings (cf. Table 5-2).

OB

sampling intervals of 48 hrs

1-1	Larvacea, gelatinous housings of Larvacea, Ctenophora, faecal pellets
1-2	Larvacea, 1 carnivor amphipod, 1 Calanus hyperborens
1-3	Larvacea, 1 carnivor amphipod
1-4	Ctenophora (Pleurobrachia sp.), Larvacea, 1 Calanus hyperboreus
1-5	Larvacea, faecal pellets
1-6	Larvacea, faecal pellets, 1 Limacına sp. (Pteropod)

YENISEI

sampling intervals of 24 hrs

1-1	Larvacea, many faecal pellets
1-2	Larvacea, faecal pellets
1-3	Larvacea, faecal pellets
1-4	faecal pellets only

6.1 Phytoplankton of the Ob and Yenisei transects

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Phytplankton algae communities are primary producers of organic matter in marine environments. They are of special interest for isotope organic geochemistry because the carbon isotope composition of the phytoplankter biomass is inherited by sedimentary organic matter. Up to now, data on the carbon isotope composition of the phytoplankton in the Kara Sea are absent. Thus, one of the main goal of the expedition was to get samples of phytoplankton for isotope studies.

About 20 samples of phytoplankton were collected for isotope analysis. The green and diatomic algae have been separated from each other in some samples by filtration of the water samples through two hand nets with a pore size of 90 and 10 µm and selective decantation.

71 phytoplankton samples were collected on 3 horizons of the water body and prepared for microscopic observation, 19 water samples for chlorophyll measurement, and 42 plankton samples from the total water mass from the bottom to the surface for zooplankton investigation.

Significant differences were determined in the phytoplankton species composition between the Ob and Yenisei transects. In the Ob gulf the fresh water green and diatomic algae were dominant in the community, with the green *Rhizoclonium* (presumable!) or another closely related genus from the fam. *Ulotrichaceae* being predominant. *Asterionella formosa* and *Cyclotella sp.* were prevailing among diatomic algae. The proportion of the above mentioned algae species in the community decreased towards the open sea, and a marine *Thalassiosira* appeared, getting predominant in the northernmost station of the Ob transect.

Another situation was observed in the Yenisei transect. The typical spring algae community were represented by marine diatoms exclusively, with the genus *Thalassiosira* being predominant (up to 80%). Species composition of the community varied smoothly from the open sea to the shore.

In August-September 1999, a microalgae spring bloom was observed in the study area. It was getting reduced in the Ob, whereas in the Yenisei an earlier stage of the bloom was observed due to later ice thawing this year.

6.2 The Distribution of Zooplankton in the Kara Sea

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Introduction

The two big rivers systems Ob and Yenisei discharge high amounts of organic carbon into the Kara Sea. This carbon, mainly referred to as detritus, may serve as an important food source for many planktonic species that live in the rather oligotrophic adjacent ocean regime. Within the planktonic community copepods have the biggest share. They are a very important group within the marine ecological foodweb because they are seen as a significant link between the primary production and secondary consumers (e.g. fishes, chaetognaths etc.). Their very first stages (nauplii and copepodits) are a substantial food source for juvenile fishes and therefore may strongly influence the fishery recruitment.

One aim of this investigation was to gather information about the composition of the mesozooplanktic community and distribution of species along the salinity gradient from the inner estuaries of the Ob and Yenisei rivers to the more marine influenced outer areas. Not only the horizontal aspect, however, is taken into account, also the vertical distribution of species was investigated.

The utilisation of carbon from the upper water layers by planktonic animals and their production of faecal pellets may enhance the transfer of organic carbon to the lower water layers and make it therefore (directly ?) available for bottom living, benthic animals. Here of special interest is the role of zooplankton in the transformation of organic matter. It is still highly unknown to which degree the animals from the marine layers can utilise the river-born detritus as a food source. From in-situ faecal pellet production we expected information about the current feeding situation which should (and may) contribute to a better understanding of the overall diet of the single species. In addition in-situ egg production will give us an insight into the efficiency of energy exploitation as well as actual maturity state of adult females.

As a result of the high freshwater input from the rivers a highly stratified water column is established. This may act as a barrier especially for marine species to utilise the carbon from the detritus-rich, less saline layers. Also brackish water species that inhabit the upper water layers may be able to enter the more marine milieu. They may - mainly via the production of faecal pellets - enhance the amount of carbon that is imported into the lower water layers. Therefore it is an important aspect to investigate the tolerance (of species) to low or high salinities, respectively.

Material and Methods

Sampling

At 25 stations zooplanktonic samples were taken with a Nansen closing net (Fig. 6-1). The net had a mesh size of 150µm and was hauled vertically with a speed of about 0.5 m s^{-1}. According to the water layers four net hauls were taken at every station: two below and two across and above the pycnocline, respectively. One haul from each layer was preserved and the animals stored in 4% borax-buffered formaline. The remaining two catches were used for visual observation and for sorting of living animals for experiments. At very shallow stations (< 10 m) a short net of 1m total length and a mesh size of 150 µm was used. Since this net could not be closed only two samples through the total water column were taken at those stations (Table 6-1)

Experiments

The animals for all of the following experiments were identified with help of a Wild M8 Stereomicroscope (20-80 x magnification). If not differently noted all animals were stored in 0,45 µm-filtered sea- or brackish water (6 ‰), respectively.

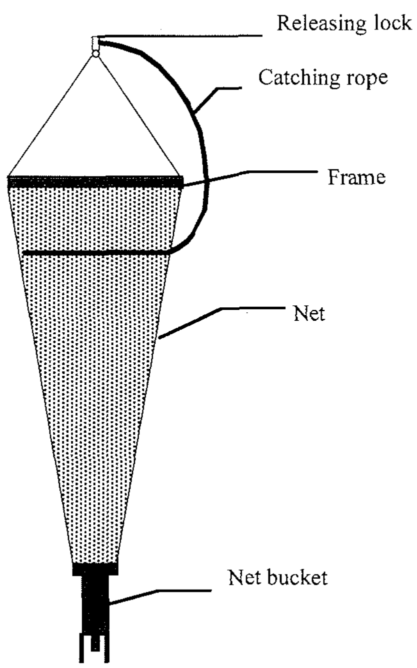

Fig. 6-1
Nansen closing net

Table 6-1
Zooplankton sampling stations

Date	Station	Lat	Lon	Depth [m]	Pycnocline [m]	Sal/Temp [psu/°C] (Surface)	Sal/Temp [psu/°C] (Bottom)	Nets	Sample depth [m]	Experiments*	Comments
25. Aug	BP 99-01	73° 59,45' N	74° 30,40' E	27	6-11	6/3,9	31/-1,8	4	20-11; 11-0		
	BP 99-02	74° 30,04' N	75° 55,63' E	29.6	7-8	5,5/4,1	29,3/-1,9	4	20-8; 8-0		
26. Aug	BP 99-03	73° 48,88' N	79° 59,48' E	31.7	8-10	5,9/3,7	30,6/-1,7	4	30-10; 10-0	EP, FP	
27. Aug	BP 99-06	72° 17,14 N	80° 01,88' E	6.5	5-6	2,6/6,6	3/6,6	2	5-0		Short net used due to low Pycnoline
	BP 99-08	72° 55,77' N	79° 59,38' E	21.5	11-13	4,7/5,9	29/-1,3	4	18-13; 13-0	EP, FP	
28. Aug	BP 99-11	73° 46,37' N	79° 59,22' E	36	5-8	7,0/3,1	33,2/-1,5	4	30-8; 8-0	S, EP, FP	
	BP 99-12	73° 45,56' N	78° 28,81' E	25	7-15	4,6/4,5	31,5/-1,3	4	23-15; 15-0		
29. Aug	BP 99-13	74° 29,84' N	78° 00,00' E	35.5	8-10	8,8/4,4	33,1/-0,6	4	30-10; 10-0	EP, FP	
30. Aug	BP 99-17	72° 51,44' N	73° 56,44' E	19	6-8	5,3/3,6	29,9/-1,2	4	19-8; 8-0		
31. Aug	BP 99-18	72° 19,98' N	74° 00,00' E	15.3	7-8	1,7/4	26/-0,4	4	14-8; 8-0	EP, FP	Pycnocl. not stable, oszilating down to 9m
	BP 99-19	72° 11,34' N	74° 11,15' E	13.8	9-11	1,9/2,5	11/0,6	2	11-0		Short net used due to low Pycnoline
01. Sep	BP 99-20	72° 30,81' N	74° 43,90' E	16.3	12-13	2,8/3,9	27,7/0,1	2	15-0		Short net used due to low Pycnoline
02. Sep	BP 99-21	73° 14,79' N	74° 02,01' E	16	8-10	7/3,5	23,5/-1,4	4	15-8; 8-0	EP, FP	
	BP 99-22	73° 26,03' N	74° 52,26' E	20	10-12	6,4/3,6	29,5/-1,4	4	19-12; 12-0		
03. Sep	BP 99-25	74° 00,06' N	73° 59,76' E	26,4	7-12	8,9/3,4	32/0,1	4	25-12; 12-0		
	BP 99-26	74° 00,00' N	75° 21,62' E	~31	??	9,7/4,4	32,1/-0,2	4	26 (~140l); 3,5 (~150l)		Storm !! No net samples could be taken
04. Sep	BP 99-28	73° 25,40' N	78° 48,73' E	23,3	7-8	8,8/3,2	28/-1,4	4	21-8; 8-0		
	BP 99-29	73° 05,52' N	78° 30,79' E	16,7	9-11	8,7/3,4	26,9/-1	4	16-11; 11-0	S, EP, FP, D	
05. Sep	BP 99-30	72° 27,45' N	79° 17,95' E	13,7	11,5-12	5,3/5,5	13/3,9	2	13-0		Short net used due to low Pycnoline
	BP 99-31	72° 29,16' N	79° 45,66' E	16,9	11-13	4,4/5,8	29,6/-1,1	2	15-0		Short net used due to low Pycnoline
06. Sep	BP 99-32	73° 08,07' N	79° 57,24' E	27,4	13-17	5,9/5,3	31,1/-1,5	4	25-17; 17-0		
	BP 99-35	74° 18,05' N	78° 20,04' E	33,5	7-11	12,1/2,9	33,3/-1,3	4	32-11; 11-0		
07. Sep	BP 99-37	74° 18,03' N	74° 20,05' E	29,7	7-8	9,8/2,9	32,3/-1	4	28-8; 8-0		
	BP 99-38	74° 15,00' N	75° 36,34' E	30,3	7-9	11,1/3,1	32,2/-0,3	4	29-9; 9-0		
08. Sep	BP 99-39	74° 17,92' N	76° 49,88' E	37,8	7-9	10,6/2,9	33/-0,8	4	35-9; 9-0	FP, D	
S = 25 Stations				Min = 6,5m Max = 37,8m		Min = 1,7/2,5 Max = 12,1/6,6	Min = 3/-1,9 Max = 33,3/6,6				

* S = Salinity tolerance experiment
EP = In-situ egg production
FP = In-situ faecal pellet production
D = Detritus feeding experiment

(1) In-situ faecal pellet production experiments

Both copepodite stage V and females of *Calanus* spp. and *Limnocalanus macrurus* were kept individually in Cell Wells® (Fig. 6-2). After 24 hours incubation at about 4°C, the pellets were removed from the cells with an Eppendorf glass pipette, fixed in Lugol solution and stored cool.

Since very few pellets were produced, about 100 individuals of *L. macrurus* were kept in a 2l beaker with a 300 µm net insertion (Fig. 6-3). After 24 hours the pellets were concentrated on a 50 µm screen and stored in Lugol solution. At the home laboratory the preserved pellets will be closer examined with SEM in order to get more information about the dietary uptake of the copepods.

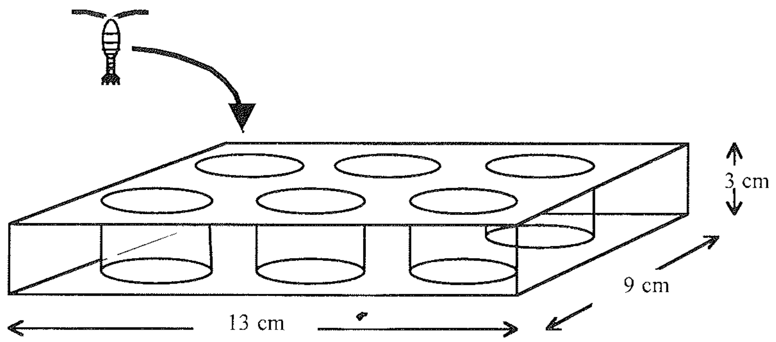

Fig. 6-2
Cell Wells® used for In-situ egg and faecal pellet production

(2) In-situ egg production

Mature females of *Calanus* spp (if available), *L. macrurus* and *Drepanopus* spp. were incubated for several days at about 4°C in Cell Wells®. Every 24 hours the cells were checked for eggs. Eggs were then counted.

(3) Feeding experiments

Animals from experiment (1) were fed with detritus-rich surface water from the Ob river estuary. Since the surface water was less saline than the water the animals were collected in, an ambient amount of artificial marine salt was added. Salinity was measured with a temperature compensated WTW LF 330 Salinometer. Every 24 hours the cells were checked for pellets. The pellets were removed from the cells and stored in Lugol.

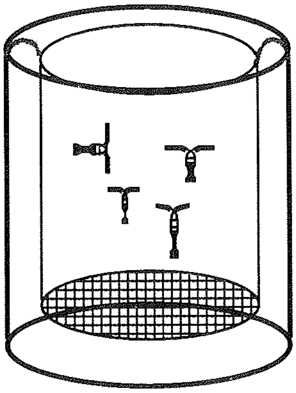

Fig. 6-3 Beaker with net insertion

(4) Salinity tolerance experiments

All species and stages of a catch were split up into eight equal portions and filled in 250ml beakers. After an incubation time of 24 hours the initial salinity was estimated and all beakers were searched for dead or damaged animals. Two of the beakers were chosen as controls to estimate the "natural" mortality caused by the experimental device. During the time the experiment was conducted, the two controls were left in their original state while the salinity of the other six beakers were altered.

Two experiments were conducted:

a) animals from upper, brackish layer (Station 11) were taken and confronted in increasing steps of 5 ‰ to more saline water. At this station the initial salinity was 10 ‰. The experiment was terminated when 40 ‰ was reached.
b) animals from a lower, marine layer (Station 29) were chosen. In this sample both typical marine and brackish water species were present. Since the initial salinity was about 20 ‰, 3 of the beakers were used to check for low salinity and the remaining 3 for high salinity tolerance. Also here the animals were exposed to a dilution respectively increasing series in steps of 5 ‰. The experiment was terminated when a salinity of 0 ‰ and 40 ‰, respectively, was reached.

Every 24 hours the beakers where checked. Dead animals where removed and preserved in 40% alcohol. They will be used for further examination in the home laboratory to gather information about the salinity tolerance of the single species and stages, respectively. After checking the beakers and removal of the dead animals, the copepods were put into higher/lower saline water. At the end of the experiment all surviving animals were preserved in alcohol to estimate the relative death rate for every species individually. This is necessary since the absolute number of animals and the composition of species in each beacon is not known.

Results and Discussion

At first view it seems that the composition of the planktonic community is much less diverse than during the 1997 expedition that was conducted in nearly the same area. The most dominant species that was present at almost all stations was the copepod *Limnocalanus macrurus* (Fig. 6-4).

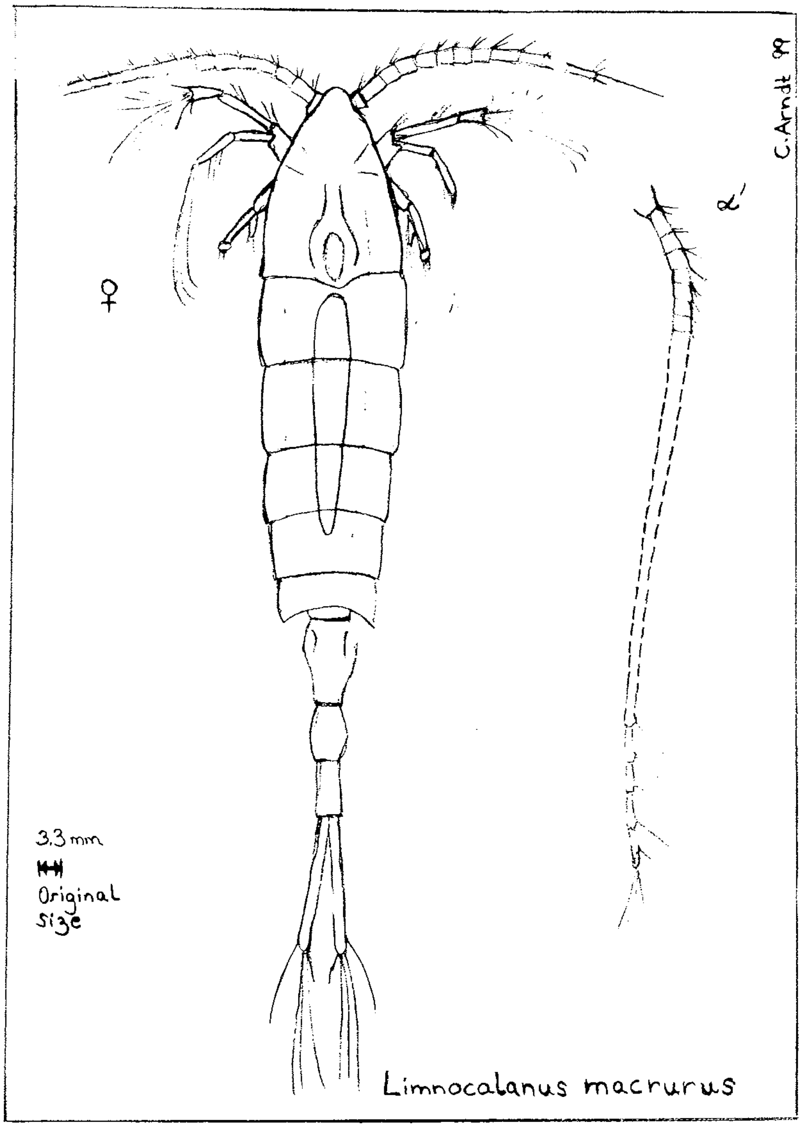

Fig. 6-4
Drawing of *Limnocalanus macrurus* (Hand-drawing by Carolin Arndt)

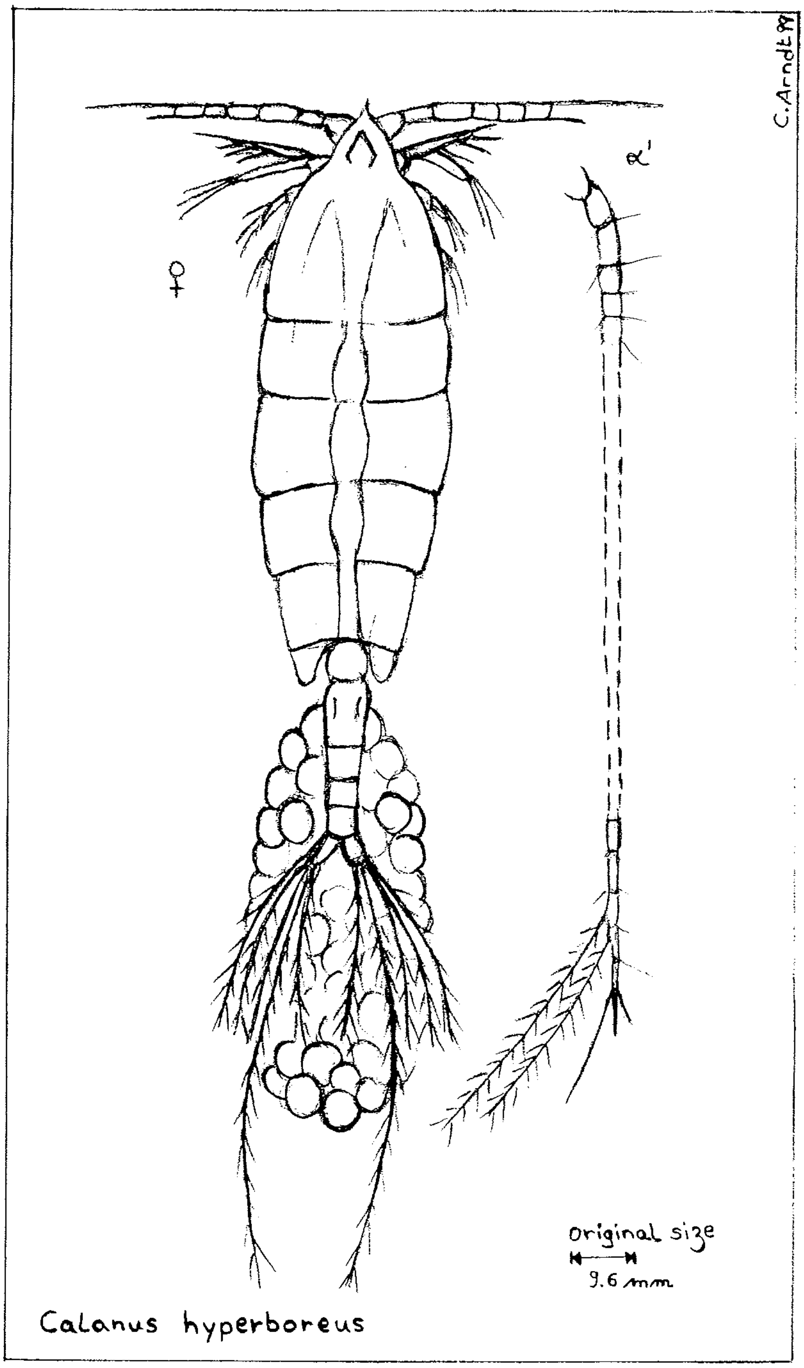

Fig. 6-5
Drawing of *Calanus hyperboreas* (Hand-drawing by Carolin Arndt)

Along the river plume transect a gradual change from limnic-brackish to a more marine species composition was detected. While the inner parts of the estuaries were mainly characterised by typical freshwater species, e.g. *Cyclopina* spp., in the more marine influenced deeper parts (>20 m depth) big calanoid species such as *Calanus hyperboreus* (Fig. 6-5) and *C. glacialis* were found. The marine shallower parts were strongly influenced by the smaller calanoid forms, e.g. Para-/Pseudocalanus spp. (Further species identification will be done at AWI from formalin-preserved samples). The hauls of the upper layers between the river plumes showed mostly true brackish water species like *Drepanopus* spp. (Brodskii 1967, Dussard & Defay 1995) and *Limnocalanus macrurus*, which in the literature (e.g. Brodsskii 1967, Sars 1903) is referred to as a freshwater species.

Interestingly juvenile stages of copepods (Copepodites) were very rarely found. Only few were present at the inner parts of the Ob estuary. Most of them seem to belong to *L. macrurus*.

The estuaries of Ob and Yenisei were extremely different concerning species diversity and abundance. In the Yenisei estuary only *L. macrurus* was present. In addition many juvenile Euphausiacea were found. The Ob estuary was characterised by a phytoplankton bloom of the Chlorophycea *Oedogonium* sp. and the diatom *Astrionella* spp. (pers. comm. Victor V. Larionov, 1999). In contrast to the Ob, the estuary of Yenisei was strongly influenced by high terrigenous input.

Neither *Limnocalanus macrurus* nor *Calanus glacialis* produced any faecal pellets during our experiments. To estimate whether deeper living marine species like *C. glacialis* are able to utilise the detritus from the enriched upper water layers, showed that here no faecal pellets were produced, too. This indicates that the detritus cannot be used by those species as a food source. Here in both cases more detailed long-term experiments would be necessary. A more detailed analysis of the diet will be done from gut contents of the preserved animals.

During our in-situ egg production experiments with the two species *C. glacialis* and *L. macrurus* no eggs were produced. Closer examination showed that the gonads of *C. glacialis* and *L. macrurus,* though fully developed, were not in the state of spawning yet. Sars (1903) remarked that *L. macrurus* may propagate during the winter months, which is in contrast to the observation that juveniles of *L. marcrurus* were found in the Ob estuary during our study. Only fertile females of *Drepanopus* spp. showed a rich egg production. Here, as mentioned earlier, the fixated material will give further information.

The first results concerning salinity tolerance of the most common species in the sampling area showed that the big Calanoid species are rather sensitive to salinity changes and tolerate only moderate changes down to about 20 ‰. More tolerance was shown by *Para-/Pseudocalanus* spp. and *Drepanopus* spp. This is in good accordance with the literature since Para/Pseudocaloiids are known as fully marine species (see e.g. Sars 1903, Dahl 1928, Brodskii 1967) while *Drepanopus* spp. is referred to as a truly brackwater species (see above). Only *L. macrurus* which is known as limnic species, seems to tolerate the full range of salinity offered: they were highly active from 5 ‰ up to 35 ‰.

They survived even 40 ‰ saline water but were then very lethargic. This indicates that it is not salinity that restricts their distribution within the river plumes. Sars (1903) characterised this species, which he only found in the bigger Norwegian lakes, as a relict marine form which may explain its high tolerance to high saline water.

6.3 Species composition and distribution pattern of the macrozoobenthos of the southern Kara Sea

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Introduction

The structure, dynamic and composition of polar benthic communities are influenced by the amount of organic matter produced during the short summer season. Certain factors including the Arctic light regime, the ice condition and the freshwater input from the large Siberian rivers are important in regulating the biological production and the following turnover and decomposition processes. The function of this "pelagic-benthic coupling" under Arctic conditions and the relevance of organic material transported by the large Eurasian rivers Ob and Yenisei concerning the benthic production, is rather unknown. The area of Ob and Yenisei estuaries and the adjacent inner shelf of the Kara Sea (< 76° N) was mainly investigated by Russian scientists, but only few ecological and process-oriented studies as compared to other studies on the biology of benthic invertebrates or structure of benthic communities, have been carried out in the past.

Material and Methods

Based on quantitatively and qualitatively sampling methods [Large Box Corer (LBC); dredge] the study of distribution patterns of macrozoobenthic organisms in the area of Ob and Yenisei estuaries and the adjacent southern part of the Kara Sea was the aim of benthic research during the 1999 expedition of RV "Akademik Boris Petrov". In total, 44 LBC and 18 dredges were collected at 24 stations at water depths between 12 to 41 m (Table 6-2). The LBC covering an area of 0,25m^2, whereas the dredge ("Kieler Kinderwagen") has a mouth opening of 100 by 30 cm and a mesh size of 0,5 cm in the cod-end. The separation of animals and sediment of the LBC samples was done by sieving over 500 µm screens. The dredge material was rinsed through a 1000 µm sieve. Both samples were preserved in bufferd 7% formaldehyde solution and will later stained with Rose Bengal, sorted and identified using a stereomicroscope and transferred to 70% ethanol.

Preliminary Results

Aboard RV "Akademik Boris Petrov" no sample analyses could be performed because of technical requirements and must be produced after the expedition at the Alfred Wegener Institute in Bremerhaven. Along the south-north transects accompanied by increasing salinity and water depth the preliminary results indicate changes in species composition of the benthic fauna from brackish to marine species. In general, crustaceans, polychaetes, molluscs, echinoderms, and sipunculids represent the important taxonomic groups in the area investigated. Most polychaetes are small in body size but abundant at all stations. The crustaceans are dominated by amphipods and isopods while the molluscs are characterized by bivalves. *Portlandia aestuariorum*, *Nicania montagui*, *Musculus sp.* and *Yoldia amygdalea hyperborea* are important bivalve species. Only in the eastern part of the study area gastropods occurred in the dredge samples. The mussel *Portlandia aestuariorum* and the isopod *Mesidotea entomon* (Fig. 6-6) seemed to be closely associated to brackish waters and occurred mainly in the more southern part of the estuaries of Ob and Yenisei (< 74°N). Echinoderms, usually abundant in Arctic shelf areas, were only sampled north of 74°N. Only few echinoderm species were recorded in the study area. The low species number of asteroids (*Urasterias linki*, *Ctenodiscus crispatus*), ophiurids, and holothurians at the sea floor north of 74°N is most likely coupled to the influence of brackish waters from Ob and Yenisei. For many echinoderms low salinity is an important limiting factor. The ophiurids *Stegophiura nodosa* and *Ophiocten sericeum*, and the holothurian *Myriotrochus* c.f. *rinkii* penetrate in brackish-water zones, and were the southernmost echinoderms in the study area.

Table 6-2
List of samples for macrobenthic investigations

station	date	depth	LBC	dredge
BP-99-**01**	25.08. 1999	26 m	0	1
BP-99-**02**	25.08. 1999	30 m	2	1
BP-99-**03**	26.08. 1999	32 m	2	1
BP-99-**04**	26.08. 1999	33 m	2	0
BP-99-**08**	27.08. 1999	22 m	2	1
BP-99-**11**	28.08. 1999	41 m	2	1
BP-99-**12**	28.08. 1999	25 m	2	0
BP-99-**13**	29.08. 1999	36 m	2	1
BP-99-**17**	30.08. 1999	19 m	2	1
BP-99-**18**	31.08. 1999	15 m	2	0
BP-99-**19**	31.08. 1999	15 m	2	1
BP-99-**20**	01.09. 1999	16 m	2	0
BP-99-**21**	02.09. 1999	15 m	0	1
BP-99-**24**	02.09. 1999	16 m	2	1
BP-99-**25**	03.09. 1999	22 m	2	1
BP-99-**26**	03.09. 1999	27 m	0	1
BP-99-**28**	03.09. 1999	19 m	2	1
BP-99-**29**	04.09. 1999	12 m	2	1
BP-99-**30**	05.09. 1999	14 m	2	0
BP-99-**31**	05.09. 1999	12 m	2	0
BP-99-**32**	06.09. 1999	23 m	2	1
BP-99-**35**	06.09. 1999	29 m	2	1
BP-99-**38**	07.09. 1999	27 m	2	1
BP-99-**39**	08.09. 1999	33 m	2	1
Σ			**44**	**18**

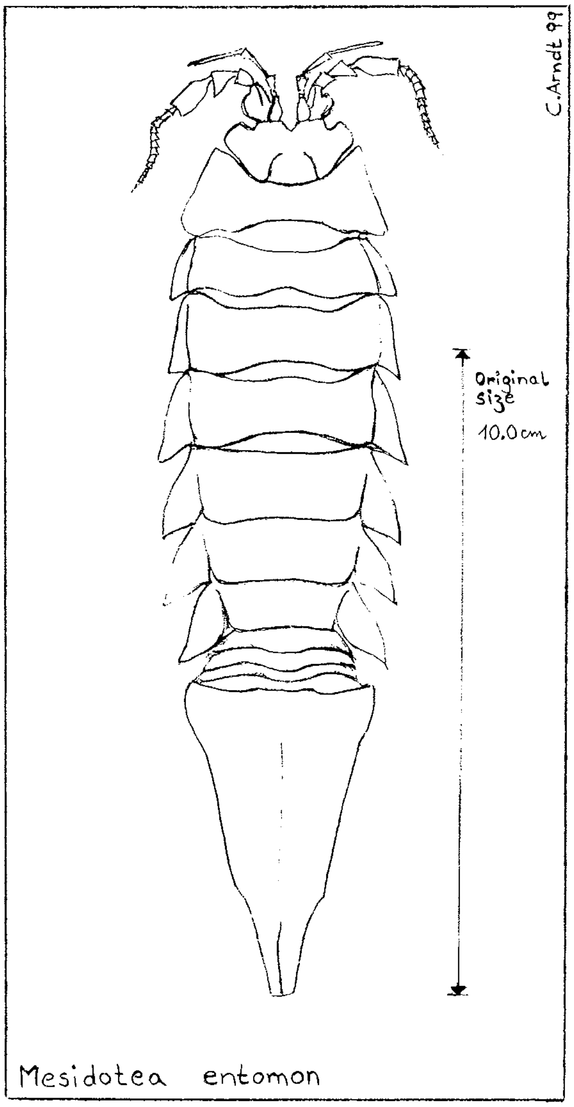

Fig. 6-6
Drawing of *Mesidotea entomon*
(Hand-drawing by Carolin Arndt)

7 Marine Geology

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The present state of the Arctic Ocean itself and its influence on the global climate system strongly depend on the large river discharge, which is equivalent to 10 % of the global runoff. Today, the freshwater inflow by the major rivers reaches a total of 3300 km^3/yr. Major contributors are the Yenisei (603 km^3/yr), Ob (530 km^3/yr), Lena (520 km^3/yr), and MacKenzie (340 km^3/yr) (Aagaard and Carmack, 1989; Gordeev et al., 1996). The Arctic rivers also transport large amounts of dissolved and particulate material (i.e., chemical elements, siliciclastic and organic matter, nutrients, etc.) onto the shelves (Gordeev et al., 1996) where it is accumulated or further transported by different mechanisms (sea-ice, icebergs, turbidity currents, etc.) towards the open ocean (e.g., Stein and Korolev, 1994). Thus, river-derived material contribute in major proportions to the entire Arctic Ocean sedimentary and chemical budgets. Furthermore, the different rivers carry suspension loads characterized by different mineralogical and geochemical tracers, dependant on the geology of the hinterland. These parameters (such as clay-mineral and heavy-mineral compositions as well as main and trace elements) can be used as tracers for specific source areas (e.g., Lapina, 1965; Levitan et al., 1996; Stein and Korolev, 1994; Behrends et al., 1999; Wahsner et al., 1999). An enhanced surface water productivity, which is due to a strong nutrient supply as is typical in front of river systems, may significantly shape the depositional environment in respect to increased accumulation of marine organic carbon. Within the suspension load, major amounts of terrigenous organic carbon is also supplied, which has to be distinguished from the marine organic carbon mainly produced by phytoplankton (Fahl and Stein, 1997; Stein and Fahl, 2000).

In the recent years, several major expeditons were already carried out into the Kara Sea dealing with the investigation of hydrological, biological, geochemical, and geological processes (e.g., RV "Dmitry Mendeleev" in 1993, Lisitzin and Vinogradov, 1995; RV "Professor Logachev" in 1994, Ivanov et al., 1995; RV "Akademik Boris Petrov" in 1995 and 1997, Galimov et al., 1996; Matthiessen and Stepanets, 1998). The overall goal of the RV "Akademic Boris Petrov" Expedition 1999 is to study these processes in the Ob and Yenisei estuaries and the adjacent inner Kara Sea in detail. Within this concept, the main interest of the marine geological investigations of the material obtained during this expedition (Fig. 7-1) are the quantification and characterization of the supply of siliciclastic and organic material by the rivers Ob and Yenisei, its accumulation in the estuaries, its transfer onto the open Kara Sea shelf, and its changes in time and space.

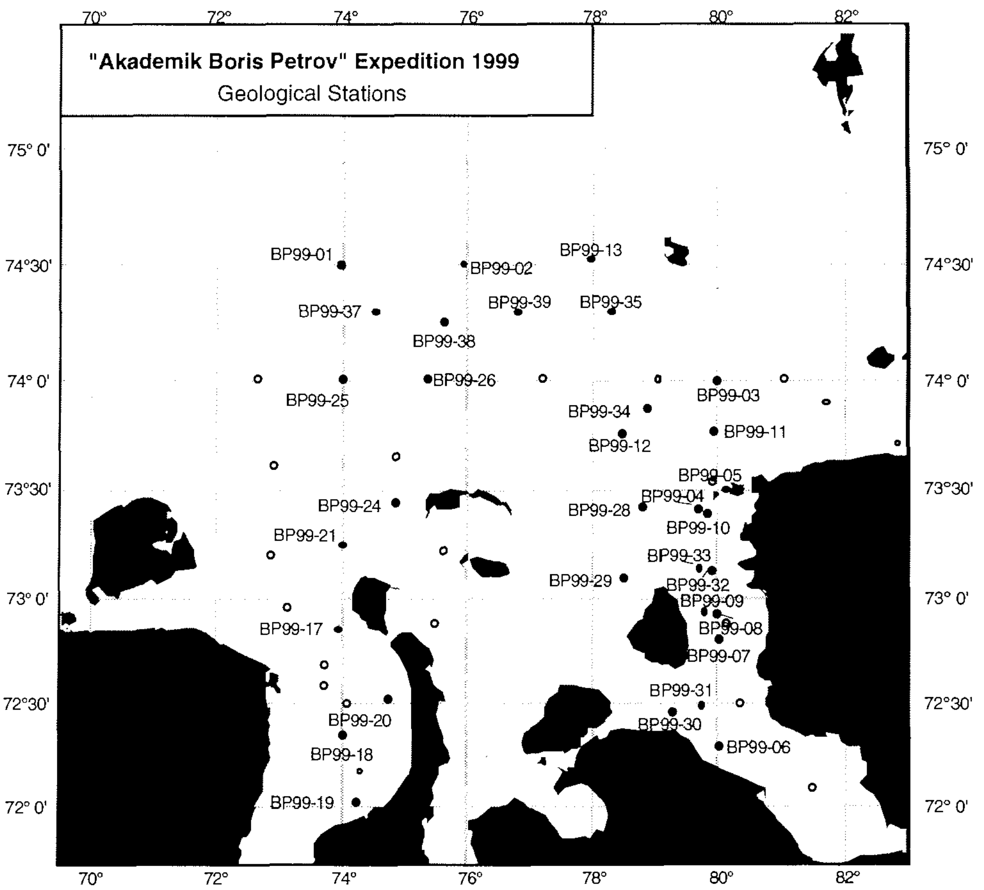


Fig. 7-1
Map of the study area of the "Akademik Boris Petrov" Expedition 1999 in the inner Kara Sea and Ob and Yenisei estuaries, presenting the locations of geological stations. In addition, the locations of the stations of the "Akademik Boris Petrov" Expedition 1997 (Matthiessen and Stepanets, 1998) are shown (open circles).

Key objectives are:

* the characterization and quantification of the terrigenous (fluvial) sediment supply and its change through time;

* the characterization and quantification of the organic carbon flux in relation to surface-water prductivity and terrigenous supply;

* the development of a high-resolution stratigraphic framework;

* the reconstruction of temporal and spatial changes in the late Weichselian and Holocene paleoenvironment along transects from the estuaries of the rivers Ob and Yenisey towards the open Kara Sea; and

* the calculation of (Holocene) total sediment and organic carbon budgets for the Ob and Yenisei estuaries and the inner Kara Sea.

The methods to be used are summarized in Annex Table 10-4. The investigations will be performed on suspended matter, sediment-trap material, surface sediments and sediment cores.

7.1 Geological Sampling Program

The water column and the sediments were generally sampled at the same stations in order to study the relationship between modern processes in the surface waters and their reflection in the surface sediments. The sampling program concentrated on the estuaries of the two major rivers Ob and Yenisei and the adjacent Kara Sea shelf south of 74°30'N (Fig. 7-1). Especially transects along the salinity gradient were of major interest. Furthermore, the area between latitudes 74°N and 74°30'N, i.e., north of the working area of the "Akademik Boris Petrov" Expedition 1997 (Matthiessen and Stepanets, 1998). was sampled (Fig. 7-1).

The geological stations were carefully selected based on sediment profiling results (cf., Chapter 7.2). The sampling usually started after the ship cast anchor and the water sampling was finished. Surface and near-surface sediments were sampled by means of the Giant Box Corer and the Multicorer, long sediment cores were obtained using the Gravity Corer.

<u>Giant Box Corer</u>

The giant box corer (weight of ca. 500 kg; volume of sample 50 x 50 x 60 cm; manufactured by Fa. Wuttke, Henstedt-Ulzburg, Germany) was successfully used 85 times on 29 geological stations. Only in 2 box cores the sediments were disturbed and 1 box core was overfilled because of overpenetration. In general, the recovery ranged from ca. 30 to 45 cm. The box cores were sampled for the following investigations.

(1) surface sediments:

- stable isotope analysis of benthic calcareous organisms (Geomar)
  10 x 10 from the upper 1 cm (100 cm^3) fixed with bengal-rose-methanol-solution
  10 x 10 from the upper 5 mm (50 cm^3)
- benthic foraminifera and stable isotopes (AWI-Geology)
  10 x 10 from the upper 1 cm (100 cm^3) fixed with bengal-rose-methanol-solution
- studies on benthic macrofauna (AWI-Biology)
- organic geochemistry (Vernadsky-Institute)

(2) profiles (tubes 120 mm in diameter):

- sedimentology, grain-size analysis and clay mineralogy (AWI-Geology)

- organic geochemical bulk parameters (TOC, $CaCO_3$, C/N ratio, Rock Eval pyrolysis) and biomarkers as well as $\partial^{13}C$ of specific biomarkers (AWI-Geology)
- palynology (AWI-Geology)
- archive core (AWI-Geology)
- organic geochemistry, radio-nuclides (Vernadsky-Institute)

Multicorer

The standard 12-tubes-version multicorer (weight of 495 kg; manufactured by Fa. Wuttke, Henstedt-Ulzburg, Germany) with an inner tube diameter of 6 cm was used. The penetration weight was always 250 kg. The multicorer was successfully used 46 times on 24 stations, and usually recovered undisturbed surface sediments and overlying bottom water. Only in three runs it was empty because of technical problems.

The sediment column of one tube was visually described from all stations (see lithological core descriptions, Annex 10.3) while the core was cut into 1 cm slices. Sediment colours were identified according to the "Munsell Soil Color Chart" (Kollmorgen Instruments Corp., Newburgh, USA). The tubes were sampled according to the following scheme depending on the number of tubes filled with sediments:

(1) surface sediments:

- palynology (AWI-Geology)
  2-3 tubes, ca. 30-90 cm^3
  1 tube (10 cm^3) from the upper 0.5 cm, stored cold and dark for stain living dinoflagellate cysts
- inorganic geochemistry (AWI-Geology)
  1 tube, ca. 10-20 cm^3
- grain size analysis and clay mineralogy (AWI-Geology)
  1 tube, ca. 10-20 cm^3
- diatoms (AWI-Geology)
  1 tube, ca. 10-20 cm^3
  - organic geochemical bulk parameters (TOC, C/N, Rock Eval pyrolysis, $CaCO_3$) (AWI-Geology)
  1 tube ca. 10-20 cm^3
- biomarkers and $\partial^{13}C$ of specific biomarkers (AWI, Geology)
  1-2 tubes, ca. 20-40 cm^3, stored frozen at -20°C
- stable isotope analysis of benthic calcareous organisms (Geomar)
  2 tubes (40 cm^3) from the upper 1 cm fixed with bengal-rose-methanol-solution to stain living organisms

(2) profiles:

- sedimentology, mineralogy (AWI-Geology)
  1 tube cut into 1 cm slices, stored cool
- palynological studies (AWI, Geology)
  1 tube cut into 1 cm slices, stored cool
- archive (AWI-Geology)

1 tube cut into 1 cm slices, stored cool
- organic geochemical bulk parameters (C/N ratio, Rock Eval pyrolysis, TOC, $CaCO_3$) and biomarkers as well as $\partial^{13}C$ of specific biomarkers (AWI-Geology)
  1 tube cut into 1 cm slices, stored cool
  samples (10-20 cm³) from the upper 3 cm, stored frozen at -20°C; tube sampled at 5 cm intervals and additionally at lithological changes, stored frozen at -20°C
- organic geochemical analysis (Corg/N, carbonate, biogenic silica (Opal), carbohydrates, amino acids) (IfBM)
  samples (20 cm³) from the upper 3 cm, stored frozen at -20°C, tube sampled at 5 cm intervals and additionally at lithological changes, stored frozen at -20°C
- organic geochemistry (Vernadsky)
  2-4 tubes

In addition, bottom water (100 ml) was sampled from the multicorer tubes for stable isotope measurements (Geomar).

Table 7-1
Penetration and recovery of gravity corer. (SL-5: 5m core barrel; SL-8: 8m core barrel)

Core	Gear	Water depth (m)	Penetration (m)	Recovery (m)	Remarks
BP99-02/5	SL-5	30.0	2.4	2.30	
BP99-03/6	SL-5	31.2	5.5	4.85	
BP99-03/7	SL-8	31.2	6.5	5.27	
BP99-04/7	SL-8	27.8	8.3	7.95	
BP99-05/1	SL-5	33.9	4.8	4.10	
BP99-07/3	SL-8	17.8	8.5	5.71	
BP99-08/7	SL-8	16.7	8.5	5.42	
BP99-09/1	SL-8	19.2	3.5	1.85	Core barrel destroyed
BP99-10/2	SL-8	28.5	6.2	5.18	
BP99-11/6	SL-5	36.1	3.0	1.05	Core barrel destroyed
BP99-17/6	SL-8	14.5	8.0	5.66	
BP99-18/7	SL-5	10.8	5.2	4.83	
BP99-18/8	SL-8	10.8	6.0	4.36	
BP99-19/7	SL-8	9.3	8.1	5.51	
BP99-20/7	SL-8	11.8	8.2	4.48	
BP99-24/9	SL-5	15.5	5.0	4.51	black sediments
BP99-25/8	SL-5	21.9	0.5	0.00	empty; sand layer ?
BP99-26/1	SL-5	27.3	4.8	3.88	
BP99-28/7	SL-5	18.8	2.2	1.58	black sediments; H_2S
BP99-29/7	SL-5	12.2	2.0	1.57	Core barrel destroyed
BP99-30/8	SL-5	9.2	4.0	3.31	
BP99-31/10	SL-8	12.4	8.0	4.78	black sediments; H_2S
BP99-32/8	SL-8	23.0	9.5	5.68	
BP99-33/1	SL-5	25.0	?	0.00	empty; sand layer ?
BP99-38/6	SL-5	26.8	3.8	2.81	
BP99-39/6	SL-5	33.3	2.4	2.05	

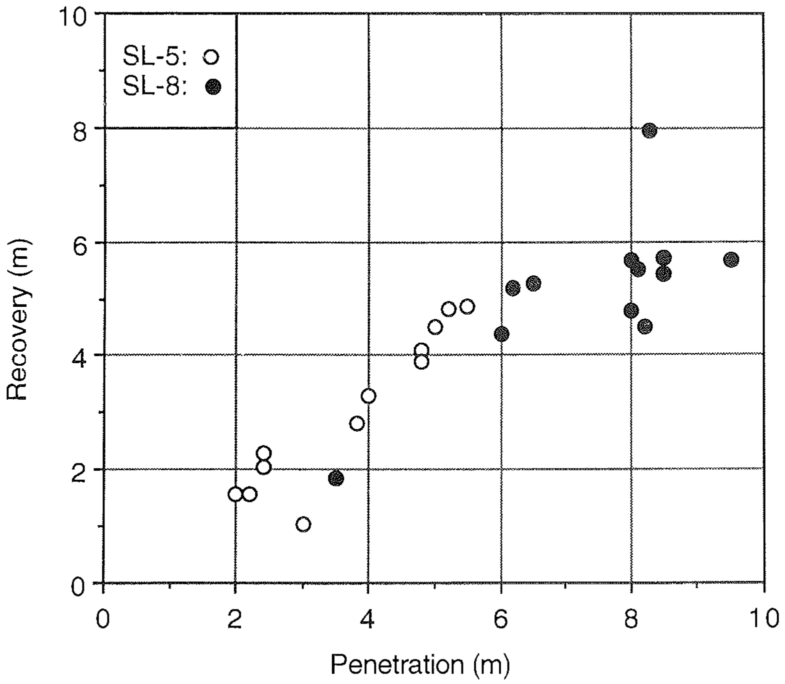


Fig. 7-2
Correlation between penetration and recovery of gravity corers. Open circles are data points from gravity corer with the 5m core barrel (SL-5), solid circles are data points from gravity corer with the 8m core barrel (SL-8).

Gravity Corer

The gravity corer has a penetration weight of up to 1.5 t and core barrel segments of 300 cm and 500 cm in length and 120 mm in diameter. During the "Akademic Boris Petrov" Expedition 1999, core barrels with a length of 500cm and 800 cm were used on a total of 26 stations (Table 7-1). Sediment penetration and sediment recovery range from 240 cm to 950 cm and from 105 cm to 795 cm, respectively (Fig. 7-2 and 7-3, Table 7-1). In most cases, the topmost part of the cores contains brownish sediments, indicating that the surface (near-surface) sediments have been recovered. Three core barrels were destroyed during coring, and two cores were empty due to stiff or sandy sediment layers close to the sediment surface (Table 7-1). After recovery the sediment cores were cut into 100 cm sections and stored under cool conditions. Additionally, core catchers were sampled. In order to get a first estimate of grain size and compostion of the sediments, smear slides of sediment samples taken from the surface and at the bases of each 100 cm section in a few selected sediment cores, were analyzed under a light microscope.

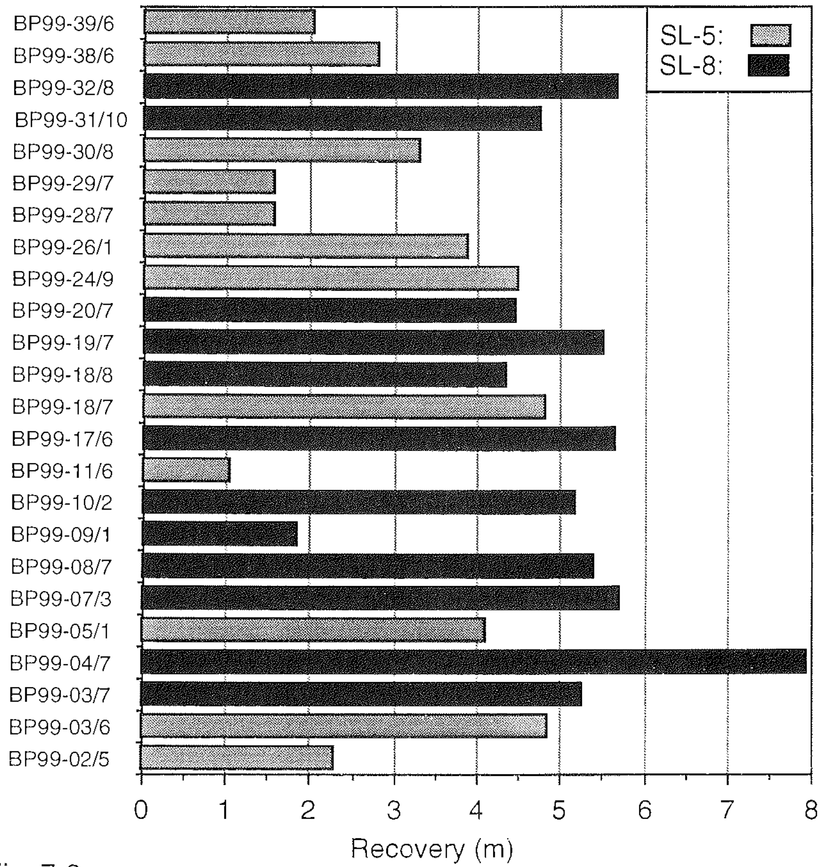


Fig. 7-3
Length (Recovery) of gravity cores obtained during the "Akademik Boris Petrov" Expedition 1999.

7.2 Sediment Profiling

RV "Akademik Boris Petrov" is equipped with an ELAC echograph LAZ 72 constructed by Honeywell-Nautik, Kiel, Germany. The system can be used for either fishfinding, surveying, navigation or oceanography and thus offers different operating modes. For sediment profiling the echosounder had to be set to an operating frequency of 12 kHz, an impulse length of 1 ms and 200 W transmitting power to show best possible results. Analogical recording was carried out by plotting the received signal directly on Spark recording paper and digital recording by using an AIWA audio DAT-recorder. Limiting profiling factors were the relatively high frequency which did not provide higher resolution of layered sediments and the small water depth causing a very strong backscatter signal from the seafloor and high amplitude multiple echos especially when increasing the transmitting power. Despite these limiting factors the ELAC echograph was a very successful tool to distinguish between soft clayey sediments which show higher penetration and single seismic reflectors and sandy sediments of higher density characterized by a hard reflector and no deeper penetration.

The ELAC echograph was in continous operation along all cruise tracks between arrival and departure at the working area in the Kara Sea. In total more than 3000 km of sediment profiles were obtained (Fig. 7-4). The aims of the sediment profiling were:

* to select coring stations for gravity coring;
* to get a detailed picture of the modern bottom topography; and
* to get information about the thickness and structure of the youngest (Holocene?) sedimentary cover and the pre-Holocene bottom topography

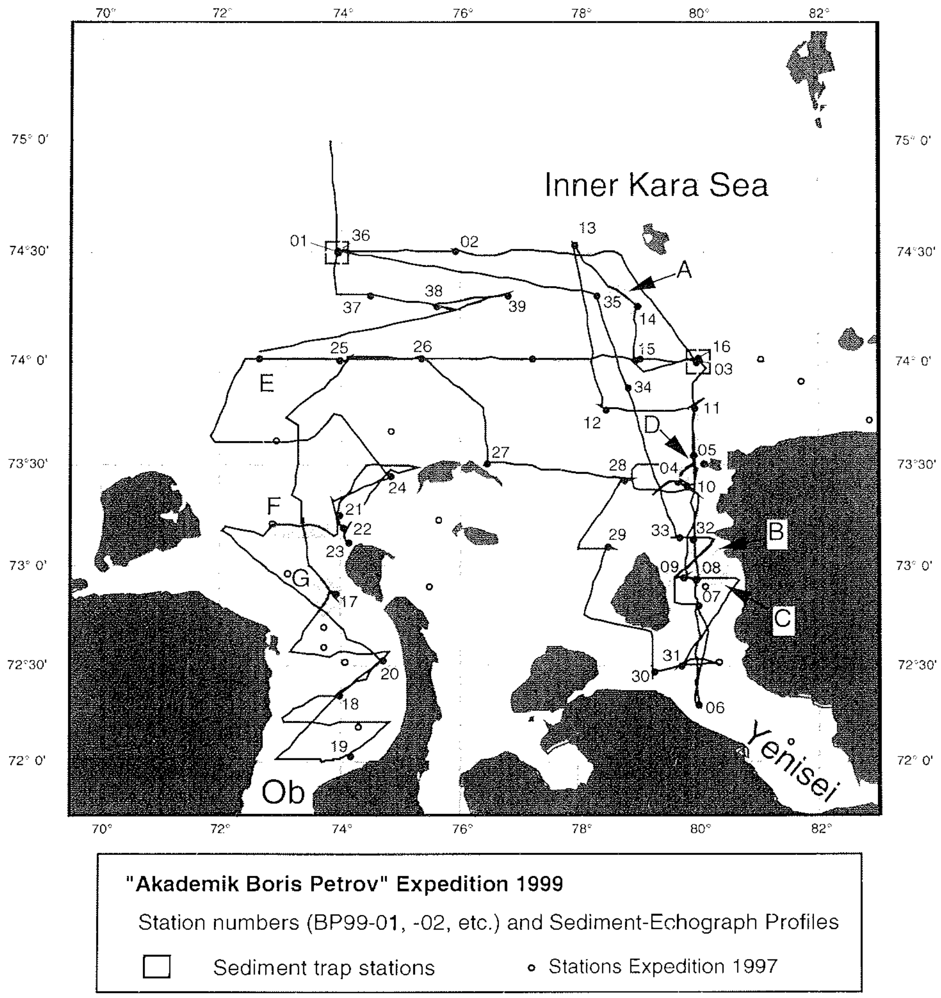


Fig. 7-4
Map of the study area of the "Akademik Boris Petrov" Expedition 1999 in the inner Kara Sea and Ob and Yenisei estuaries, presenting the location of sampling sites, sediment echograph profiles, and sediment traps deployed at stations BP99-01 and BP99-03. In addition, the locations of the stations of the "Akademik Boris Petrov" Expedition 1997 (Matthiessen and Stepanets, 1998) are shown (open circles). The locations of sediment echograph profiles shown in Figures 7-5 (A, B, and C), 7-6 (D), and 7-7 (E, F, and G), are indicated.

In terms of "acustic or seismic stratigraphy", two acustic (seismic) units can be generally distinguished in the echograph profiles. Acustic Unit I is composed of up to 20 m thick undisturbed sediments. Often subparallel subsurface reflectors occur, partly draping the underlying topography. The top of acustic Unit II (base of Unit I) is mainly represented by a strong (acustic "basement") reflector with almost no penetration below (Figs. 7-5, 7-6, and 7-7).

Based on the sediment profiling results, our study area can be divided into two major facies zones, (1) the Ob and Yenesei estuaries and (2) the inner Kara Sea.

The Ob and Yenisei estuaries are characterized by a high penetration depth of the sediment profiler, indicating thick sequences of soft young (Holocene/post-Glacial?) sediments (acustic Unit I) overlying the pre-Holocene bottom topography (acustic Unit II). The modern main channels seem not to be erosional, but sedimentary features, with lower sedimentation rates inside the channel and higher sedimentation rates outside ("levee deposits"). Maximum penetration, i.e., maximum sediment accumulation, of up to 20 m was recorded south of about 73°N in the Ob estuary and south of about 73°30´N in the Yenisei estuary, outside the main modern channel valleys (Figs. 7-4 to 7-7). Towards the north as well as towards the flanks of the estuaries, the penetration depth of the sediment profiler (i.e. the thickness of Unit I) sharply decreases to < 5 m, indicating a decrease in accumulation rates. Furthermore, several small incised paleo-channels were recorded north of the Ob and Yenisei estuaries (Figs. 7-5 and 7-6). The width of the channels were in the order of 2 kilometers, the depths are about 5 to 8 meters. All channels are filled with young (probably Holocene) sediments (acustic Unit I). These channels may be related to Pleistocene drainage of the Ob and Yenisei and were cut during times of lowered sea level. Similar observations based on PARASOUND profiling results were also reported for the paleo-Lena river in the Laptev Sea (Kleiber and Niessen, 1999). This implies that considerable freshwater drainage occurred during pre-Holocene (post-glacial to glacial?) times from the Eurasian continent into the Arctic Ocean. If these paleo-Ob channels are really of last Glacial age, this gives a further argument against an extended last Glacial ice sheet covering the Kara-Laptev Sea shelf as proposed by Grosswald (1990). In order to prove this hypothysis, however, absolute AMS^{14}C datings of the basis of the paleo-river channels and the overlying sediments in the Ob and Yenisei area are necessary (see further discussions in Chapter 7.4).

In the inner Kara Sea (Facies 2) a strong reflector is recorded at the surface with almost no penetration below. That means, acustic Unit I is almost missing here. Only in small channels and depressions some penetration of 3 to 5 m below the sediment surface is observed (Figs. 7-5 and 7-6). This suggests that modern sedimentation mainly takes place in these channels. In comparison to facies zone (1), however, sedimentation rates are also very low in the channels and depressions.

More detailed evaluation of the profiling records will be performed to quantify the sediment accumulation in the different parts of the estuaries and in the areas towards the north.

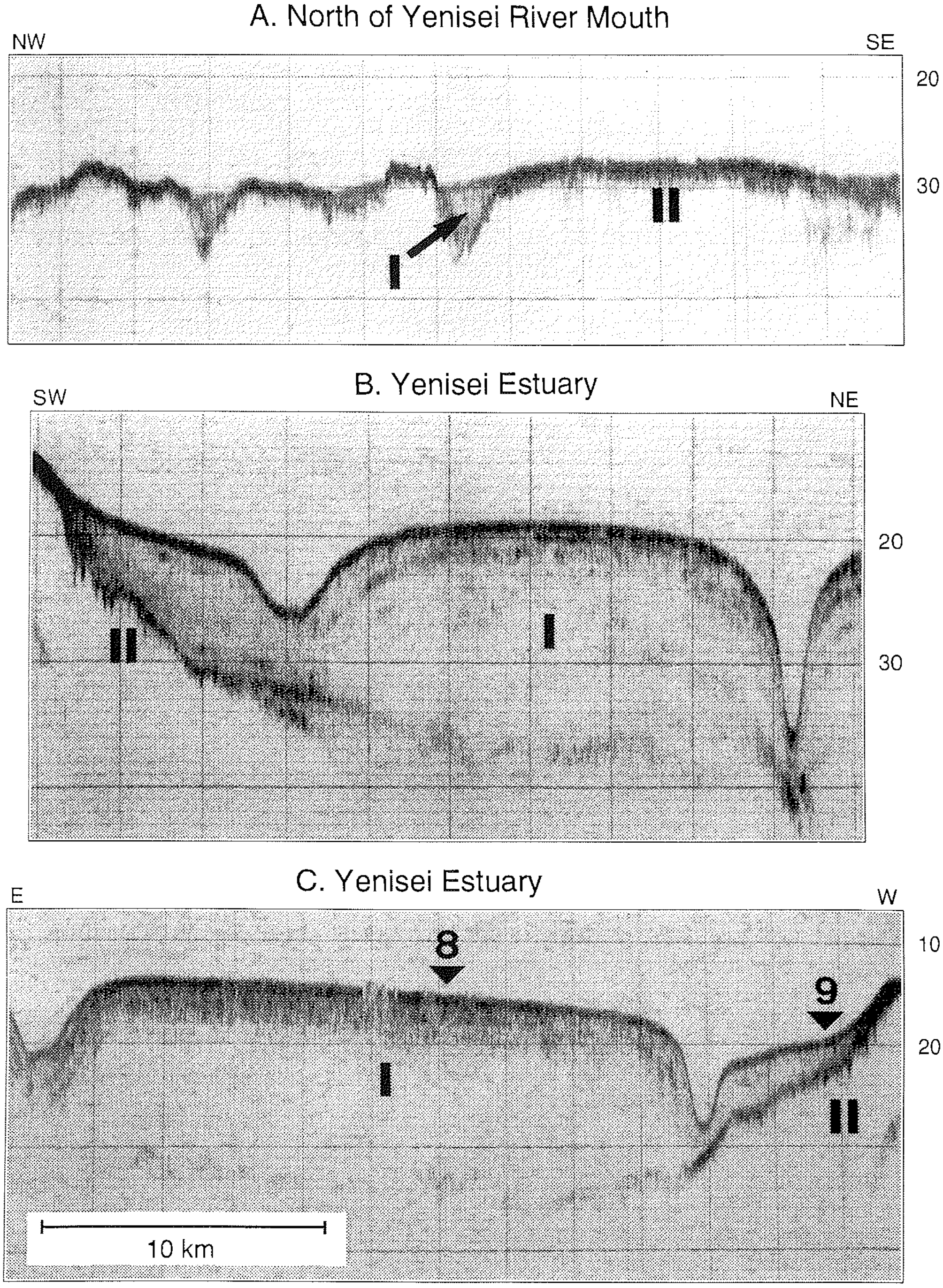


Fig. 7-5
Sediment echograph profiles A to C from the Yenisei area. Profile A: North of Yenisei River mouth; profiles B and C: Yenisei estuary. Roman numbers indicate acustic units I and II. Bold numbers 8 and 9 indicate location of sediment cores BP99-08/7 and BP99-09/1. Numbers at the right side of the profiles indicate water depth in meters. For location of profiles see Figure 7-4.

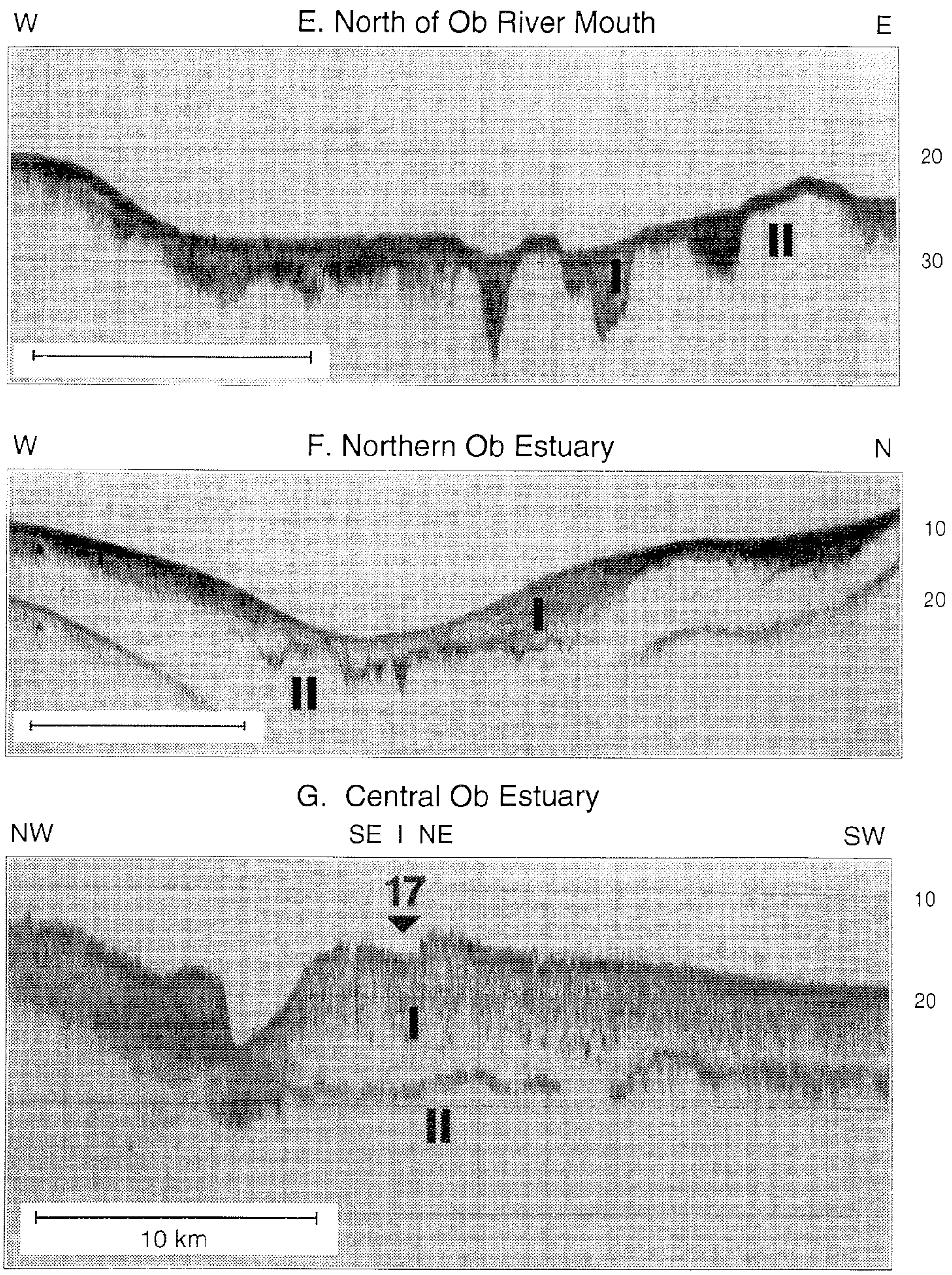


Fig. 7-6
Sediment echograph profiles E to G from the Ob area. Profile E: North of Ob River mouth; profiles B and C: Ob estuary. Roman numbers indicate acustic units I and II. Bold number 17 indicates location of sediment core BP99-17/6. Numbers at the right side of the profiles indicate water depth in meters. For location of profile see Figure 7-4.

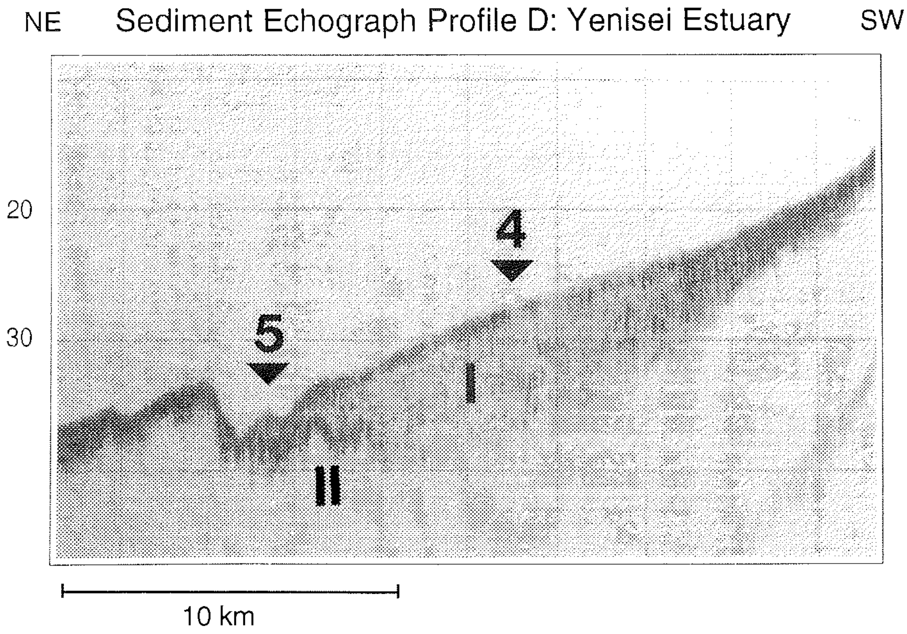


Fig. 7-7
Sediment echograph profile D from the Yenisei estuary. Roman numbers indicate acustic units I and II. Bold numbers 4 and 5 indicate location of sediment cores BP99-04/7 and BP99-05/1. Numbers at the left side of the profiles indicate water depth in meters. For location of profile see Figure 7-4.

7.3 Sediment Composition

Composition of surface and near-surface sediments

Based on the visual description of the multicorer profiles, the inspection of the surfaces of the Giant Box Cores, and a few smear slide analyses, the surface sediments are mainly composed of brownish silty clay/clayey silt (cf. lithological core descriptions, Annex 10.3). Only in the northern part of the study area (at stations BP99-01, BP99-02, BP-99-12, BP99-13, BP99-24, BP99-25, BP99-28, BP99-37, BP99-38, and BP99-39), an increased sand content was determined. Major sediment components are quartz and clay minerals with minor amounts of feldspars and heavy minerals. Despite the rare occurrence of diatoms and plant debris, biogenic components are almost absent. Below 3 to 5 cm, the sediment color changes from brown to dark green, dark gray or black, indicating the transition from oxic to anoxic conditions. This very shallow redox boundary is probably caused by high organic carbon contents and very fine-grained sediments. Near the base of Giant Box Core BP99-32/1, at about 50 cmbsf, a large piece of wood (length of 15 cm) was found.

Composition of long sediment cores

The recovery of long sediment cores of 5 to 8 m in length is restricted to the high-sedimentaion rate area of the Ob and Yenisei estuaries. In the northern part of the study area the recovery is less than 3 m. Because the long sediment cores were not opened onboard "Akademik Boris Petrov", only few information about the lithology and ist change versus depth is available now. Based on the limited amount of smear slide analyses performed on sediment samples taken at the bases of each 100 cm section in selected number of sediment cores (BP99-02/5, BP99-03/6, BP99-04/7, BP99-05/1, and BP99-19/7), the compostion of the (Holocene?) sediments do not show any major changes in grain size and composition (Figs. 7-8 to 7-12). Dark gray and dark green silty clay to clayey silt is the predominant lithology, quartz and clay minerals, similar to the surface sediments, the major components. The amount of diatoms seems to be increased in the lower part of Core BP99-03/6 (Fig. 7-9). In Core BP99-30/8 (southern Yenisei estuary), a large piece of wood (4 cm in length) and shell debris were found at 130 cmbsf and 331 cmbsf, respectively. In Core BP99-31/10 (southern Yenisei estuary), dominantly black sediments with a strong H_2S smell were recovered, suggesting very high amounts of labile organic matter being preserved in the sediments, ands its decomposition.

Sediment cores BP99-04/7 and BP99-05/1 (northern Yenisei estuary) have been opened and described at AWI. Furthermore, magnetic susceptibility values were determined (Fig. 7-13). Based on the lithological core description, the sedimentary sequences can be divided into two lithological units, correlating with the two acustic units described above. The deposits of lithological Unit I are predominantly fine-grained siliciclastic sediments (cf., Figs. 7-10 and 7-11). The upper part of Unit I is strongly bioturbated (Subunit Ia), underlain by laminated sediments (Subunit Ib). The boundary between both subunits is marked by a distinct change in magnetic susceptibility (Fig. 7-13). In Core BP99-05/1 penetrated through the entire acustic Unit I down to the "basement reflector" and into acustic Unit II (Fig. 7-7), the sediments of Unit II are more sandy and partly cross-bedded, and do have much higher magnetic susceptibility values at least in the Yenisei (Fig. 7-13). The dominance of sand is also indicated in the smear-slide data (Fig. 7-11). Occasionally wood fragments and pieces of wood occur. In the upper part of Unit II, correlating with higher magentic susceptibility values, sandy intervals are more common than in the lower part.

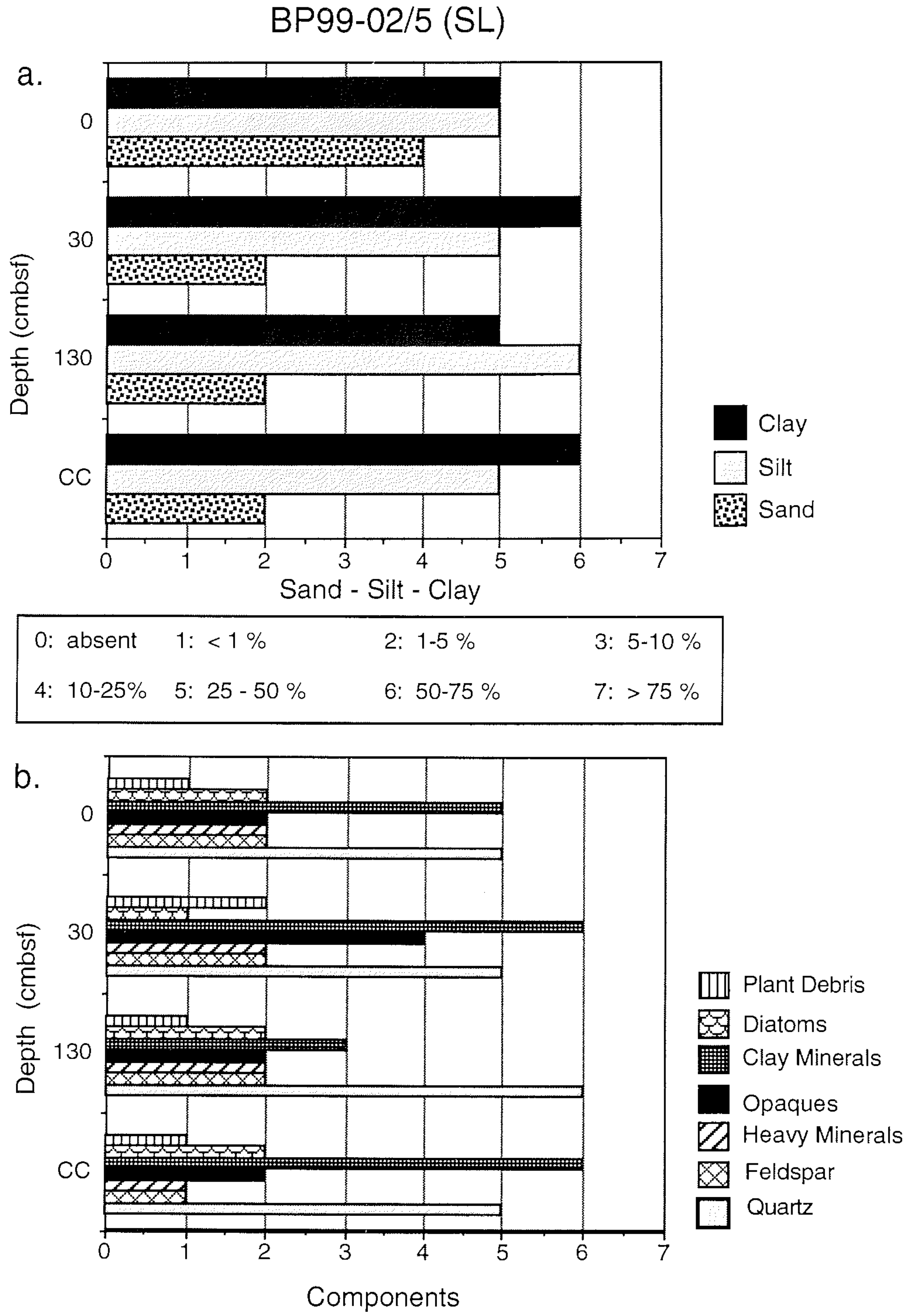
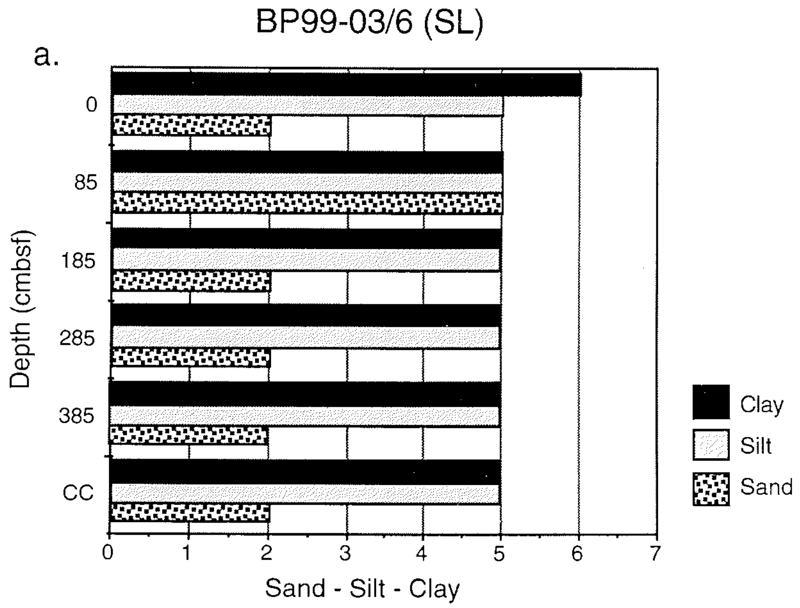


Fig. 7-8
Grain size and composition of selected samples from Core BP99-02/5, based on smear-slide estimates.



0: absent	1: < 1 %	2: 1-5 %	3: 5-10 %
4: 10-25%	5: 25 - 50 %	6: 50-75 %	7: > 75 %

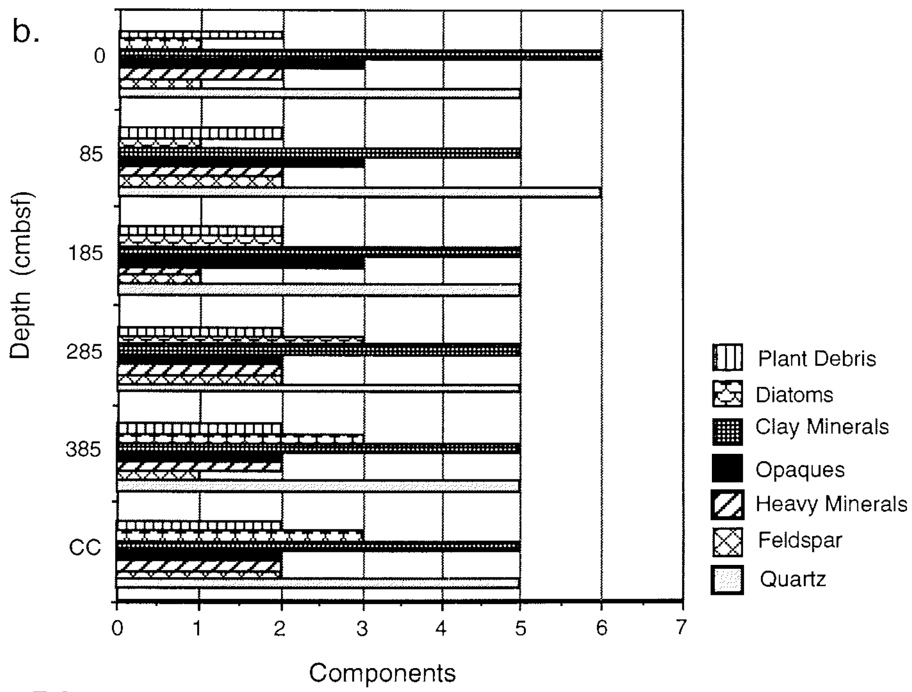


Fig. 7-9
Grain size and composition of selected samples from Core BP99-03/6, based on smear-slide estimates.

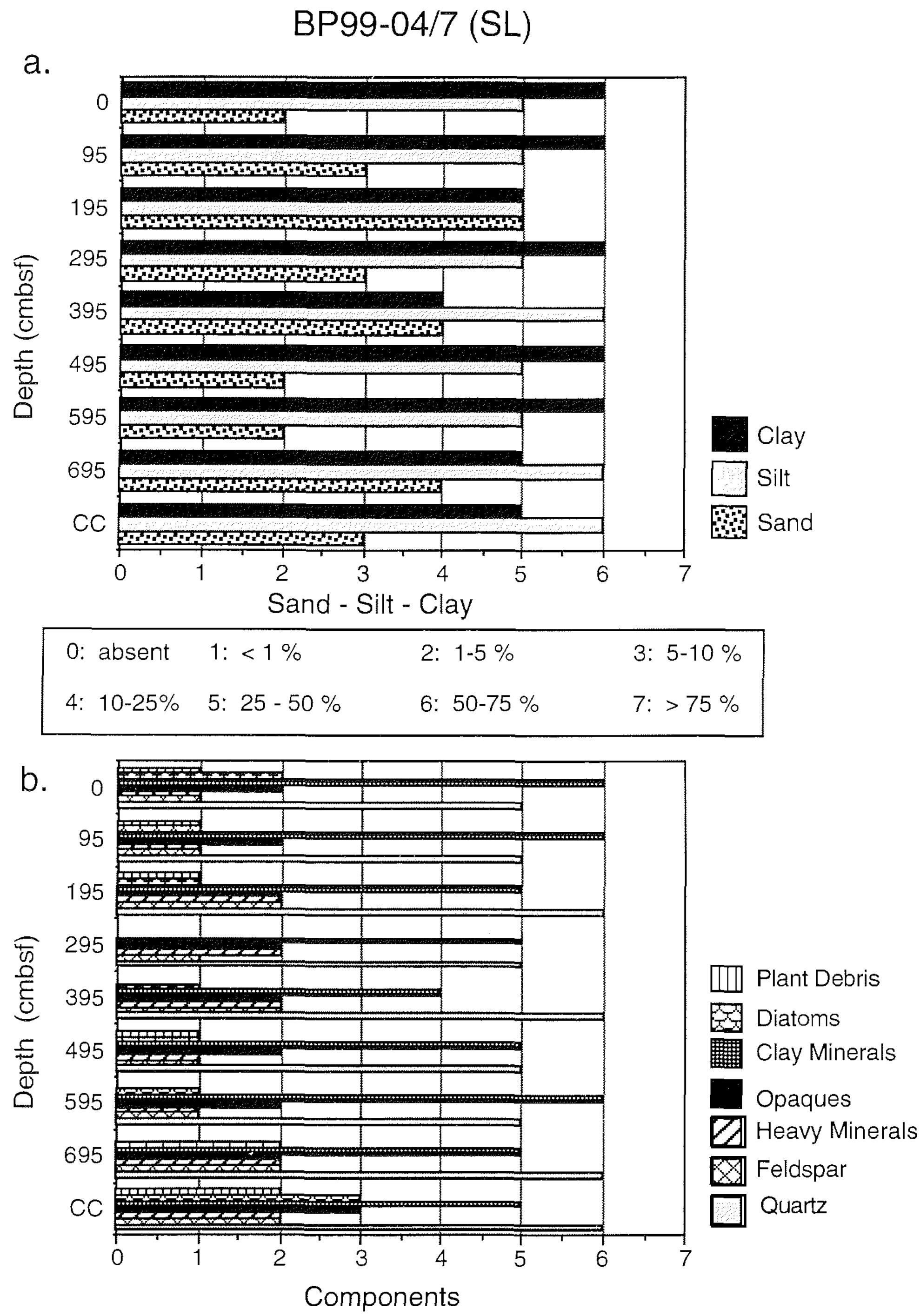
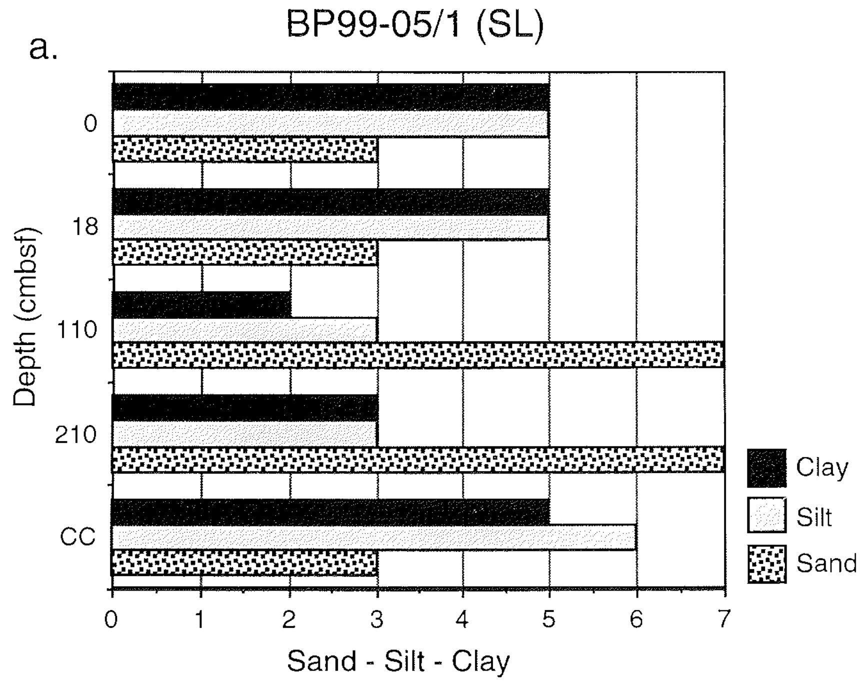


Fig. 7-10
Grain size and composition of selected samples from Core BP99-04/7, based on smear-slide estimates.



0: absent	1: < 1 %	2: 1-5 %	3: 5-10 %
4: 10-25%	5: 25 - 50 %	6: 50-75 %	7: > 75 %

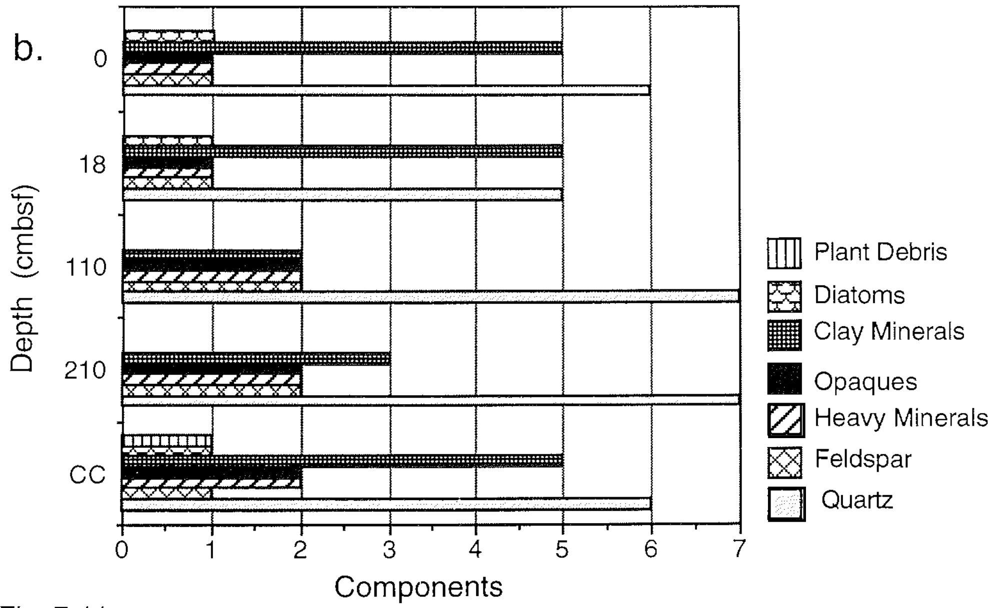


Fig. 7-11
Grain size and composition of selected samples from Core BP99-05/1, based on smear-slide estimates.

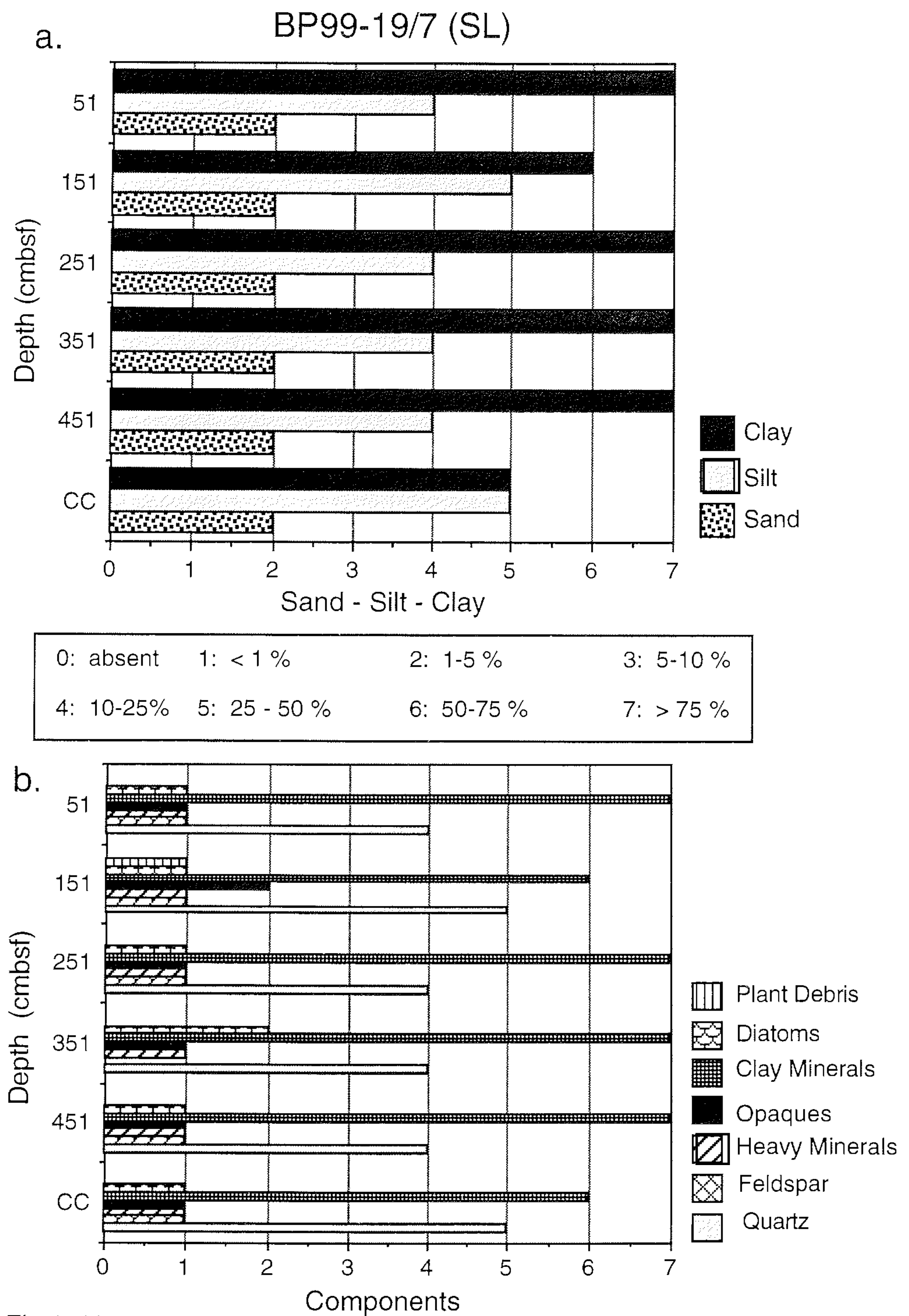


Fig. 7-12
Grain size and composition of selected samples from Core BP99-19/7, based on smear-slide estimates.

7.4 Depositional Environment

Based on the shipboard investigations, the sediments are predominantly of terrigenous origin, indicating the importance of riverine supply in the entire study area. According to the sediment description and the profiling results, the depositional environment can be clearly divided into two different facies zones, (1) the Ob and Yenisei estuary zone and (2) the inner Kara Sea zone. This, in general, was already known from the results of the "Akademik Boris Petrov" Expedition 1997 (Matthiessen and Stepanets, 1998; Matthiessen et al., 1999). The major step forward, however, is that during the this-year-expedition a large number of long undisturbed sediment cores were taken and a detailed sediment profiling survey of the study area was carried out, which will allow a much more quantitative investigation of the depositional environment and its change through time.

Facies zone (1), the inner Ob and Yenisei estuaries, is characterized by the deposition of large amounts of fine-grained siliciclastic sediments. In the Ob and Yenisei estuaries, maximum thicknesses of young (Holocene/post-Glacial?) soft sediments were recorded with the sediment profiler south of about 73°N and 73°30'N, respectively (Figs. 7-4 to 7-7; acustic Unit I). These high accumulation rate areas are probably associated with the mixing zone of marine and riverine water where large amounts of dissolved and particulate matter sink to the bottom due to flocculation and coagulation ("marginal filters" according to Lisitzin, 1995). Within facies zone (1), also maximum organic carbon contents of 2.3 to 3.2 % are preserved in the surface sediments (Boucsein et al., 1999), probably due to high sedimentation rate and high supply rates of terrigenous (riverine) organic matter. The presence of maximum abundances of freshwater palynomorphs (Matthiessen, 1999) and freshwater diatoms (Polyakova, 1999) as well as organic geochemical parameters (Stein, 1996; Boucsein et al., 1999) also indicate a dominantly terrigenous source of the organic matter. It can be inferred from these observations that most of the fine-grained terrigenous sediments are already deposited in the southern estuaries, and only small amounts are transported further offshore. The decrease in sedimentation rates towards the north is clearly indicated in the profiling records shown in Figures 7-5 and 7-6.

The distinct change in magnetic susceptibility determined in Core BP99-04/7 at the basis of the bioturbated interval (Fig. 7-13) is similar to a susceptibility change recorded in several cores from the Laptev Sea continental margin, AMS ^{14}C-dated to 10 ka, i.e., the base of the Holocene (Stein and Fahl, 2000). Assuming that these changes are contemporaneous this would result in Holocene sedimentation rates of about 70 cm/ky at Core BP99-04/7.

The sediments of Unit II, characterized by very high magnetic susceptibility values in Core BP99-05/1 (Fig. 7-13), may represent fluvial deposits of pre-Holocene (Last Glacial ?) age, formed during times of lowered sea level when the shallow Kara Sea shelf was exposed. The high magnetic susceptibility values suggest the widespread basalts of the Putoran Plateau drained by the Yenisei River, being the source area of this material (cf.,Kleiber and Niessen, 2000).

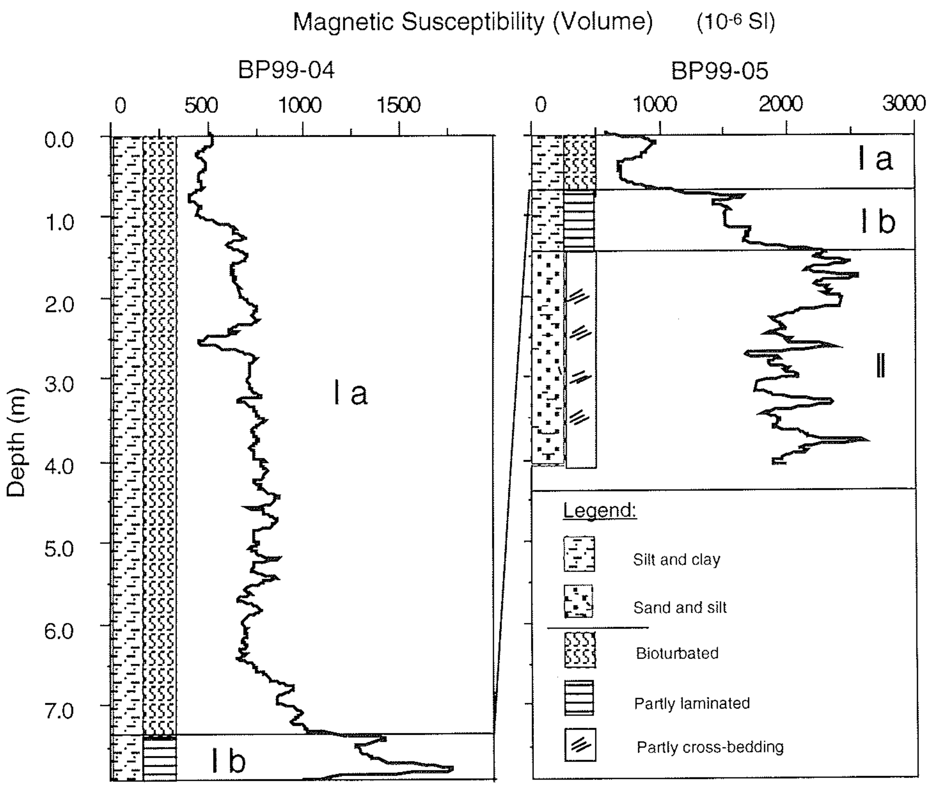


Fig. 7-13
Lithology and magnetic susceptibility records of cores BP99-04 and BP99-05. The magnetic susceptibility measured with a "Multi-Sensor Core Logging System", is defined as the dimension-less proportional factor of an applied magnetic field in relation to the magnetization in the sample (here expressed in SI units) and indicative for the sedimentological/mineralogical composition of the sediments (Kleiber and Niessen, 2000). Roman numbers indicate lithological units/subunits. Magnetic susceptibility measurements were performed by M. Pirrung and M. Kraus (AWI Bremerhaven).

Facies zone (2), the inner shallow Kara Sea, is characterized by the deposition of more sandy material. Only in the small channels and depressions, some accumulation of fine-grained, silty-clayey sediments occurs. This suggests that outside the channels and depressions non-deposition, reworking and erosion due to current and waves activity may dominate. Furthermore, this may reflect the general decrease of terrigenous (fluvial) sediment supply towards the north. Due to this decrease, the marine influence relatively increases north of 73°30′N which is also supported by the increase in the abundances of marine palynomorphs (Matthiessen, 1999) and marine diatoms (Polyakova, 1999). In addition, some higher primary productivity induced by fluvial nutrient influx may have caused the increased marine influence.

Future, more detailed geochemical, sedimentological and stratigraphical analyses of the long sediment cores, however, are required to provide more precise information on the late Quaternary paleoenvironmental evolution in this area on a high-resolution timescale. Furthermore, the combination of the detailed study of the long sediment cores (including absolute AMS ^{14}C dating) and the sediment profiling results will allow (i) to calculate total sedimentary as well as organic carbon budgets for the Ob and Yenisei estuaries and the adjacent inner Kara Sea for the Holocene time interval and, thus, to quantify how much of sediments and organic carbon are trapped in the estuaries and how much is transported towards the inner Kara Sea, and (ii) to determine the age and size of the pre-Holocene river valleys and to estimate pre-Holocene (Glacial) discharge rates.

8.1 Biogeochemistry of dissolved organic matter in the southern Kara Sea, Russia

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Introduction

The Arctic Ocean receives large amounts of dissolved organic matter (DOM) of terrestrial origin from Siberian rivers (Opsahl et al 1999). Two of the 3 largest Arctic rivers, the Ob and the Yenisei, discharge their waters into the Kara Sea. DOM is the largest active pool of organic carbon in the ocean and hence plays an important role in the global carbon cycle. Arctic rivers drain vast areas of the Northern Hemisphere and therefore represent a potential link between terrestrial and oceanic carbon pools in the light of global change. Other important features of terrestrially derived DOM include its role as a ligant and transport agent for trace metals and pollutants and the light adsorbing character of the dark colored DOM which is especially abundant in the two investigated rivers, Ob and Yenisei. These characteristics determine the light conditions as well as the abundance of nutrients and toxins within the coastal Kara Sea, likely having a great effect on phytoplankton and primary production. It is therefore important and interesting to understand the distribution and biogeochemistry (origin and fate) of DOM in this sparsely sampled environment.

Work program and initial qualitative results

Sampling was carried out between August 22, and September 8, 1999 in the southern Kara Sea (Fig. 8-1) covering about 30 major hydrographic stations and 75 additional surface stations. Our work program can be divided into 3 major objectives.

High-resolution sampling for the analysis of dissolved organic carbon in dependence of depth and salinity. During the cruise we took DOC samples at 30 hydrographic stations, using a CTD rosette, and at 75 additional surface stations, using a bucket (Fig. 8-1). We covered the area between 72° N and 74° 30 N and 74° E and 80° E and a salinity range from 0.6 to 33 ‰ (cf. Chapter 4.2). The high-resolution sampling for DOC in connection with salinity will give us a better idea about riverine DOM distribution and will allow to model DOM in the Kara Sea. For detailed description of the DOM sampling sites we also took samples for the analyses of inorganic nutrients at the major hydrographic stations.

At 10 stations (Fig. 8-1) we took large volume samples (>150 l) for ultrafiltration using a large volume sampler (batomat). The ultrafiltered DOM (2 l) was frozen for detailed chemical analyses at the AWI. Analyses will include elemental, isotopic and NMR analyses, as well as molecular level analysis for aldoses, D/L amino acids and lignin phenols. At the same stations we also took water samples for humic substance extractions. This will allow us to directly compare two different methods for DOM extraction on identical samples across a salinity gradient. The analyses of the UDOM samples will tell us more about the origin and diagenetic state of DOM delivered by the two rivers.

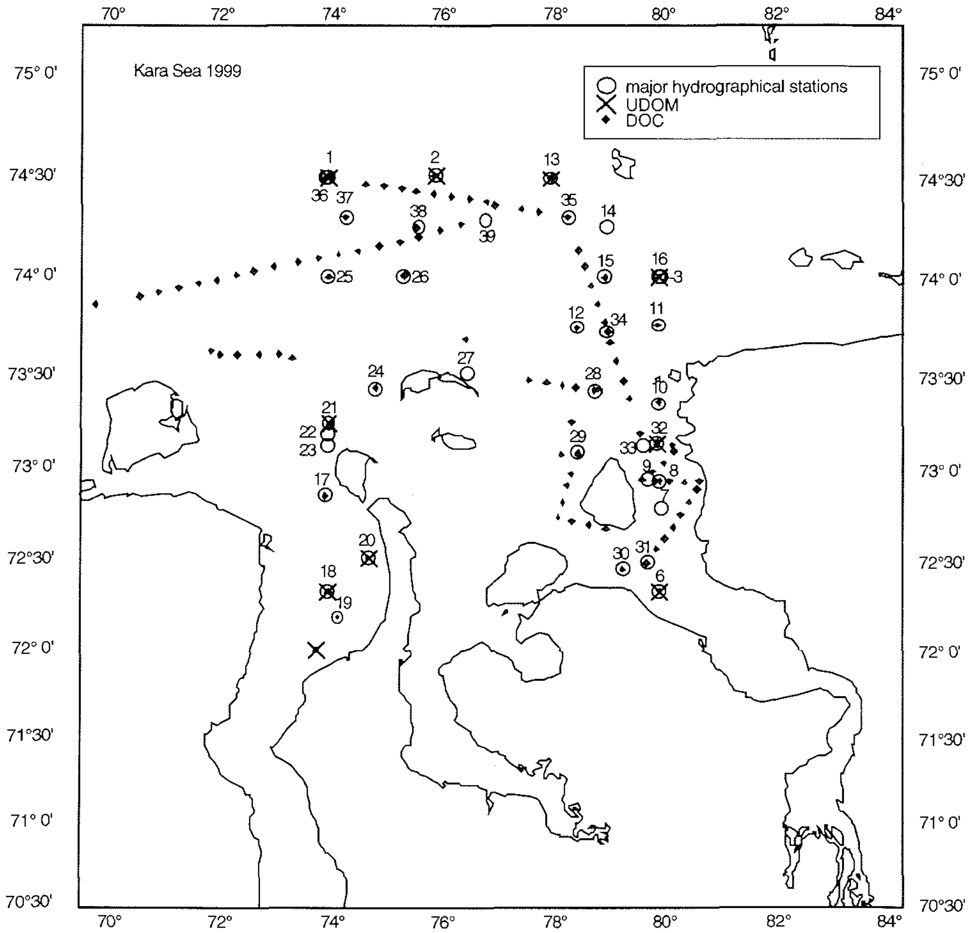

Fig. 8-1
Location of major hydrographical stations as well as DOC sampling and UDOM stations.

In a preliminary experiment we investigated potential flocculation processes during the mixing of river water with high salinity water of marine origin. For this purpose we mixed the river endmember with high salinity water (>32 ‰) to obtain 4 - 5 mixtures with different salt content. After 24 h the mixtures were filtered for the investigation of carbon and nitrogen partitioning between the dissolved and particulate phases.

The nature of the samples and the rather involved analytical investigation do not allow to give preliminary results. However, it is important to mention that we observed colored surface waters in the entire investigated area and even north of 76°N during transit. This indicates that during the summer month river water rich in colored DOM spreads across large areas of the Kara Sea and probably beyond into the open Arctic Ocean. This is consistent with recent findings that riverine DOM is abundant in the central Arctic Ocean and that a significant portion is exported through the Fram Strait into the North Atlantic (Opsahl et al. 1999)

8.2 The carbon and silica cycle in the Kara Sea shelf area

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Introduction

The biogeochemical cycle of carbon is coupled to that of silica by the biological transformation of dissolved inorganic silicious acid to biogenic opal by diatoms and other organisms such as silicoflagellates and radiolarians. Especially diatoms contribute significantly to the fixation and the export of organic carbon from the euphotic zone (Bzrezinski & Nelson, 1995; Wilson et al., 1986) and thus play an important role within the "biological pump" which is responsible for an effective drawdown of atmospheric CO_2 to the deep ocean (Longhurst & Harrisson, 1989). Due to this coupling the content of opal in sediments has been used as a proxy for the reconstruction of palaeoproductivity (e.g. Herbert et al., 1989, Mortlock & Froelich, 1989; Mortlock et al., 1991). A decoupling of both silica and carbon cycling, however, has been stated for various reasons (Nelson et al., 1995; 1996). Especially the availability of iron was found to determine the Si/C/N ratio in diatoms, the preservation potential of opal in the ocean and thus the ratio between C_{org} and silica in sediments (Takeda, 1998; Boyle, 1998).

The continental margins and the fluvial input from the continents to the oceans play a major role in both elemental cycles: the largest part of dissolved silica imported to the ocean is delivered by rivers (DeMaster, 1981, Trèguer et al., 1995). The fluvial nutrient supply supports high coastal primary productivity. The portion of organic carbon delivered by rivers to the oceans is sufficient to play a decisive role in the global carbon cycle, even though the fate of terrestrial organic matter in the ocean is not yet understood (Ittekkot & Lane, 1991, Hedges et al., 1997; Bauer & Druffel, 1998, Hedges & Keil, 1999).

The distribution of both biogenic opal and organic carbon in the Kara sea sediments mirrors the fluvial input (of dissolved silica and particulate matter) by Ob and Yenisei rivers with decreasing contents of opal in offshore direction and high contents of terrigenous organic matter (Nürnberg, 1996; Neumann, 1999; Boucsein et al., 1999). Little is known, however, about the distribution and the composition of opal and particulate organic matter within the water column in this area. Investigations of Kodina et al. (1999) and Lukashin et al. (1999) revealed a complex mixture of autochtonous and allochtonous sources and a dominant influence of the riverine input on the distribution of particulate material in the Ob and Yenisei estuaries. The extensive sampling program carried out during the present expedition will enable us to better understand the pathways of organic matter and silicate in an fluvial controlled shelf area. A comparision with surface sediments and the results of the other subprojects (DOC, nutrients, biomarkers, stable isotopes) will offer a comprehensive dataset which will improve our understanding of the present material transfer and transformation processes. This is also a prerequisite for deciphering the sedimentary record.

Suspended Material and Sediment Sampling Programme

Water samples for filtration of suspended matter were taken with a 24-bottles Niskin rosette water sampler and a large volume sampler (Batomat, 200 l) at 19 stations along the salinity gradient from the Ob and Yenisei estuaries towards 74°30' N. Sampling depths were chosen according to the CTD profiles. In general, water was taken from the low salinity surface layer, from just above the pycnocline and the near bottom water (Table 8-1).

Table 8-1
Stations, sampling depths and corresponding salinities from where suspended material was collected.

Station	Sampling depth and corresponding salinity[$^{o}/_{oo}$]							
BP99-01	Surface	6.0	6 m	12.0			24 m	30.0
BP99-02	Surface	5.5	7,3 m	6.3			26 m	30.0
BP99-03	Surface	6	8 m	9.2			28 m	30.6
							29 m	32.8
BP99-06	Surface	2.6						
BP99-08	Surface	4.7	12 m	5.2			15 m	7.2
BP99-11	Surface	7.4	7 m	7.9			30 m	33.2
BP99-13	Surface	8.8	8 m	10.6	15 m	25.5	31 m	33.2
BP99-17	Surface	8.3	6 m	21.2			14 m	30.5
BP99-18	Surface	1.8	8.7 m	11.7			9 m	26.0
BP99-FEM*	Surface	0.7						
BP99-20	Surface	2.9	11 m	23.7			13 m	27.8
BP99-21	Surface	7.2	10 m	21.3			13 m	30.0
BP99-25	Surface	9.2	8 m	14.9	15 m	29.3	20 m	32.4
BP99-26	Surface	9.8					26 m	32.1
BP99-30	Surface	5.3	10 m	5.7				
BP99-31	Surface	4.7	11 m	4.9			15 m	29.6
BP99-32	Surface	5.9	16 m	8.8			25 m	32.0
BP99-35	Surface	12.7	9 m	21.5			30 m	33.2
BP99-37	Surface	9.9	8.5 m	18.9			26 m	32.6

*Fluvial Endmember Ob, no regular station, sampling with bucket

One part of the obtained water was filtered through preweighted polycarbonate membrane filters (Schleicher & Schuell) with a pore size of 0.4 µm and a diameter of 47 mm for biogenic silica (opal) analyses. The remaining water was filtered through preweighted and precombusted glass fibre filters (GF/F Whatman) with a diameter of 47 and 25 mm, respectively, for organic compound analysis and calculation of total suspended matter concentration. The filters were dried at 40°C for 24 hours.

Additionally, 174 multicorer samples were collected from 22 sediment cores with lengths between 11 and 46 cm. Samples were taken at 5 cm intervals and from individual lithological units (Table 8-2). All sediment samples were stored frozen at -16°C.

Both suspension and sediment samples will be analysed for their content of organic carbon and total nitrogen, carbonate, biogenic opal (silica), lithogenic material as well as for amino acids, amino sugars and carbohydrates.

First Results

It was obvious that the concentration of the total suspended matter decreased with increasing salinity as already described by Lukashin et al. (1999). Within the water column, the distribution of suspended material was related to the strong stratification of the water column with high concentrations in the surface layer and above the pycnocline. The layer just above the pycnocline was sampled only sporadically and showed lowest particle concentrations indicating that only a minor fraction of the suspended material leaves the stable mixed surface layer. Higher concentrations were observed again near the bottom possibly due to resuspension.

Visual inspections with a binocular showed significant differences in the composition of the material delivered by Ob and Yenisei, respectively. The Ob material was dominated by green algae (pers. comm. I. Fetzer) while the Yenisei suspension contained large amounts of lithogenic detritus with only minor contribution of green algae. Diatoms could be identified only in Ob river waters (pers. comm. I. Fetzer).

Table 8-2
Stations of multicorer sampling, number of samples obtained from each station and length of sediment cores.

Station	Sample	Core Length
BP99-01	5	18 cm
BP99-02	5	19.5 cm
BP99-03	7	23 cm
BP99-04	8	28.8 cm
BP99-08	10	40 cm
BP99-11	7	25 cm
BP99-12	9	11 cm
BP99-13	8	20.5 cm
BP99-17	7	31 cm
BP99-18	5	20 cm
BP99-19	10	46 cm
BP99-20	10	37 cm
BP99-24	9	32.5 cm
BP99-25	8	29.5 cm
BP99-28	7	30.5 cm
BP99-29	9	36.5 cm
BP99-30	9	35.2 cm
BP99-31	8	32.5 cm
BP99-32	9	38.5 cm
BP99-35	7	28 cm
BP99-38	8	30.5 cm
BP99-39	9	34.5 cm

8.3 Organic mater and hydrocarbon gases in the river estuaries and adjacent open Kara Sea

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The objective of the work was to extend the study of the impact of the largest Siberian rivers Ob and Yenisei on sedimentation processes in the Arctic Ocean. The main objectives of the study are the determination of genetic types (terrigenous vs marine) of the recent sediment organic matter in the Kara Sea and the investigation of the role of the Kara Sea as a source area of settling material (including organic matter) for other regions of the Arctic Basin. Organic carbon and nitrogen isotope analysis together with other organic geochemistry experimental techniques enable us to get reliable criteria for identification of the terrestrial versus marine sources of the sedimentary organic matter.

During the expedition, specific emphasis has been given to study the peculiarities of the geochemical behavior of organic matter and hydrocarbon gases in the shallow-water shelf area which is influenced by huge river discharge. The working program of the organic geochemistry group during the cruise included:

1. Sampling of sediments, water, particulate matter, plankton, and gases for carbon isotope analysis to reveal regularities of spatial distribution of the two main genetic types of organic matter in the surface horizons of the recent surface sediments; mapping of the inner Kara Sea area by the $\partial^{13}C$-values.

2. Studies of the special features of the geochemical processes involving organic matter in bottom sediments and the water column as deduced from the variations of the main hydrochemical parameters of the marine and riverine water and the dynamics of the parameters of the interstitial water through the vertical sedimentary profiles.

3. Studies of methane and its homologues content in marine/fluvial water and sediments; methane carbon isotope composition and genesis.

In the context of the above mentioned program the following experimental work were carried out:

- Sampling of particulate matter by glass-fiber filtration of the water samples taken through the vertical water profiles.
- Sampling of sediments taken with LBC and GC through the vertical profiles of the recent sediments to squeeze-out the interstitial water, to prepare the gas samples, and to investigate organic matter in the stationary lab by using isotopic, pyrolysis and other techniques. Geochemical

characterization of the sediments: color, redox-potential, water content, density. Sampling of the top, mobile sediment layer (fluff) from MUC.

- Hydrogeochemistry of the interstitial sediment water; content of the basic nutrients: pH, TAlk, total [PO_4-P], organic P, [NO_3-N], [NO_2-N], [NH_4]
- Analysis of hydrocarbon gases: methane and its homologues C_2-C_6. Preparation of concentrated gas samples from the sea water and sediments throughout the water column and sediment vertical profiles.

Preliminary results

Particulate organic matter of the water column.

Particulate organic matter (POM) samples were received by water samples filtered under vacuum through precombusted (450°C) Whatman fiber-glass filters GF/F, pore size of 0,75 µm, diameter of 47mm. Water sample volume for filtration varied between 0,5 to 10 L. A total of 90 POM samples were prepared on 3 to 4 horizons at 28 stations. The Ob transect contains 10 stations from 72° to 74°30' N, the Yenisei transect 17 stations. 12 stations belong to 3 latitudinal transects along 74°0', 74°20', and 74°30´ N. Organic carbon and nitrogen concentration and isotope composition will be measured to determine the biological sources of the organic matter and to calculate the proportion of riverine POM. Data on the carbon isotope composition of the fresh-water, marine phytoplankton, and terrestrial plant remains are important in this aspect.

The information on the POC isotope composition will be compared with similar data from the top mobile layer (0-0,3cm) of MUC surface sediment samples to reveal feasible isotopic effects during the POM transport and settling to the bottom, as well as in biogeochemical transformation in the top sediment horizon.

Geochemistry of sediment interstitial water.

Chemical composition of the sediment interstitial water and its variations with depth mirror the early diagenesis reactions. The evolution of these reactions is largely controlled by the abundance and quality of organic matter.

In 130 sediment samples taken at 19 stations with the LBC (108 samples) and GC (22 samples), the interstitial water was squeezed-out in a cold room under pressure. The depth of sediment sampling in the first case reached 40-45 cm, in the latter case 60 to 485 cm. The following parameters were measured with the classical chemical techniques: TAlk, total [PO_4-P], organic P, [NO_3-N], [NO_2-N], and pH and [NH_4] with the electrochemical technique. A total of more than 500 measurement were performed onboard. Sulfate concentration, chlorinity, and DIC isotope composition will be determined in the home lab later.

Geochemical description of the surface bottom sediments.

All studied surface (0-40cm) sediments contain a top oxidized brown silt layer (clay, silty clay, sandy clay, sand). The thickness of the layer ranges from 0,2-0,5 cm to 5-7 cm. It is a soupy sediment, water content is 65-85%, density 1,0 - 1,1g/cm^3 or higher (up to 1,7 g/cm^3) when sand grains were present. Redox potential is high; Eh-value reaches sometimes +450 mV due to the presence of highly oxidized iron and manganese, which are responsible for the brown, dark-brown or reddish-brown color of the sediment. The layer is especially well developed in the mixing zone of the fresh and saline waters. In many cases the presence of the rich benthic fauna including alive worms, was observed, as well as biogenic remains, especially chitinic and iron-impregnated polychaete tubes. Bioturbation is responsible for deep oxygen penetration (up to 10-15 cm) and for an exchange of liquid compounds between the surface and deeper horizons.

A light olive gray, jelly-like layer occurs underneath the surface brown layer. It is characterized by a water content of 50-60% and much lower Eh-values of +150 mV to 0 due to the presence of Fe^{2+}-ions. Some brownish spots within the gray background resulted from bioturbation and oxygen diffusion from the upper layer.

The boundary to the underlying silt layer is well-defined by increased sediment density (up to 1,3 - 1,5 g/cm^3 and higher), curd-like texture, and dark gray color due to occurrence of black inclusions of iron monosulfides. Black color is getting more intense with depth due to the progress of sulfate reduction. A drop in Eh-values to -270 mV at the depth of 80-210 cm (Station 31 in the Yenisei transect) and transformation of the interstitial water composition result from the continuous evolution of organic diagenesis. The black sediment (Station 31) has a H_2S smell. This is indicative of a highly reductive state of the sediment, the presence of hydrogen, and methane generation by microbial reduction of organogenic CO_2.

Methane and its homologues in the sediments and sea water.

Gas samples were prepared from several sediments horizons taken with LBC and GC at 27 stations (a total of 120 samples). Water samples for gas separation were taken on 3 horizons with RS and partly with MUC (a total of about 90 samples at 28 stations).

A special procedure has been developed to get the gas samples which are satisfactory for measurement of the concentration of the methane saturated and unsaturated homologues C_2-C_6. The technique is based on using salt saturation, high temperature (70 - 80°C) and vacuum to concentrate the minor hydrocarbon compounds into small gas volumes (10-20ml) by using large volumes (200ml) of the initial natural material (sediment, water).

8.4 Geochemistry of particulate organic matter in the water column and sediments

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Introduction

The estuaries of the Ob and Yenisei rivers and the adjacent coastal zone of the southern Kara Sea build-up a large area where mixing of freshwater and seawater occurs. This mixing process is the main mechanism controlling the accumulation and composition of organic matter in the sediments of the study area. The large quantities of freshwater supplied by Ob and Yenisei are the main sources of terrestrially derived organic matter and freshwater algae. Within the mixing zone and further northwards, marine organic matter is an additional organic carbon source supplied from the water column to the bottom sediments. Information on the quantitative amounts of organic carbon derived from the respective sources (i.e. terrestrial/freshwater vs. marine) can be deduced from detailed organic-geochemical investigations of the suspended matter in the water column and the sedimentary organic carbon fraction. Both, bulk data (TOC, C/N-ratios, hydrogen index) as well as quantitative and qualitative biomarker distributions (*n*-alkanes, fatty acids, sterols, hopanoids, etc.) and $\partial^{13}C$ of biomarkers will be used to characterise and identify the different sources of the particulate and sedimentary organic carbon pool. Further information will be obtained by microscopic investigations (maceral analysis) and the use of palynological methods.

Sampling of particulate organic matter and sediments

55 water samples from 18 stations were obtained either by use of a Niskin rosette water sampler or a large volume sampler (Bathomat, 200 L). Sample locations were selected according to the salinity gradient recorded by the CTD-system. Water sampling stations, depth of the subsamples and the respective salinity are given in Table 8-3. In general, three water depths were sampled at each of the selected stations: surface water, the pycnocline (mixed-water) layer and bottom-water. The water samples were filtered through precombusted glas-fiber filters (Whatman GF/F, 47mm diameter). The particulate organic matter collected on these filters was pre-extracted onboard with a mixture of 10ml Dichlormethane/Methanol (1:1) and stored under light-protection at -20°C. The quantitative and qualitative distribution of individual biomarkers (*n*-alkanes, fatty acids, sterols, hopanoids) will be used to investigate the biological sources (marine vs. terrestrial) and the conversion of the particulate organic matter prior to sedimentation.

In addition to the water samples, at 17 stations surface samples and multicorer samples were taken for future organic-geochemical investigations. Subsamples from the multicorer were taken usually at the following depths: 0-1 cm, 1-2 cm, 2-3 cm and then in 5 cm intervals. Additionally, zones of lithological changes were also sampled. The sediment samples were stored frozen (-20°C) and under light-protection in precleaned 100 ml glass-bottles.

At station BP99-31, additional multicorer samples were taken, as at this station darkest sediment colours and a strong H_2S-smell occurred. This material will be used to investigate the formation of sulfur-organic compounds and to check if and what portion of biomarkers is integrated into macromolecular sedimentary organic fractions.

Composition and sources of particulate organic matter in the water column (Preliminary results)

The pre-extraction of the particulate organic matter resulted in different colours of the extraction solvents, ranging from pale/colourless to dark green. Direct comparison of all samples at the end of the cruise allowed to distinguish between 4 colour-groups: dark-green, green, yellow-green and pale/colourless. The colour of the extracts can be used as a first hint for the contents of solvent extractable organic compounds. Most probably, the green and yellow-green colours originate from the extraction of chlorophyll and other pigments and thus might reflect different degrees of phytoplankton productivity in the surface water. Figures 8-2 and 8-3 show the colour-distribution of the particulate organic matter extracts. Although only derived from visual inspection, the so obtained data-set shows a distinct distribution pattern.

Three regions of different solvent-colours are recognised in the surface water-derived particulate organic matter extracts (Fig. 8-2). Low degrees of colouring (yellow-green) appeared in the solvent extracts derived from surface water particulate matter of the Yenisei estuary, whereas samples obtained in the Ob estuary showed the most intensive (dark-green) colour. Further to the north, i.e. in the more marine area, intermediate (yellow-green) colours were recognised. It is speculated that the different degrees of colouring already reflect distinct areas with characteristic compositions of the particulate organic matter in the upper water column. The differences between the Ob and Yenisei estuaries could result from differences in the suspension (nutrients) load and composition, thus controlling the phytoplancton/freshwater algae composition and/or supply of terrestrially derived organic matter in the respective estuary. Differences in the light penetration due to different suspension loads of the Ob and Yenisei rivers might also affect surface water productivity. Towards the more marine areas, marine surface water productivity and mixing with the riverine water masses should result in a mixed organic carbon composition of the suspended matter. This will be verified by detailed organic-geochemical (biomarker) analysis as well as palynological investigations at AWI in Bremerhaven.

Within the intermediate (pycnocline) water layer, which occurred in different depths in the investigated area (see Table 8-3), no such distinct trend or areas with respect to the colour distribution (data not shown here) of the solvent extracts could be observed. This is probably attributed to mineralisation processes and/or grazing by zooplankton. However, it seems that within the pycnocline of the more marine stations, mineralisation and grazing is not as effective as in the riverine stations, as the darkest solvent extract colours are found in the northernmost part of the investigation area.

The colour of the extracts from the particulate matter of the bottom water samples (Fig. 8-3) indicates, that the organic material in the Ob (green) and

Yenisei (yellow-green) samples differ in composition. Comparable to the surface samples, the pale/colourless bottom water extracts derived from the more marine area are distinguishable from the riverine samples. With respect to the portion of suspended organic matter and organic carbon reaching the seafloor, it is interesting to note that the filter extracts derived from bottom water samples showed a similar distribution in colour as the surface water samples, although to a somewhat lesser degree in colour. This indicates, that the portion and composition of the organic carbon reaching the seafloor might represent the situation found in the surface water.

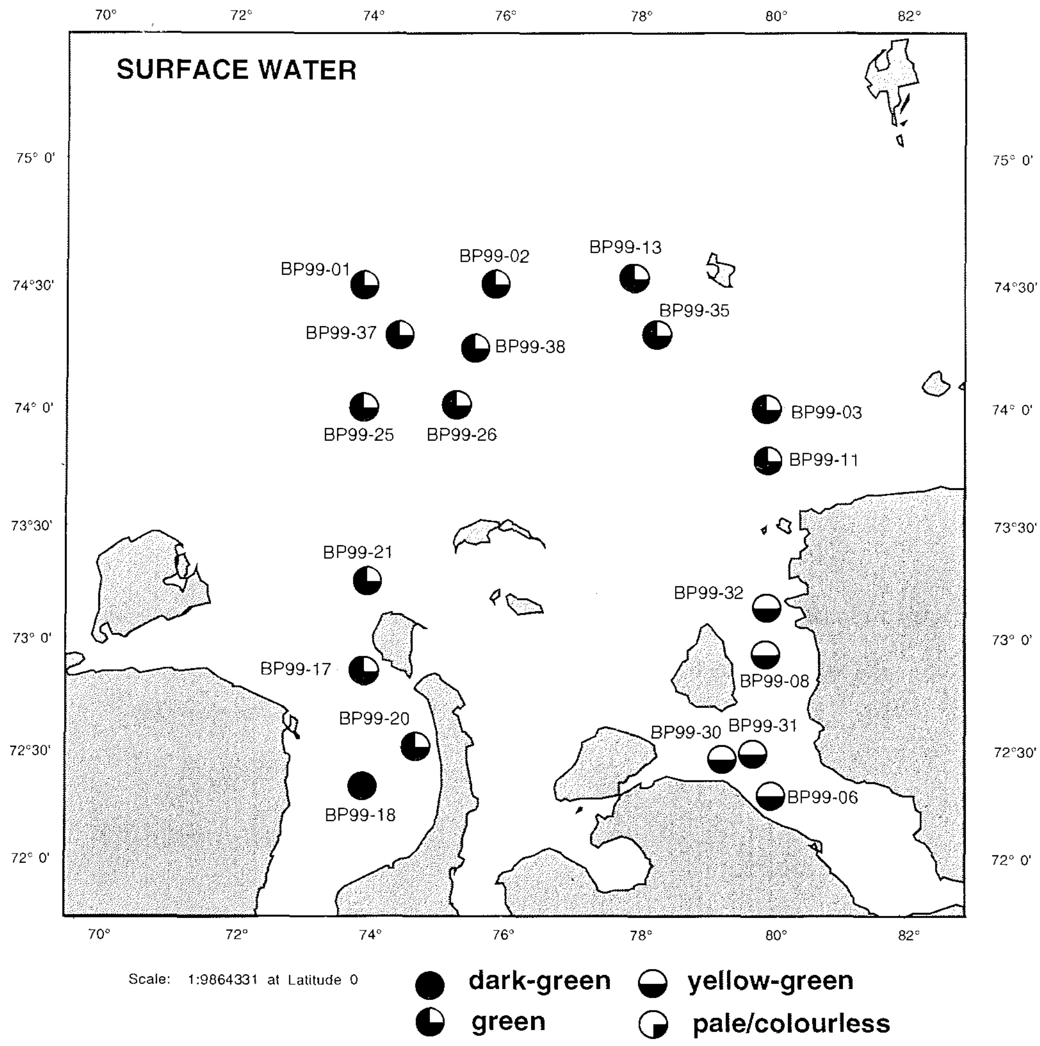

Fig. 8-2
Colour-distribution (solvent-extracts of particulate organic matter) in the surface-water samples.

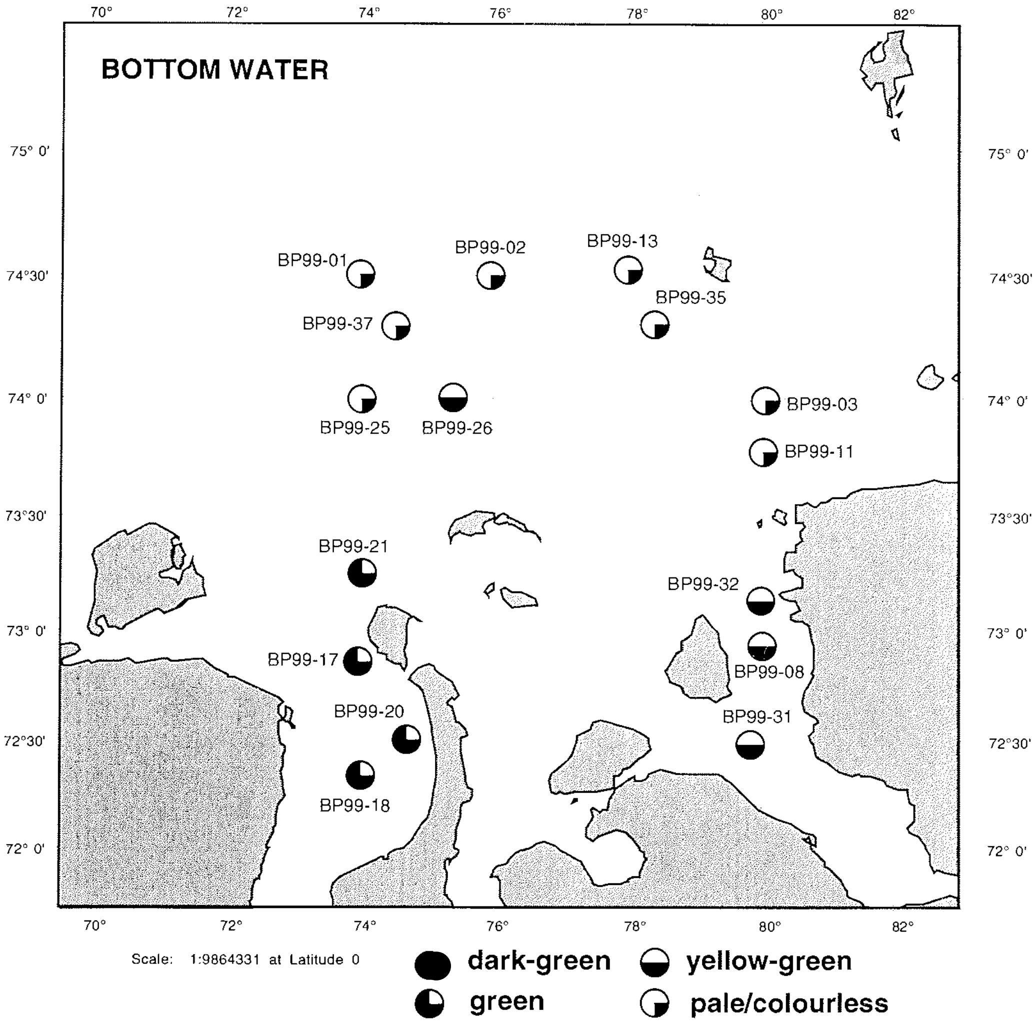

Fig. 8-3
Colour-distribution (solvent-extracts of particulate organic matter) in the bottom-water samples.

Future work

Detailed organic geochemical analyses of the particulate organic matter will be performed in Bremerhaven (AWI). This includes quantitative extraction and chromatographic separation of the respective biomarker classes (*n*-alkanes, fatty acids, steroids, hopanoids, etc.). Structural identification and quantification of the individual biomarkers will be done by gas-chromatography and gas-chromatography/mass spectrometry. Furthermore, $\partial^{13}C$ values will be determined in specific biomarkers.

Table 8-3
Stations used for sampling of particulate organic matter

Station	Sample-depth (m)	Salinity (‰)	Volume (L)
BP99-01	1.5	6	4.8
	6	12	5
	24	30	5
BP99-02	1.5	5.5	4.7
	7.3	6.3	4.8
	26	29.3	10
	27	29.3	5
BP99-03	2	5.9	5
	8	9.2	5
	28	30.6	5
	29	30.6	10
BP99-06	3	2.6	4.5
BP99-08	3	4.7	5
	12	5.2	5
	15	7.2	9.8
BP99-11	2	7.4	5
	7	7.9	5
	30	33.2	10
BP99-13	2	8.8	5
	8	10.6	5
	15	25.5	5
	31	33.1	10
BP99-17	2.5	8.3	5
	6	21.2	5
	16	29.9	10
BP99-18	2.6	1.8	5
	8.7	11.7	5
	9	26	6
BP99-20	2	2.9	5
	11	23.7	5
	14	27.7	7
BP99-21	2	7.2	5
	10	21.3	5
	14	23.5	8
BP99-25	3	9.2	5
	8	14.9	5
	15	29.3	5
	20	32	10
BP99-26	3	9.8	5
	26	32.1	10
BP99-30	3.5	5.3	5
	10	5.7	5
BP99-31	1.5	4.7	9.8
	11	4.9	4.7
	15	29.6	4.7
BP99-32	2.5	5.9	5
	16	8.8	5
	25	31.1	7
BP99-35	2.5	12.7	5
	8.5	21.6	4.8
	30	33.3	10
BP99-37	2.5	9.9	5
	8.5	18.9	4.4
	26	32.3	8

8.5 Research of ecological conditions in the Ob and Yenisei estuaries and adjacent Kara Sea shelf

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There is a serious basis for comprehensive studies of radioecological conditions of the Arctic Ocean. On Novaya Zemlya Islands more than 80 nuclear explosions (air, underground, underwater) were performed in the past. By this way as much as about 1,3 million curie Cs-137 found its way into the earth atmosphere. 48 underground explosions were realized between 1965-1991, which have resulted in local contaminations on land. With rain and snow, these contaminations could penetrate into marine environments.

In the present days, liquid and solid radioactive wastes, including reactors of nuclear submarines and the ice breaker "Lenin", flooded in 1965-1968 and until 1992, have fixed a radioactivity only in immediate proximity from the flooded subjects. At the same time, however, they are potential sources of radioactive contamination of the Kara Sea and the entire Arctic Ocean.

A certain influence on the radioecological situation of the Kara Sea can be related to the discharge of the great Siberian rivers Ob and Yenisei, which can transfer a radioactivity from emergencies in plants (Krasnoyarsk and P.O. "Majak") or through washing-out from large drainage territories during vernal high waters.

The long way of radioactive waters from the Irish Sea (Sellafield) by the Norwegian Current can be identified in the Norwegian, Barents and Kara seas. Since 1986 the level of radioactivity of wastes in the Irish sea has decreased, and on this background the polluted water mass from Baltic and (to a lesser degree) Northern seas with the component of "Chernobyl" activity could be traced.

Our previous studies in 1997 testify a rather low level of radioactivity in the Kara Sea environment, especially in regions of the estuaries. In studies of the spatial distribution of radionuclides in bottom sediments the influence of the sediment lithology on the level of their radioactivity could be determined. In some samples from sediment cores significant variations of the contents of specific radionuclides, especially Cs-137, with depth were observed.

The continuation of these studies was conducted during the present expedition. The main tasks of the radioecological studies onboard RV "Academik Boris Petrov" in 1999 were the following:

- Study of pecularities of horizontal distribution of radioactivity in the river estuaries and adjacent shelf of the Kara Sea;
- estimation of accumulation rates in estuaries by using the data of vertical distribution of specific radionuclides and analysis of Pb-210 throughout the core;

- study of kinetic parameters of sorption and desorption of radionuclides Cs-137 and Sr-90 (method of radioactive tracers) by various sediment types in experiments onboard;

- study of the level of contents of cesium, strontium and plutonium radionuclides throughout the water column (sampling from various horizons), with special interest on the relationship to the climatic peculiarities of the summer season 1999, characterized by the occurrence of sea ice in large parts of the Kara Sea and the late ice disappearance from the estuaries; and

- evaluation of the role of suspended matter in accumulation of radionuclides from sea water based on the data of filtration of large (up to ~ 1000 L.) water volumes through membrane filters of various pore size (0,45 and 1,0 µm).

For this study, the water column and bottom sediments were sampled at 39 stations (Tables 8-4 and 8-5).

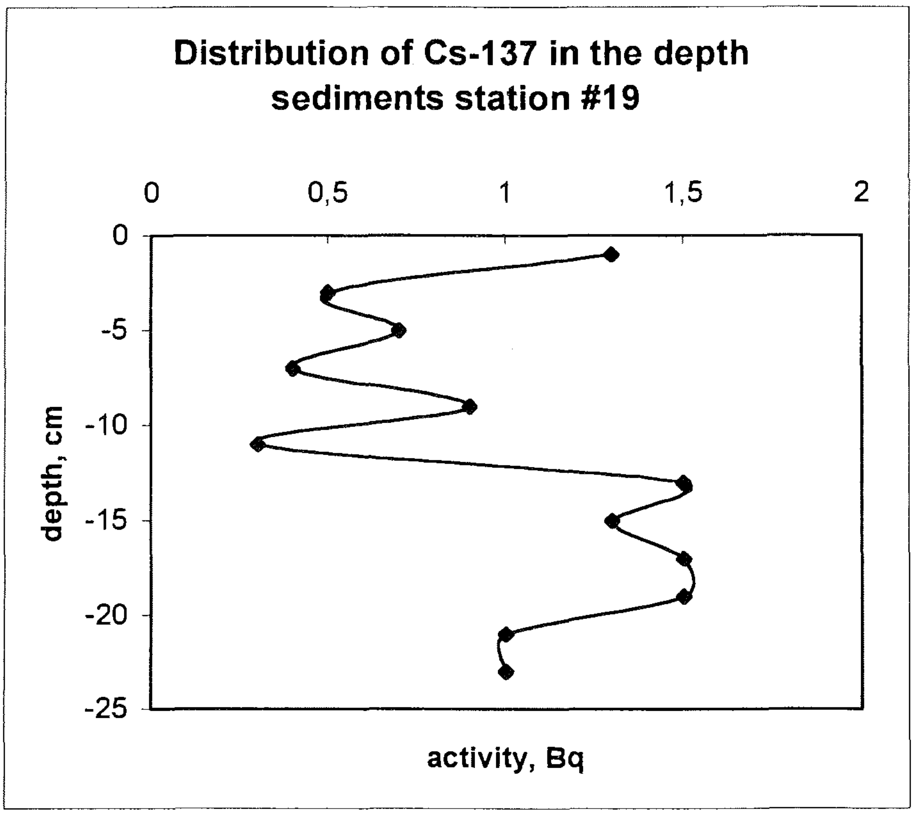

Fig. 8-4
Distribution of Cs-137 vs. depth at station BP99-19.

For evaluation of possible sources of radioactive contamination of the water, water surface samples for analysis of Cs-137, Sr-90 and Pu-239,240 were taken. During the expedition a direct gamma-spectrometric determination of Cs-137 in sediment samples was conducted onboard as well as the determination of radionuclides Cs-137 and Sr-90 in water samples by preliminary radiochemical concentration and measurement of selected preparations. The results of the sample analysis are presented in Tables 8-6 and 8-7 and Figure 8-4.

Preliminary results show a significant difference in the level of activity of the bottom sediments in the Ob and Yenisei estuaries, that is related to different lithologies of the deposits. An increase of Cs-137 contents in the subbottom layer of water with a high salinity was observed. The distribution of Sr-90 in the water samples was rather uniform. In the vertical Cs-137 distribution significant variations were determined. The relationship to time frames of possible anthropogenic contamination of the study area will be conducted after the determination of accumulation rates in this region, based on the data of the natural Pb-210 distribution.

Considering the data on radionuclide variations in bottom sediments together with the data on the vertical natural Pb-210 distribution will allow to point-out the problem of the time frames of some local anthropogenic contamination in the study area.

Table 8-4
Geological sampling of Box Cores.

Station	^{137}Cs		^{90}Sr	$^{239,240}Pu$	Heavy elements	
	Sampling	Analysis on board			Sampling	Analysis on board
-99-01			+	+		
0 - 2	+	+			+	+
2 - 4	+	+				
4 - 6	+	+				
6 - 8	+	+				
8 - 10	+	+				
10 - 12	+	+				
12 - 14	+	+				
14 - 16	+	+				
16 - 18	+	+				
18 - 20	+	+				
-99-02	+		+	+	+	+
-99-03	+		+	+	+	+
-99-04	+		+	+	+	+
-99-05						
-99-06 0 -			+	+		
2	+	+			+	+
2 - 4	+	+				
4 - 6	+	+				
6 - 8	+	+				
8 - 10	+	+				
10 - 12	+	+				
12 - 14	+	+				
14 - 16	+	+				
16 - 18	+	+				
18 - 20	+	+				
20 - 22	+	+				
22 - 24	+	+				
-99-07	+		+	+	+	+
-99-08	+		+	+	+	
-99-09						
-99-10	+		+	+	+	
-99-11	+		+	+	+	
-99-12	+		+	+		
-99-13	+		+	+	+	
-99-14						
-99-15						
-99-16						
-99-17	+		+	+	+	
-99-18	+		+	+	+	

Table 8-4
cont.

Station	^{137}Cs		^{90}Sr	$^{239,240}Pu$	Heavy elements	
	Sampling	Analysis on board			Sampling	Analysis on board
-99-20	+		+	+	+	
-99-21	+		+	+	+	
-99-22						
-99-23						
-99-24	+		+	+	+	
-99-25	+		+	+	+	
-99-26						
-99-27						
-99-28	+		+	+	+	
-99-29	+		+	+	+	
-99-30	+		+	+	+	
-99-31	+		+	+	+	
-99-32	+		+	+	+	
-99-33						
-99-34						
-99-35						
-99-36						
-99-37	+		+	+	+	
-99-38	+		+	+	+	
-99-39	+		+	+		

Table 8-5
Sampling and analysis of water

Stat.	^{137}Cs		^{90}Sr		$^{239,240}Pu$	Heavy elements	
	Sampling	Analysis on board	Sampling	Analysis on board		Sampling	Analysis on board
-99-01	+(s,b)	+(s,b)	+(s,b)	+(s,b)			
-99-02							
-99-03	+(s,b)	+(s,b)	+(s,b)	+(s,b)	+		
-99-04							
-99-05						+	+
-99-06	+(s)	+(s)	+(s)	+(s)	+		
-99-07							
-99-08							
-99-09							
-99-10	+(b)	+(b)	+(b)	+(b)	+		
-99-11							
-99-12							
-99-13	+(s)	+(s)	+(s)	+(s)	+		
-99-14							
-99-15							
-99-16	+(s)	+(s)	+(s)	+(s)			
-99-17	+(b)	+(b)	+(b)	+(b)	+		
-99-18	+(s)	+(s)	+(s)	+(s)	+		
-99-19	+(s)	+(s)	+(s)	+(s)			
-99-20	+(b)	+(b)	+(b)	+(b)	+		
-99-21							
-99-22							
-99-23							
-99-24	+(b)	+(b)	+(b)	+(b)	+		
-99-25	+(b)	+(b)	+(b)	+(b)	+		
-99-26	+(s)	+(s)	+(s)	+(s)	+		
-99-27							
-99-28							
-99-29							
-99-30			+(s)	+(s)	+		
-99-31	+(s,b)	+(s,b)	+(s,b)	+(s,b)	+		
-99-32	+(b)	+(b)	+(b)	+(b)	+		
-99-33			+(b)	+(b)	+		

Table 8-6

Results of measurements of Cs-137 (specific activity [Bq/m^3]) in samples of a sea water in the 32 cruise of RV Akademik Boris Petrov.

sample	station	Latitude	Longitude	Depth, m	specific activity Bq/m^3
1	-	71º56'	42º12'	3	14 ± 2
2	-	75º53'	74º30'	3	8 ± 2
3	1	74º29'9"	73º59'	24	49±5
4	1	74º 29'9"	73º59'	3	4±2
5	3	74º00'09,5"	79º59'8"	26	60±10
6	3	74º00'09,5"	79º59'8"	3	7±3
7	6	72º20'3"	79º59'63"	5	8±2
8	10	73º21'72"	79º59'7'	26	12±2
9	13	74º30'	77º59'54"	3	11±5
10	16	74º00'09,2"	79º58'72"	3	6±3
11	17	72º49'99"	74º00'9"	16	9±3
12	18	72º19'8"	74º00'	3	<0,3
13	19	72º01'47"	74º11'38,3"	3	<0,3
14	20	72º33'16"	74º36'63"	14	9±3
15	24	73º26'03"	74º52'26"	16	14±5
16	25	74º00'	74º00'	20	17±4
17	26	74º00'19,2"	75º21'37,8"	3	5±2
19	31	72º29'10"	79º45'6"	3	3±2
20	31	72º29'10"	79º45'6"	14	12±4
21	32	73º08'02"	79º57'23"	21	15±4
23	37	74º18'03"	74º22'09"	26	15±4
24	38	74º14'96"	75º36'25"	3	4±3
25	39	74º17'97,7"	76º49'85"	21	6±4
26	-	72º38'	60º03'	3	6±4
27	-	70º09'5"	56º02'	3	8±3
28	-	69º25'	41º59'	3	15±4

Table 8-7
Results of measurement of Sr-90 in samples of sea water.

Station	Depth, m	Latitude	Longitude	S, ‰	Activity Bq/m^3
1	24	74° 30'	73°59'	30.0	3,21±0,64
1	3	74° 30'	73°59'	4.7	3,91±0,78
3	26	79°59'	74°30'	31.0	0,96±0,19
3	5	79°59'	74°30'	6.0	3,18±0,64
6	4	72°20'	79°59'	2.6	8,0±1,60
10	26	73° 21'	79°59'	32.7	2,25±0,45
13	3	74° 30'	77° 59'	9.0	2,75±0,56
16	3	74° 00'	80° 30'	7.0	2,30±0,46
17	16	72° 49'	74° 00'	30.0	1,31±0,26
18	3	72°19'	73° 59'	1.8	0,81±0,16
19	3	72°01'	74° 11'	2.6	3,65±0,73
20	14	72°33'	74°36'	27.0	3,67±0,73
24	16	73° 26'	74°52'	28.0	0,76±0,15
25	20	74° 00'	74° 00'	32.0	2,54±0,51
26	3	74° 00'	75° 21'	10.0	1,87±0,37
30	3	72° 27'	79° 17'	5.3	3,73±0,75
31	3	72° 29'	79° 45'	4.4	4,27±0,85
31	14	72° 29'	79° 45'	30.0	1,69±0,34
32	21	73° 08'	79° 57'	31.6	3,46±0,69
33	14	73° 08'	79° 49'	9-15	1,43±0,29
38	3	74° 14'	75° 36'	11.0	1,88±0,38
39	3	74° 14'	76° 46'	31.0	2,09±0,42

8.6. The identification of radionuclide sources in the mixing zone of river and marine waters in the Kara Sea

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One of the purposes of research during the second joint Russian-German expedition in the Kara Sea was collecting additional bottom sediment samples in the Ob and Yenisei estuaries. This activity is a logical prolongation of research started in 1995 and directed to the identification of radioactive contamination sources, related to the great Siberian rivers Ob and Yenisei (Matthiessen and Stepanets, 1998; Matthiessen et al., 1999).

During the 32-th cruise of the RV *Akademik Boris Petrov*, 20 sediment sub-cores with a diameter of 105 mm were taken from LBC box cores. These sub-cores were sampled in layers of 10 (20) mm thickness each and stored in plastic jars. Thus, a total of 397 samples were obtained (Table 8-8).

Table 8-8
List of samples.

	Station	Number of Layers	Thickness of Layers (mm)	Height (mm)	Equipment
1	BP 99-01	23	10	230	Box Corer
2	BP 99-02	28	10	280	Box Corer
3	BP 99-03	26	10	260	Box Corer
4	BP 99-04	36	10	360	Box Corer
5	BP 99-06	36	10	360	Box Corer
6	BP 99-08	15	10	150	Box Corer
7	BP 99-10	38	10	380	Box Corer
8	BP 99-17	10	20	200	Box Corer
9	BP 99-18	1	350	350	Box Corer
10	BP 99-19	40	10	400	Box Corer
11	BP 99-20	35	10	350	Box Corer
12	BP 99-24	35	10	350	Box Corer
13	BP 99-25	5	20	100	Box Corer
14	BP 99-29	5	20	100	Box Corer
15	BP 99-30	5	20	100	Box Corer
16	BP 99-31	10	20	200	Box Corer
17	BP 99-32	15	20	300	Box Corer
18	BP 99-35	17	20	340	Box Corer
19	BP 99-38	2	20	40	Box Corer
20	BP 99-39	15	20	300	Box Corer

All samples will be analyzed for Cs-137, Sr-90, Co-60, and K-40 by radiochemistry/ alpha spectrometry and mass spectrometry. All samples will also be analyzed for stable isotopes Na, K, Ca, Fe, Mg, Al, Cu, Mn, Mo, Zn, Co, Ti, Bi, V, Ag, Pb, Be, Co, Cr, As, S, Br, Rb, Zr, Sr, Sb, Te, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Au, Ba, Br, Ir, Ga, Cd, Gd, Re, Sc by the method of instrumental neutron-activation analysis (INAA). Furthermore, part of the samples will be analyzed for Pu isotopes. Pb-210 analysis by alpha spectrometry/radiochemistry method is also planned to determine absolute ages of sediment layers and sediment accumulation rates.

On the basis of the data obtained during three expeditions and the development of efficient application methods, the geochemical characteristics of the sediment material supplied by the Ob and Yenisei rivers may become an instrument for tracing of sediments of various origin up to the area of their complete mixing. Accordingly, the forecast of the distribution of artificial radionuclides associated with solid particles of the Ob or Yenisei seems to be possible.

Within different methods of studying ecological conditions in shelf zones of the Arctic Ocean data on heavy elements in water and bottom sediment samples are of major relevance. Thus, a special task has been in obtaining information about the content and distribution of heavy elements, including anthropogenic effects, in high-accumulation-rate areas of the Ob and Yenisei estuaries and the adjacent Kara Sea.

The contents of heavy elements are determined by a X-Ray-fluorescence method using the X-ray spectrometer SPARK-1, which allows to determine chemical elements from Ti up to Sr and from Ba up to U. The analysis is carried-out by the method of external standards. For this study, samples were taken on 24 stations. Onboard the vessel samples from 12 stations were already analyzed for 12 elements. In addition, 10 pore-water samples were analyzed after concentration of the samples into small-volume solution.

The preliminary results (Table 8-9) show significant differences in the content of different elements in sediment samples from the Ob and Yenisei estuaries, that can be explained by the various geochemical nature of bottom sediments of these rivers. Future X-ray-fluorescence analysis of samples in the home laboratory, including the use of ratios of the various elements to a "reference" element, will allow in more detail to evaluate the influence of the geological nature of the rivers on the element distribution in deposits from the mixing zone and to reveal the possible contribution of anthropogenic effects on the heavy element distribution in the study area.

Table 8-9
Results of determination of the heavy elements in the sediment samples by X-ray fluorescent method.

Element station	Rb (ppm)	Th (ppm)	Pb (ppm)	Zn (ppm)	Cu (ppm)	Ni (ppm)	Co (ppm)
1	152	<10	<10	24	130	24	16
2	181	54	63	92	186	32	23
3	131	16	<10	138	112	54	44
4	<10	22	<10	128	140	78	47
6	48	12	<10	132	64	80	39
7		<10	<10	144	92	88	46
8	62	<10	<10	127	48	69	46
10		<10	<10	125	70	72	45
11		<10	<10	116	64	51	39
13		<10	<10	93	(9)	34	27
17		<10	<10	109	44	42	34
18		<10	<10	117	31	53	47
Water st6	40	2.30	4.50				

Element station	Fe (%)	Mn (%)	Cr (ppm)	V (ppm)	Ba (%)	Ti (%)	
1	1.8	0.14	50	64	0.07	0.23	
2	3.1	0.19	98	111	0.063	0.39	
3	6.9	0.32	162	172	0.02	0.44	
4	7.8	0.37	77	144	<0.002	0.51	
6	6.0	0.28	82	111	<0.002	0.50	
7	(8.5)	(0.88)	112	142	0.02	0.56	
8	(8.7)	0.71	106	160	0.01	0.57	
10	(8.6)	(0.93)	104	151	~0.002	0.58	
11	7.3	0.37	128	191	~0.002	0.54	
13	5.2	0.27	55	91	<0.002	0.38	
17	6.9	0.61	67	108	<0.002	0.47	
18	(9.3)	0.46	127	154	<0.002	0.59	
Water st6							

9 References

Aagaard, K. and Carmack, E.C., 1989. The role of sea ice and other fresh water in the Arctic circulation. J. Geophys. Res., **94** (C10): 14485-14498.

Bauer, J.E. and Druffel, E.R.M., 1998. Ocean margins as a significant source of organic matter to the deep open ocean. Nature, **391**: 482-484.

Behrends, M. (1999) Distribution Patterns of Heavy Minerals in Siberian Rivers, the Laptev Sea and the eastern Arctic Ocean: An Approach to Identify Sources, Transport and Pathways of Terrigenous Matter. In Land-Ocean Systems in the Siberian Arctic: Dynamics and History (edited by Kassens, H., H.A. Bauch, I. Dmitrenko, H. Eicken, H.W. Hubberten, M. Melles, J. Thiede and L. Timikhov) Berlin (Springer Verlag), 265-277.

Boucsein, B., Fahl, K., Siebold, M., and Stein, R., 1998. Quantity and quality of organic carbon in surface sediments of the Ob and Jensesei estuaries and adjacent coastal areas - Marine productivity and terrigenous input. In: Matthiessen, J., Stepanets, O., Stein, R., Fütterer, D., and Galimov, E. (Eds.), The Kara-Sea Expedition "Boris Petrov" 1997: First Results of a Joint Russian-German Pilot Study, Ber. Polarforsch., **300**: 116-126.

Boyle, E., 1998. Pumping iron makes thinner diatoms. Nature, **393**: 733-734.

Brodskii, K.A., 1967. Calanoida of the far eastern seas and polar basin of the USSR, Zoological Institute of the Academy of Sciences of the USSR, No.35, translated from Russian (Original published by the Zoological Institute, Moskva - Leningrad 1950), Israel Program for Russian Translation, Jerusalem.

Burenkov, VI and AP Vasil'kov. 1995. The influence of runoff from land on the distribution of hydrologic characteristics of the Kara Sea. Oceanlogy, 34:591-599.

Dahl, F., 1923. Crustacea. In: Tierwelt Deutschlands, Band. 9, Gustav-Fischer Verlag, Jena

DeMaster, D.J., 1981. The supply and accumulation of silica in the marine environment. Geochim. Cosmochim. Acta, **45**: 1715-1732.

Dussart and Defay, 1995. Copepoda: Introduction in the Copepoda (fresh water species), SPB Academic Publishing, London.

Fahl, K. and Stein, R., 1997. Modern organic-carbon-deposition in the Laptev Sea and the adjacent continental slope: Surface-water productivity vs. terrigenous input. Org. Geochem., **26**: 379-390.

Galimov, E.M., Laverov, N.P., Stepanets, O.V. and Kodina, L.A., 1996. Preliminary results of ecological and geochemical investigation of the Russian Arctic seas. Geochem. Intern., **34** (7): 1-18.

Gordeev, V.V., Martin, J.M., Sidorov, I.S., and Sidorova, M.V., 1996. A reassessment of the Eurasian river input of water, sediment, major elements, and nutrients to the Arctic Ocean. American Journal Science, **296**: 664-691.

Grosswald, M.G., 1990. Late Pleistocene ice sheet in the Soviet Arctic. In: V.M. Kotlyakov and V.E. Sokolov (Eds.), Arctic Research - Advances and prospectives (Vol. 2), Proceedings of the conference of Arctic and Nordic Countries on coordination of research in the Arctic, Academy of Sciences of the USSR, Leningrad, December 1988, p. 18-23.

Hargrave, B.T., von Bodungen, B., Stoffyn-Egli, P and Mudie, P.J., 1993. Seasonal variability in particle sedimentation under permanent ice cover in the Arctic Ocean. Cont. Shelf Res., **14**: 279-293.

Hebbeln, D. and Wefer, G., 1991. Effects of ice coverage and ice-rafted material on sedimentation in the Fram Strait. Nature, **350**: 409-411.

Hedges, J.I. and Keil, R.G., 1999. Organic geochemical perspectives on estuarine processes: sorption reactions and consequences. Mar. Chem., **65**: 55-65.

Herbert, T.D., Curry, W.B., Barron, J.A., Codispoti, L.A., Gersonde, R., Keir, R.S., Mix, A.C., Mycke, B., Schrader, H., Stein, R. and Thiersten, H.R., 1989. Geological reconstruction of marine productivity. In: Productivity in the Ocean: Present and Past. W.H. Berger, V.S. Smetacek and G. Wefer (Eds.), 409-428, Wiley & Sons, New York.

Ittekkot, V. and Laane, R.W.P.M., 1991. Fate of riverine particulate organic matter. In: Biogeochemistry of major world rivers. E.T. Degens, S.Kempe and J.E. Richey (eds.), SCOPE, Wiley & Sons Ltd., 356 pp.

Ivanov, G.I., Shevchenko, V.P., and Nescheretov, A.V., 1995. Cruise in the Saint Anna Trough. Priroda (Nature), **10**: 56-62 (in Russian).

Kleiber, H.P. and Niessen, F., 1999. Late Pleistocene Paleoriver Channels on the Laptev Sea shelf - Implications from Sub-Bottom Profiling. In Land-Ocean Systems in the Siberian Arctic: Dynamics and History (edited by Kassens, H., H.A. Bauch, I. Dmitrenko, H. Eicken, H.W. Hubberten, M. Melles, J. Thiede and L. Timikhov) Berlin (Springer Verlag), 657-665.

Kleiber, H.P. and Niessen, F., 2000. Variations of continental discharge pattern in space and time - Implications from the Laptev Sea continental margin, Arctic Siberia. Int. Journ. Earth Sci. (Geol. Rundschau), in press.

Kodina, L.A., Bogacheva, M.P., Vlaslova, L.N., Meschanov, S.L. and Ljutsarev, S.V., 1999. Isotope geochemistry of particulate organic carbon in the Yenisei Estuary: Sources and regularities of distribution. In: Matthiessen, J., Stepanets, O., Stein, R., Fütterer, D., and Galimov, E. (Eds.), The Kara-Sea Expedition "Boris Petrov" 1997: First Results of a Joint Russian-German Pilot Study, Ber. Polarforsch., **300**: 91-101.

Lampitt, R.S. and Antia, A.N., 1997. Particle Flux in deep seas: regional characteristics and temporal variability. Deep-Sea Res., **44**: 1377-1402.

Lapina, N.N., 1965. The determination of distribution paths of sediments, based on mineralogical investigations of marine deposits (example Laptev Sea). Uchennye Zapiski NIIGA, Ser. Region. Geol., **7**: 139-157 (in Russian).

Levitan, M.A., Dekov, V.M., Gorbunaov, Z.N., Gurvich, e.G., Muyakshin, S.L., Nürnberg, D., Pavlidis, M.A., Ruskova, N.P., Shelekova, E.S., Vasilikov, A.V. and Wahsner, M., 1996. The Kara Sea: a reflection of modern environment in grain size, mineralogy, and chemical composition of the surface layer of bottom sediments. In: R. Stein, G. Ivanov, M. Levitan and K. Fahl (eds.). Surface sediment composition and sedimentary processes in the central Arctic Ocean and along the Eurasian Continental Margin. Ber. Polarforsch., **212**: 58-80.

Lisitzin, A.P. and Vinogradov, M.E., 1995. International high-latitude expedi-tion in the Kara Sea (the 49th cruise of the R/V Dmitriy Mendeleev). Oceanology, **34** (5): 583-590.

Lisitzin, A.P., 1995. The marginal filter of the ocean. Oceanology, **34**(5): 671-682.

Lukashin, V.N., Ljutsarev, S.V., Krasnyuk, A.D., Shevchenko. V.P. and Rusakov, V.Y., 1999. Suspended particulate matter in the Ob and Yenisei estuaries. In: Matthiessen, J., Stepanets, O., Stein, R., Fütterer, D., and Galimov, E. (Eds.), The Kara-Sea Expedition "Boris Petrov" 1997: First Results of a Joint Russian-German Pilot Study, Ber. Polarforsch., **300**: 155-178.

Matthiessen, J. and Boucsein, B., 1999. Palynomorphs in surface water of the Ob and Yenisei estuaries: Organic-walled tracers for riverine water. In: Matthiessen, J., Stepanets, O., Stein, R., Fütterer, D., and Galimov, E. (Eds.), The Kara-Sea Expedition "Boris Petrov" 1997: First Results of a Joint Russian-German Pilot Study, Ber. Polarforsch., **300**: 71-78.

Matthiessen, J. and Stepanets, O.V. (Eds.), 1998. Scientific Cruise Report of the Kara Sea Expedition of RV "Akademik Boris Petrov" in 1997. Ber. Polarforsch., **266**, 102 pp.

Matthiessen, J., Stepanets, O.V., Stein, R., Fütterer, D.K. and Galimov, E.M. (Eds.), 1999. The Kara Sea Expedition of RV "Akademik Boris Petrov" in 1997: First Results of a joint Russian-German Pilot Study. Ber. Polarforsch., **300**, 239 pp.

Mortlock, R.A. and Froehlich, P.N., 1989. A simple method for the rapid determination of biogenic opal in marine sediments. Deep-Sea Res., **36**, 1415-1426.

Mortlock, R.A., Charles, C.D., Froelich, P.N., Zibello, M.A., Saltzman, J., Hays, J.D., and Burckle, L.H., 1991. Evidence for lower productivity in the Antarctic Ocean during the last glaciation. Nature, **351**: 220-223.

Neumann, K, 1999: Nitrogenous organic matter in surface sediments in the estuaries of Ob and Yenisei rivers. In: Matthiessen, J., Stepanets, O., Stein, R., Fütterer, D., and Galimov, E. (Eds.), The Kara-Sea Expedition "Boris Petrov" 1997: First Results of a Joint Russian-German Pilot Study, Ber. Polarforsch., **300**: 110-115.

Nürnberg, D, 1996: Biogenic barium and opal in shallow eurasian shelf sediments in relation to the pelagic Arctic Ocean environment. In: R. Stein, G. Ivanov, M. Levitan and K. Fahl (eds.). Surface sediment composition and sedimentary processes in the central Arctic Ocean and along the Eurasian Continental Margin. Ber. Polarforsch., **212**: 96-118.

Opsahl, S., R. Benner, R.M.W. Amon, 1999. Major flux of terrigenous dissolved organic matter through the Arctic Ocean. Limnology and Oceanography: in press.

Pavlov, V.K. and Pfirman, S.L., 1995: Hydrographic structure and variability of the Kara Sea: Implications for pollutant distribution. Deep Sea Res., **42**: 1369-1390.

Sars, G.O., 1903. An account of the crustacea of Norway, Vol. IV, Bergen Museum, Bergen.

Stein, R. and Fahl, K., 2000. Holocene Accumulation of Organic Carbon at the Laptev Sea Continental Margin (Arctic Ocean): Sources, pathways, and sinks. Geo-Mar. Lett., in press.

Stein, R. and Korolev, S., 1994. Shelf-to-basin sediment transport in the eastern Arctic Ocean. In: Kassens, H., H.W. Hubberten, S.M. Pryamikovund R. Stein (Eds.): Russian-German Cooperation in the Siberian Shelf Seas: Geo-System Laptev-Sea. Ber. Polarforsch., **144**: 87-100.

Stein, R., 1996. Organic-carbon and carbonate distribution in surface sediments from the Eastern Central Arctic Ocean and the Eurasian Continental Margin: sources and pathways. In: R. Stein, G. Ivanov, M. Levitan and K. Fahl (eds.). Surface sediment composition and sedimentary processes in the central Arctic Ocean and along the Eurasian Continental Margin. Ber. Polarforsch., **212**: 243-267.

Subba Rao, D.V. and Platt, T., 1984. Primary production of Arctic waters. Polar Biol., **3**: 191-210.

Takeda, S, 1998. Influence of iron availability an nutrient consumption ratio of diatoms in oceanic water. Nature, **393**: 774-777.

Tréguer, P., Nelson, D.M., Van Bennekom, A.j., DeMaster, D., Leynaert, A. and Quéguiner, B., 1995. The silica balance in the World Ocean: A reestimate. Science, **68**: 375-379.

Wahsner, M., Müller, C., Stein, R., Ivanov, G., Levitan, M., Shelekhova, E. and Tarasov, G., 1999. Clay-mineral distribution in surface sediments of the Eurasian Arctic Ocean and continental margin as indicator for source areas and transport pathways -A synthesis-. Boreas, **28**: 215-233.

10 Annex

10.1 Station list

Station Nr.	Date	Time (GMT)	Latitude ° N	Longitude ° E	Depth (m)	Gear Nr.	Activity	Recovery (cm)
BP99-01	24.08.1999	19:00	74° 29.822′	73° 59.616`	30.1		ST	
							CTD/ RS	
							PN/ PHN/LVS	
	25.08.1999	5:00				/01-03 (3)	LBC	
						/04-05 (2)	MUC	15
		8:19						
BP99-02	25.08.1999	11:37	74° 30.04`	75° 55.63`	34.5		CTD/ RS	
							PN/ PHN/LVS	
		14:15				/01-03 (3)	LBC	
						/04-05 (2)	MUC	18
						/06	GC 500	230
		17:41				/07	BD	
BP99-03	26.08.1999	2:00	73° 59.877`	80° 0.555`	36.2		CTD/ RS	
							PN/ PHN/LVS	
		6:30				/01-03 (3)	LBC	
						/04-05 (2)	MUC	25
						/06	GC 500	485
						/07	GC 800	527
						/08	BD	
		11:03						
BP99-04	26.08.1999	16:30	73° 24.89`	79° 40.48`	32.3	/01-03 (3)	LBC	
						/04-05 (2)	MUC	25
						/06	GC 800	795
						/07	SGC	-
						/08	BD	
		20:11						
BP99-05	26.08.1999	21:06	73° 30.097`	80° 0.662`	38.4	/01	GC	410
		22:00						
BP99-06	27.08.1999	4:30	72° 17.14`	80° 01.88`	35133		CTD/ RS	
							PN/ PHN/LVS	
						/01	LBC	
		6:30						
BP99-07	27.08.1999	9:22	72° 47.97`	80° 2.74`	35145		CTD/ RS	
							PN/ PHN/LVS	
		10:10				/01-02 (2)	LBC	
						/03	GC 800	571
		11:50						
BP99-08	27.08.1999	14:45	72° 55.77`	79° 59.38`	35115		CTD/ RS	
							PN/ PHN/LVS	
		19:20				/01	SGC	-
						/02-04 (2)	LBC	
						/05-06 (2)	MUC	30
						/07	GC 800	542
						/08-09 (2)	BD	
		20:15						
BP99-09	27.08.1999	20:30	72° 55.94`	79° 46.61`	35268	/01	GC 800	185
		21:05						
BP99-10	28.08.1999	4:30	73° 23.32`	79° 50.50`	33	/01	LBC	
						/02	GC 800	518
		7:40						

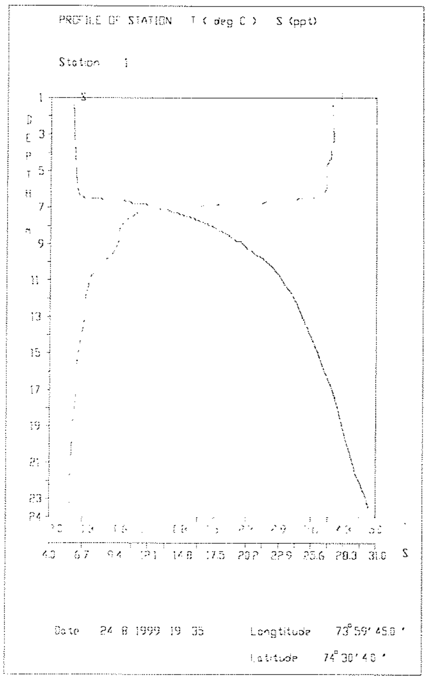
Station Nr.	Date	Time	Latitude	Longitude	Depth	Gear Nr.	Activity	Recovery
		(GMT)	° N	° E	(m)			(cm)
BP99-11	28.08.1999	10:25	73° 46.37`	79° 59.22`	40.6		CTD/ RS	
							PN/ PHN/LVS	
		12:15				/01-03 (3)	LBC	
						/04-05 (2)	MUC	23
						/06	GC 500	105
						/07	BD	
		14:47						
BP99-12	28.08.1999	17:45	73° 45.56`	78° 28.81`	25		CTD/ RS	
							PN/ PHN/LVS	
		19:00				/01-03 (3)	LBC	
						/04-05 (2)	MUC	10
		21:00						
BP99-13	29.08.1999	1:38	74° 29.836`	78° 00.000`	35.5		CTD/ RS	
							PN/ PHN/LVS	
		6:30				/01-03 (3)	LBC	41
						/04-05 (2)	MUC	22
						/06	BD	
		10:45						
BP99-14	29.08.1999	11:48	74° 15.048'	79° 0.927'	35272		CTD	
BP99-15	29.08.1999	13:32	73° 59.877'	78° 59.614'	35271		ST	
							CTD/ RS	
BP99-16	29.08.1999	11:54	74° 0.144`	80° 2.003`	32		CTD	
BP99-17	30.08.1999	11:45	72° 51.440`	76° 56.440`	19		CTD/ RS	
							PN/ PHN/LVS	
		13:30				/01-03 (3)	LBC	45
						/04-05 (2)	MUC	33
						/06	GC	566
						/07	BD	
		10:45						
BP99-18	31.08.1999	4:00	72° 19.98`	74° 00.00`	35286		CTD/ RS	
							PN/ PHN/LVS	
						/01-03 (3)	LBC	31
						/04-06 (3)	MUC	29
						/07	GC 500	483
						/08	GC 800	436
BP99-19	31.08.1999	16:05	72° 11.34`	74° 11.15`	35132		CTD/ RS	
							PN/ PHN/LVS	
						/01-03 (3)	LBC	49
						/04-06 (3)	MUC	50
						/07	GC 800	551
						/08	BD	
		20:30						
BP99-20	01.09.1999	5:41	72° 30.81`	74° 43.90`	35287		CTD/ RS	
							PN/ PHN/LVS	
						/01-03 (3)	LBC	51
						/04-05 (2)	MUC	41
						/06	SGC	
						/07	GC 800	448
		11:00						

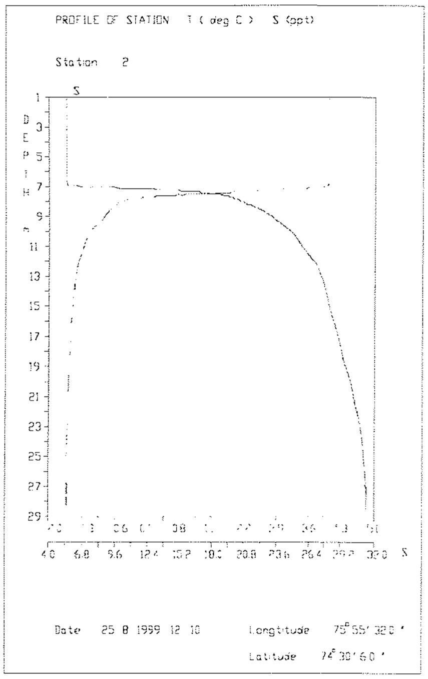
Station Nr.	Date	Time (GMT)	Latitude ° N	Longitude ° E	Depth (m)	Gear Nr.	Activity	Recovery (cm)
BP99-21	02.09.1999	2:06	73°14.79`	74° 2.01`	35317		CTD/ RS	
							PN/ PHN/LVS	
						/01-02 (2)	LBC	0
						/03	BD	
BP99-22	02.09.1999	7:30	73°11.09`	74° 4.91`	35194		CTD	
BP99-23	02.09.1999	8:25	73°6.59`	74° 10.13`	35282		CTD	
BP99-24	02.09.1999	11:24	73°26.03`	74° 52.26`	35199		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	35-42
						/05-06 (2)	MUC	32
						/07-08 (2)	SGC	
						/09	GC 500	451
						/10	BD	
		16:00						
BP99-25	03.09.1999	2:10	74°0.06`	73° 59.76`	35328		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	35-41
						/05-06 (2)	MUC	29
						/07	SGC	
						/08	GC 500	0
						/09	BD	
BP99-26	03.09.1999	14:24	74°0.33`	75° 21.62`	35150		CTD/ RS	
						/01	GC	388
						/02	BD	
BP99-27	03.09.1999	21:36	73° 30.00	76° 28.75			CTD	
BP99-28	04.09.1999	9:08	73° 25.40	78° 48.73	35294		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	40-46
						/05-06 (2)	MUC	28
						/07	GC 500	158
						/08	BD	
BP99-29	04.09.1999	17:24	73° 5.52	78° 30.79	35106		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	38-40
						/05-06 (2)	MUC	32
						/07	GC 500	157
						/08	BD	
BP99-30	05.09.1999	2:56	72° 27.45	79° 17.95	35103		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	45-47
						/05-06 (2)	MUC	31
						/07	GC 500	331

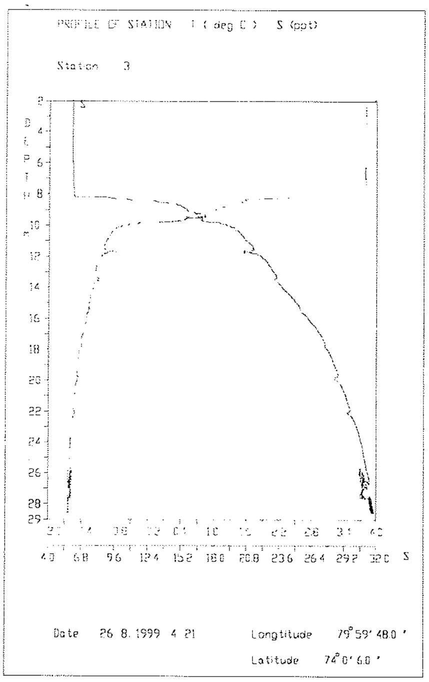
Station Nr.	Date	Time (GMT)	Latitude ° N	Longitude ° E	Depth (m)	Gear Nr.	Activity	Recovery (cm)
BP99-31	05.09.1999	11:38	72° 29.16	79° 45.66	35166		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	35
						/05-06 (2)	MUC	33
						/07	SGC	
						/08	GC 500	478
BP99-32	06.09.1999	1:45	73° 08.07	79° 57.24	35329		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	60-61
						/05-06 (2)	MUC	40
						/07	SGC	
						/08	GC 500	479
						/09	GC 800	564
						/10	BD	
BP99-33	06.09.1999	10:52	73° 08.05	74°43.02	25	/01	GC	-
BP99-34	06.09.1999						CTD	
BP99-35	06.09.1999	18:25	74° 18.05	78°20.04	29		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	34-40
						/05	MUC	25
						/06	BD	
BP99-36	07.09.1999	5:09	74° 29.87	73°59.16	35271		CTD	
BP99-37	07.09.1999	9:12	74° 18.03	74°20.05	35179		CTD/ RS	0-1
							PN/ PHN/LVS	
						/01-03 (3)	LBC	
BP99-38	07.09.1999	15:05	74° 15.00	75°36.34	35302		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	39-43
						/05	MUC	27
						/06	GC 500	281
						/07	BD	
BP99-39	08.09.1999	20:52	74° 17.92	76°49.88	33.3		CTD/ RS	
							PN/ PHN/LVS	
						/01-04 (4)	LBC	41-50
						/05	MUC	34
						/06	GC 500	205
						/07	BD	

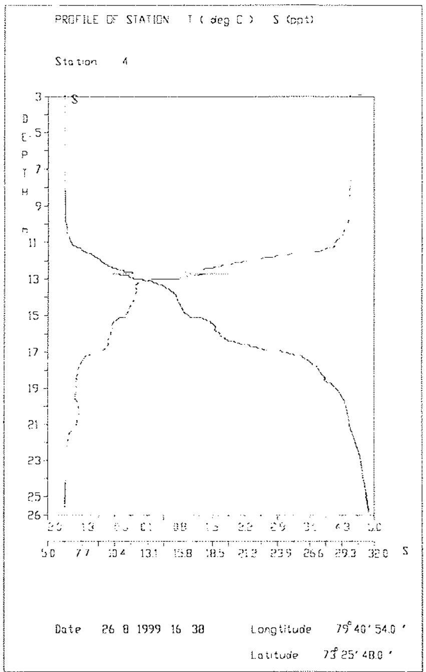
Abbreviations of activities:
BD - Benthos Dredge
CTD - Conductivity-Temperature-Depth probe for oceanography
GC 500 - Gravity Corer with 500 cm core barrel
GC 800 - Gravity Corer with 800 cm core barrel
LBC - Large Box Corer (GKG)
LVS - Large Volume Sampler (Batomat 200l)
MUC - Multiple Corer
PHN - Plankton Hand Net (10μm) (AWI, Geo)
PN - Plankton Net (150μm) (AWI, Bio)
RS - Rosette Sampler
SGC - Small Gravity Corer
ST - Sediment Trap

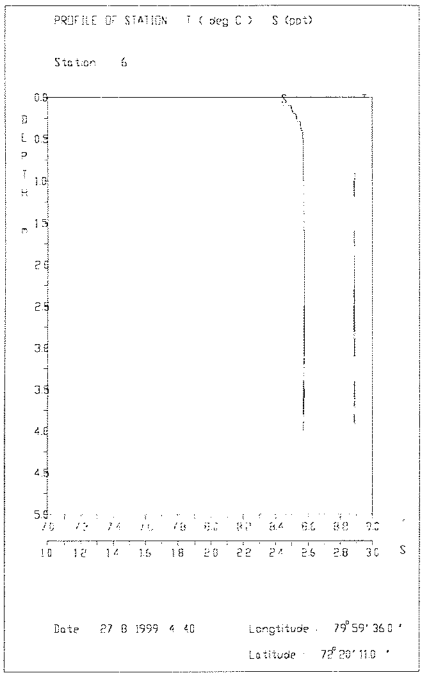
10.2 CTD profiles

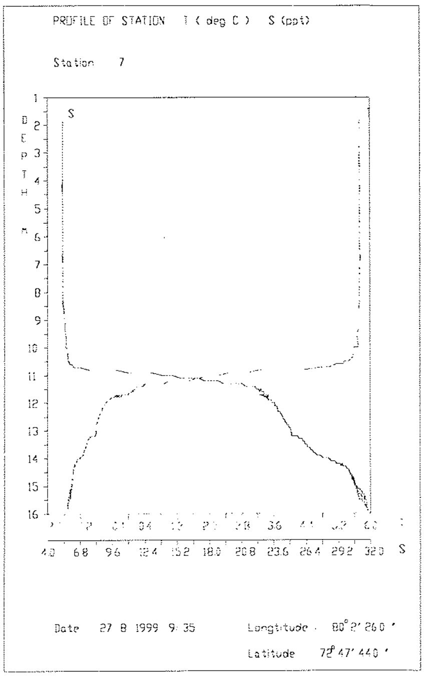

PROFILE OF STATION T (deg C) S (ppt)
Station 1
DEPTH m
4.0 6.7 9.4 12.1 14.8 17.5 20.2 22.9 25.6 28.3 31.0 S
Date 24 8 1999 19 35
Longtitude 73°59'45.0'
Latitude 74°30'4.0'


PROFILE OF STATION T (deg C) S (ppt)
Station 2
DEPTH m
4.0 6.8 9.6 12.4 15.2 18.0 20.8 23.6 26.4 29.2 32.0 S
Date 25 8 1999 12 10
Longtitude 75°55'32.0'
Latitude 74°30'6.0'


PROFILE OF STATION T (deg C) S (ppt)
Station 3
DEPTH m
4.0 6.8 9.6 12.4 15.2 18.0 20.8 23.6 26.4 29.2 32.0 S
Date 26 8. 1999 4 21
Longtitude 79°59'48.0'
Latitude 74°0'6.0'


PROFILE OF STATION T (deg C) S (ppt)
Station 4
DEPTH m
5.0 7.7 10.4 13.1 15.8 18.5 21.2 23.9 26.6 29.3 32.0 S
Date 26 8 1999 16 38
Longtitude 79°40'54.0'
Latitude 73°25'48.0'


PROFILE OF STATION T (deg C) S (ppt)
Station 6
DEPTH m
S
10 12 14 16 18 20 22 24 26 28 30 S
Date 27 8 1999 4 40
Longtitude 79°59' 36.0 '
Latitude 72°20' 11.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 7
DEPTH m
S
4.0 6.8 9.6 12.4 15.2 18.0 20.8 23.6 26.4 29.2 32.0 S
Date 27 8 1999 9:35
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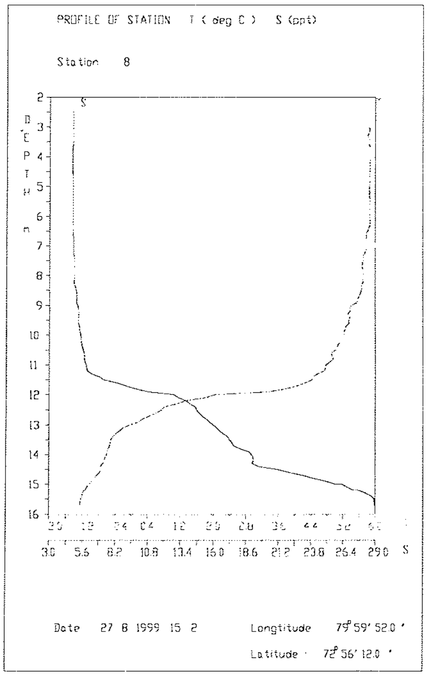
Latitude 72°47' 44.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 8
DEPTH m
S
3.0 5.6 8.2 10.8 13.4 16.0 18.6 21.2 23.8 26.4 29.0 S
Date 27 8 1999 15 2
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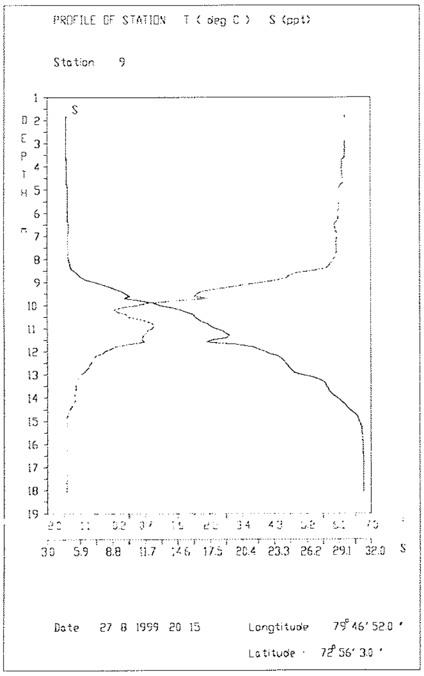
Latitude 72°56' 12.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 9
DEPTH m
S
3.0 5.9 8.8 11.7 14.6 17.5 20.4 23.3 26.2 29.1 32.0 S
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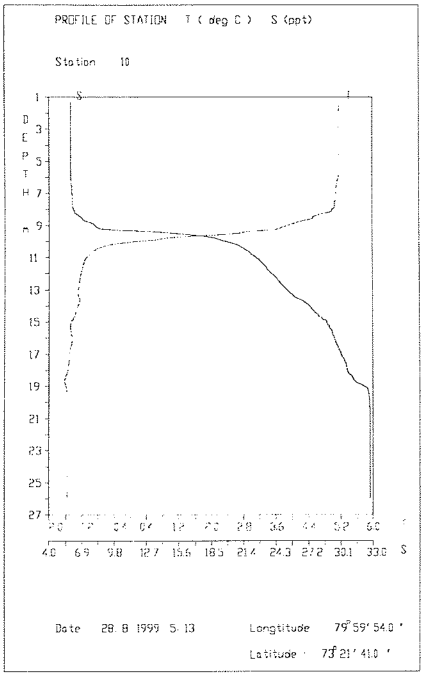
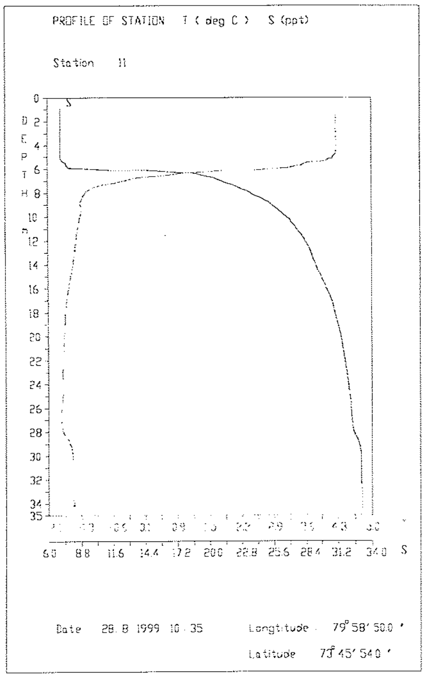
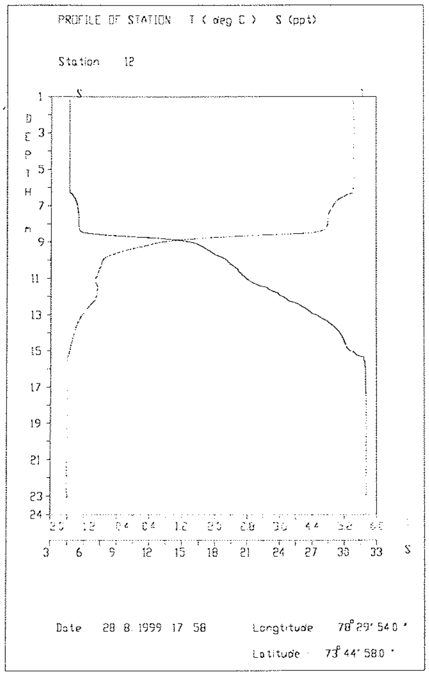
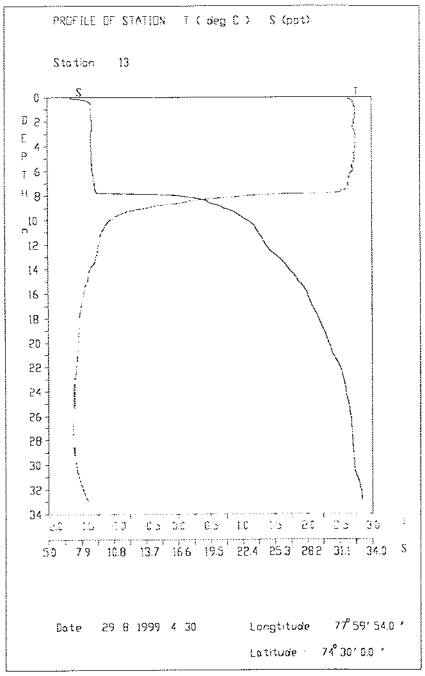
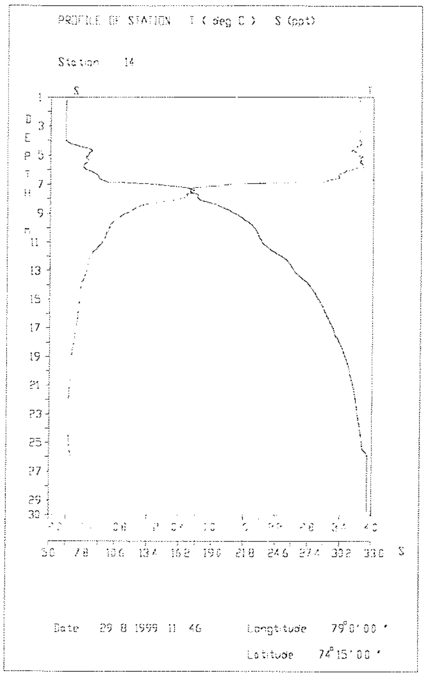
Latitude 72°56' 3.0 '

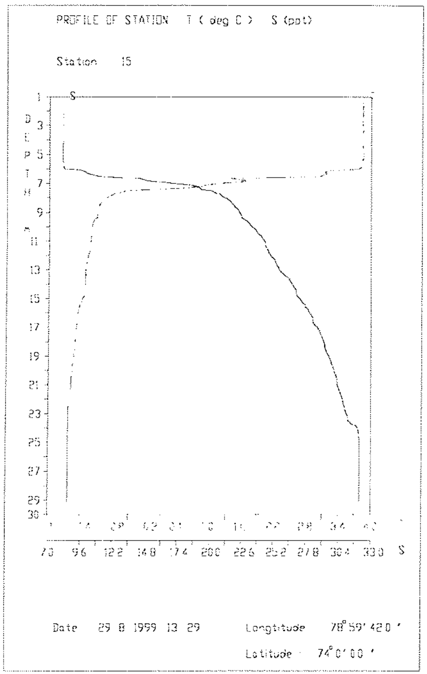

PROFILE OF STATION T (deg C) S (ppt)
Station 10
DEPTH m
4.0 6.9 9.8 12.7 15.6 18.5 21.4 24.3 27.2 30.1 33.0 S
Date 28. 8 1999 5. 13
Longtitude 79° 59' 54.0 "
Latitude 73° 21' 41.0 "

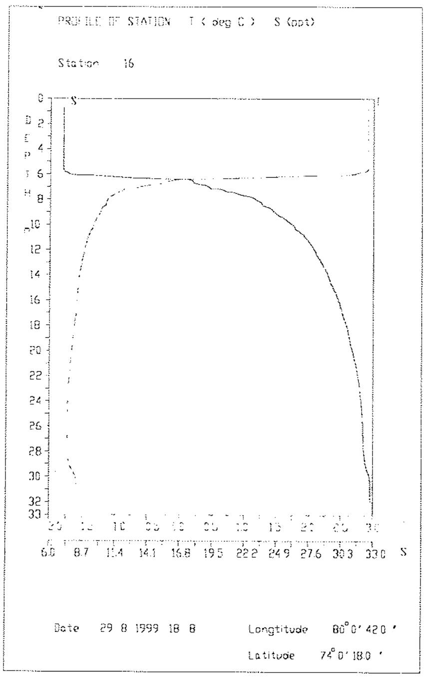

PROFILE OF STATION T (deg C) S (ppt)
Station 11
DEPTH m
6.0 8.8 11.6 14.4 17.2 20.0 22.8 25.6 28.4 31.2 34.0 S
Date 28. 8 1999 10 . 35
Longtitude 79° 58' 50.0 "
Latitude 73° 45' 54.0 "

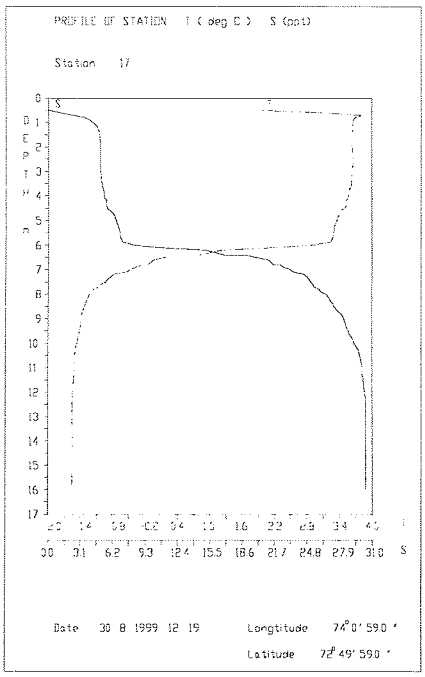

PROFILE OF STATION T (deg C) S (ppt)
Station 12
DEPTH m
3 6 9 12 15 18 21 24 27 30 33 S
Date 28 8. 1999 17 58
Longtitude 78° 29' 54.0 "
Latitude 73° 44' 58.0 "

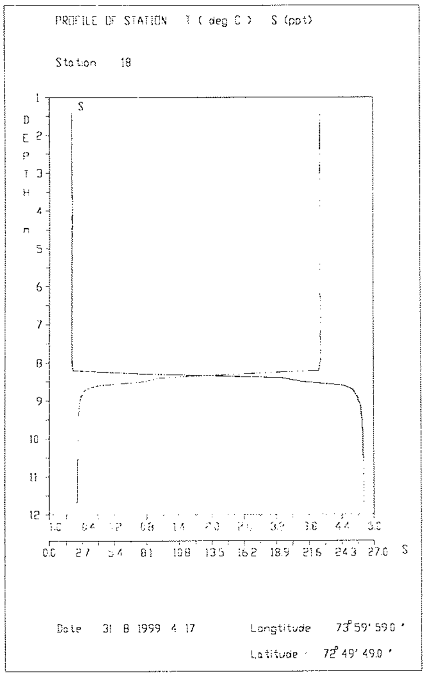

PROFILE OF STATION T (deg C) S (ppt)
Station 13
DEPTH m
5.0 7.9 10.8 13.7 16.6 19.5 22.4 25.3 28.2 31.1 34.0 S
Date 29 8 1999 4 30
Longtitude 77° 59' 54.0 "
Latitude 74° 30' 0.0 "

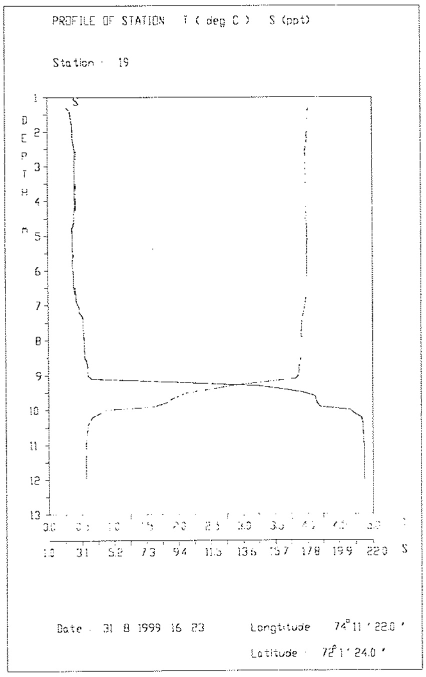

PROFILE OF STATION T (deg C) S (ppt)
Station 14
S
T
DEPTH
50 78 106 134 162 190 218 246 274 302 330 S
Date 29 8 1999 11 46
Longtitude 79°0'00 '
Latitude 74°15'00 '

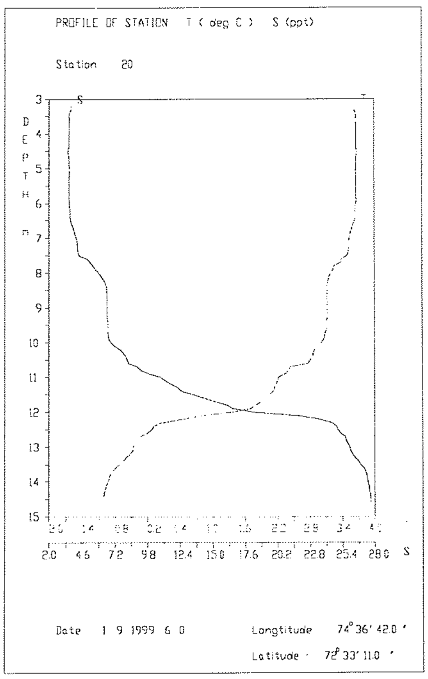

PROFILE OF STATION T (deg C) S (ppt)
Station 15
S
DEPTH
70 96 122 148 174 200 226 252 278 304 330 S
Date 29 8 1999 13 29
Longtitude 78°59'42.0 '
Latitude 74°0'00 '

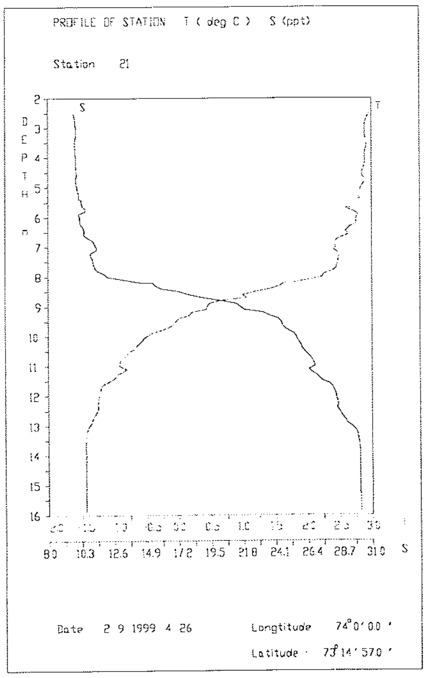

PROFILE OF STATION T (deg C) S (ppt)
Station 16
S
DEPTH
6.0 8.7 11.4 14.1 16.8 19.5 22.2 24.9 27.6 30.3 33.0 S
Date 29 8 1999 18 8
Longtitude 80°0'42.0 '
Latitude 74°0'18.0 '

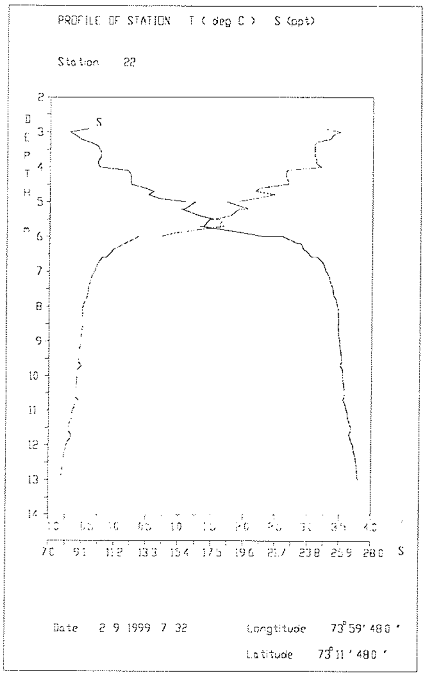

PROFILE OF STATION T (deg C) S (ppt)
Station 17
S
T
DEPTH
0.0 3.1 6.2 9.3 12.4 15.5 18.6 21.7 24.8 27.9 31.0 S
Date 30 8 1999 12 19
Longtitude 74°0'59.0 '
Latitude 72°49'59.0 '

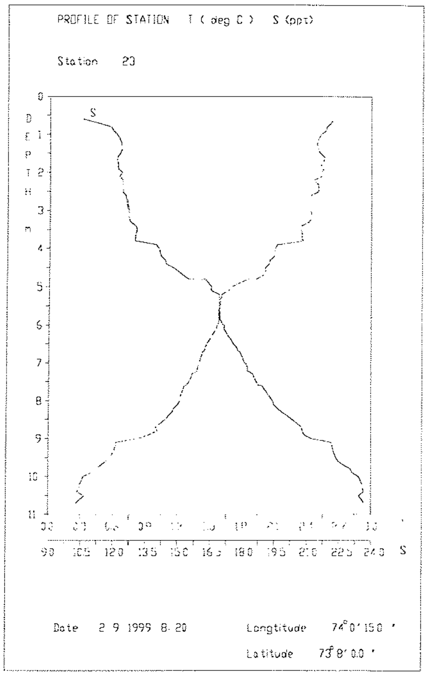

PROFILE OF STATION T (deg C) S (ppt)
Station 18
DEPTH m
S
0.0 2.7 5.4 8.1 10.8 13.5 16.2 18.9 21.6 24.3 27.0 S
Date 31 8 1999 4 17
Longtitude 73° 59' 59.0 '
Latitude 72° 49' 49.0 '

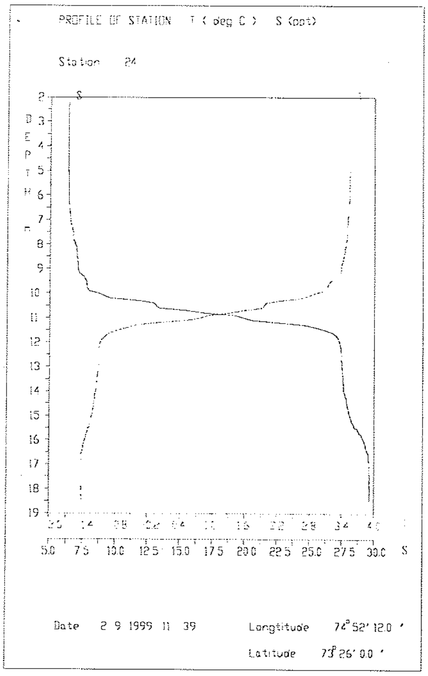

PROFILE OF STATION T (deg C) S (ppt)
Station 19
DEPTH m
S
1.0 3.1 5.2 7.3 9.4 11.5 13.6 15.7 17.8 19.9 22.0 S
Date 31 8 1999 16 23
Longtitude 74° 11 ' 22.0 '
Latitude 72° 1 ' 24.0 '

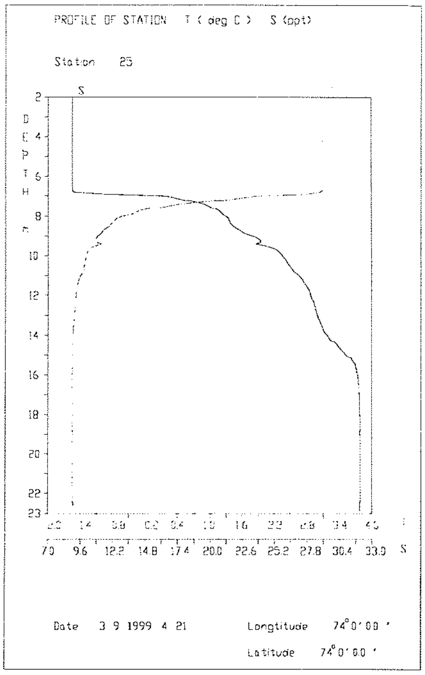

PROFILE OF STATION T (deg C) S (ppt)
Station 20
DEPTH m
S
2.0 4.6 7.2 9.8 12.4 15.0 17.6 20.2 22.8 25.4 28.0 S
Date 1 9 1999 6 0
Longtitude 74° 36' 42.0 '
Latitude 72° 33' 11.0 '

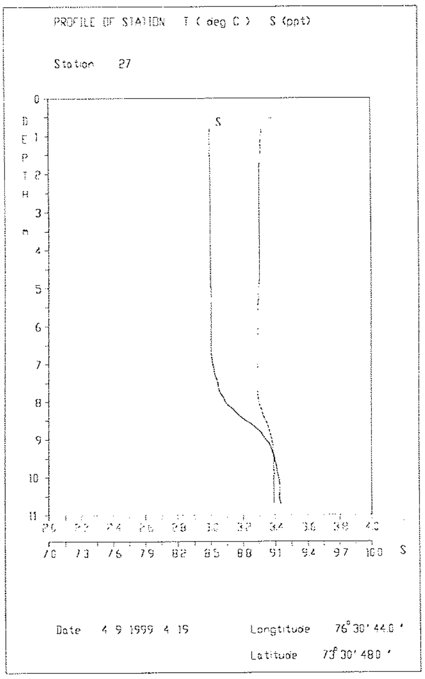

PROFILE OF STATION T (deg C) S (ppt)
Station 21
DEPTH m
S
T
8.0 10.3 12.6 14.9 17.2 19.5 21.8 24.1 26.4 28.7 31.0 S
Date 2 9 1999 4 26
Longtitude 74° 0' 0.0 '
Latitude 73° 14' 57.0 '

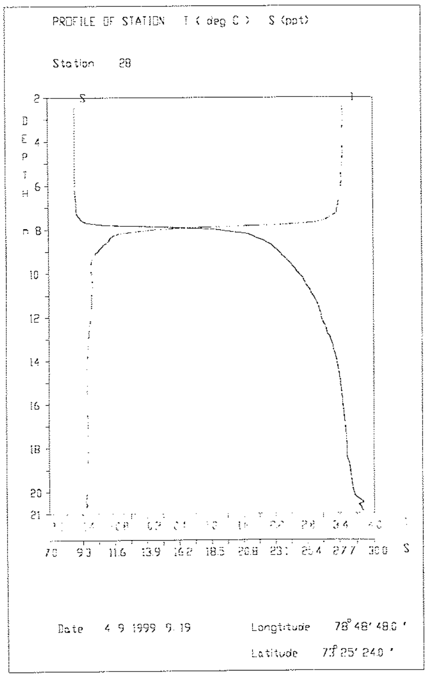

PROFILE OF STATION T (deg C) S (ppt)
Station 22
DEPTH m
S
70 91 112 133 154 175 196 217 238 259 280 S
Date 2 9 1999 7 32
Longtitude 73°59' 48.0 '
Latitude 73°11 ' 48.0 '

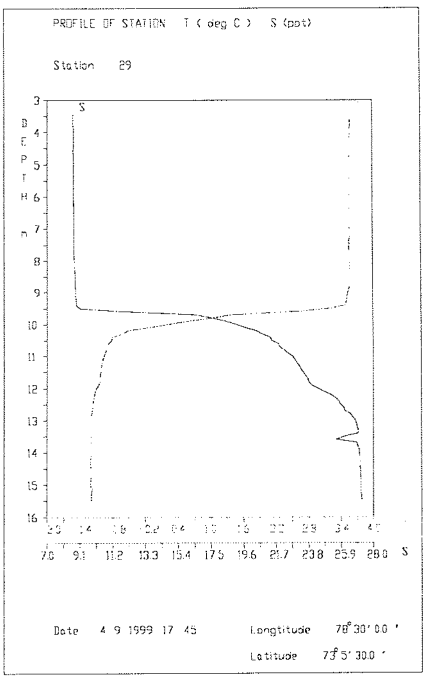

PROFILE OF STATION T (deg C) S (ppt)
Station 23
DEPTH m
S
90 105 120 135 150 165 180 195 210 225 240 S
Date 2 9 1999 8 20
Longtitude 74°0' 15.0 '
Latitude 73°8' 0.0 '

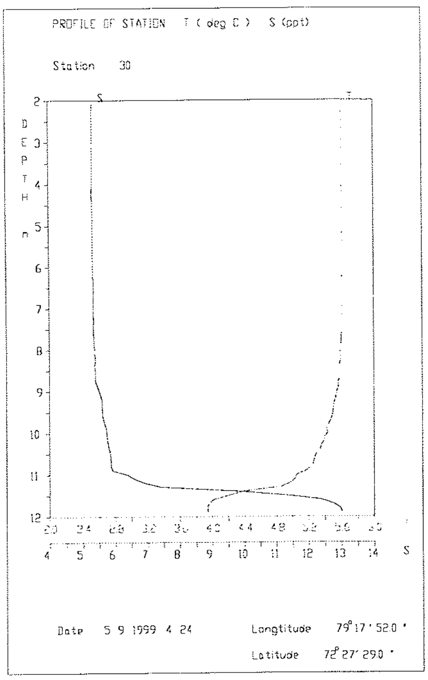

PROFILE OF STATION T (deg C) S (ppt)
Station 24
DEPTH m
S
5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 S
Date 2 9 1999 11 39
Longtitude 74°52' 12.0 '
Latitude 73°26' 0.0 '

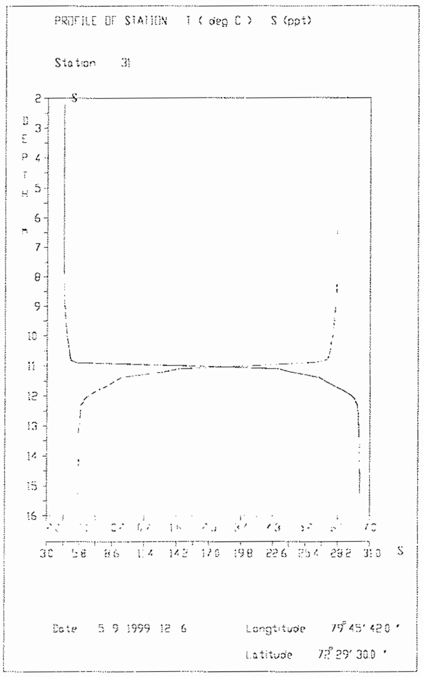

PROFILE OF STATION T (deg C) S (ppt)
Station 25
DEPTH m
S
7.0 9.6 12.2 14.8 17.4 20.0 22.6 25.2 27.8 30.4 33.0 S
Date 3 9 1999 4 21
Longtitude 74°0' 0.0 '
Latitude 74°0' 0.0 '

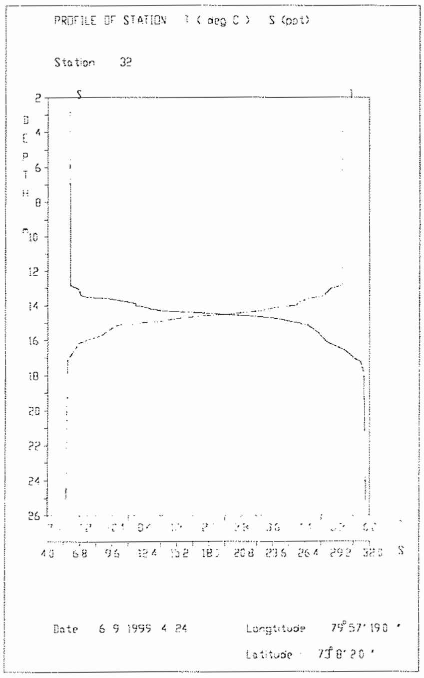

PROFILE OF STATION T (deg C) S (ppt)
Station 27
DEPTH m
70 73 76 79 82 85 88 91 94 97 100 S
Date 4 9 1999 4 15
Longtitude 76°30' 44.0 '
Latitude 73°30' 480 '

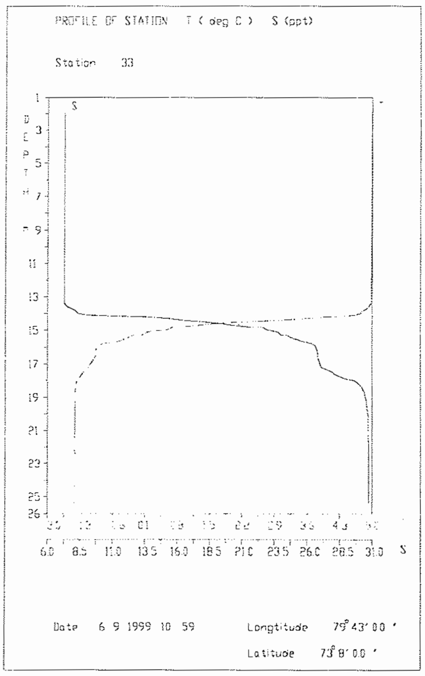

PROFILE OF STATION T (deg C) S (ppt)
Station 28
DEPTH m
70 93 11.6 13.9 16.2 18.5 20.8 23.1 25.4 27.7 30.0 S
Date 4 9 1999 9 19
Longtitude 78°48' 48.0 '
Latitude 73°25' 24.0 '

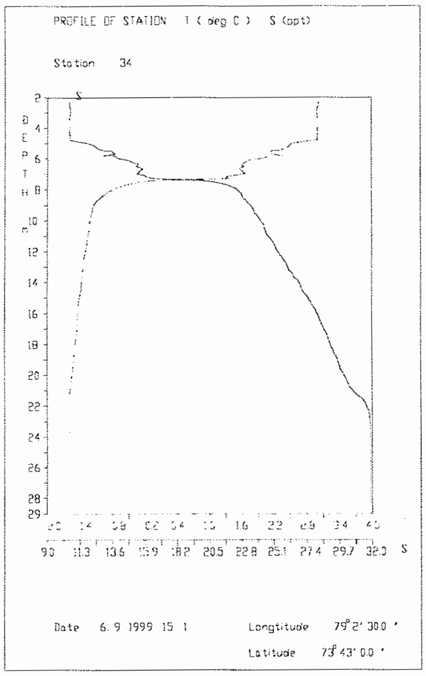

PROFILE OF STATION T (deg C) S (ppt)
Station 29
DEPTH m
7.0 9.1 11.2 13.3 15.4 17.5 19.6 21.7 23.8 25.9 28.0 S
Date 4 9 1999 17 45
Longtitude 78°30' 0.0 '
Latitude 73°5' 30.0 '

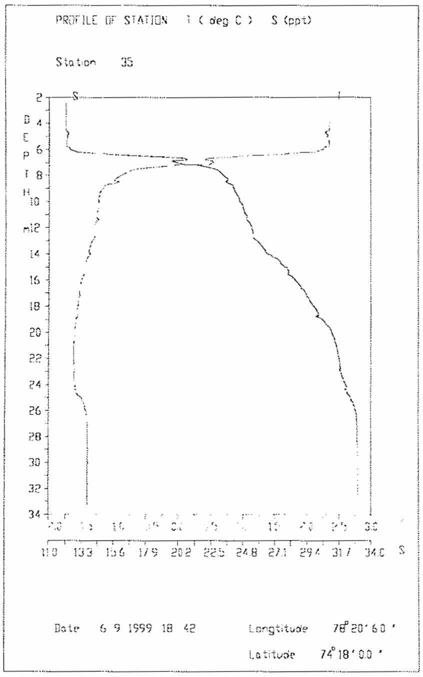

PROFILE OF STATION T (deg C) S (ppt)
Station 30
DEPTH m
4 5 6 7 8 9 10 11 12 13 14 S
Date 5 9 1999 4 24
Longtitude 79°17' 52.0 '
Latitude 72°27' 29.0 '

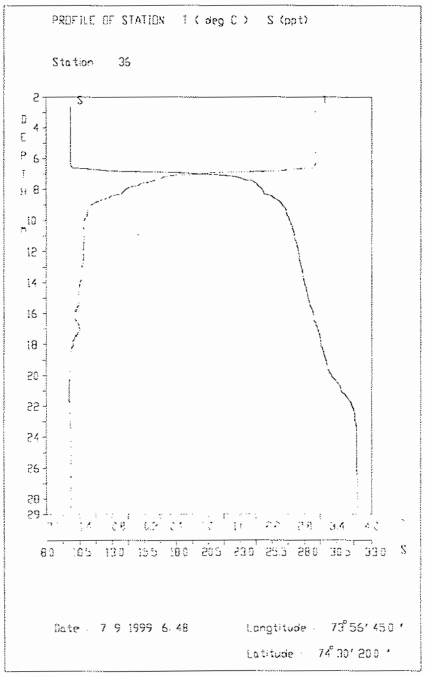

PROFILE OF STATION T (deg C) S (ppt)
Station 31
Date 5 9 1999 12 6
Longtitude 79° 45' 42.0 '
Latitude 72° 29' 30.0 '

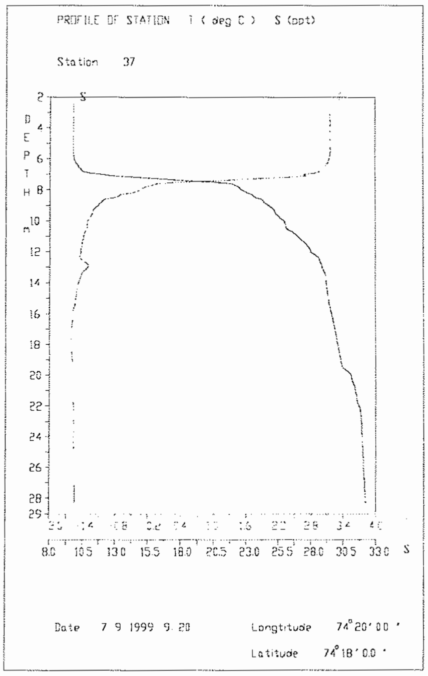

PROFILE OF STATION T (deg C) S (ppt)
Station 32
Date 6 9 1999 4 24
Longtitude 79° 57' 19.0 '
Latitude 73° 8' 2.0 '

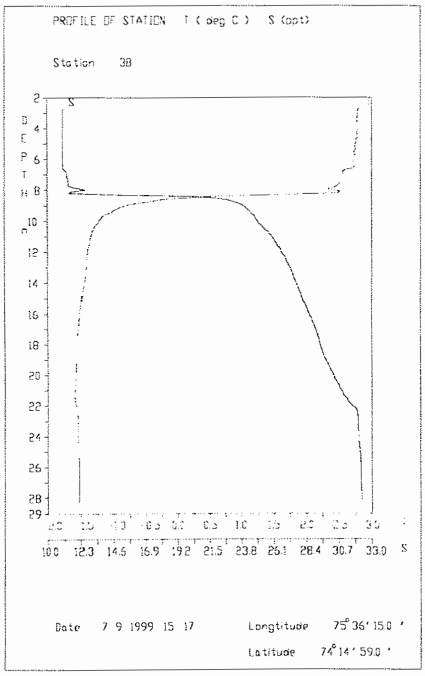

PROFILE OF STATION T (deg C) S (ppt)
Station 33
Date 6 9 1999 10 59
Longtitude 79° 43' 0.0 '
Latitude 73° 8' 0.0 '

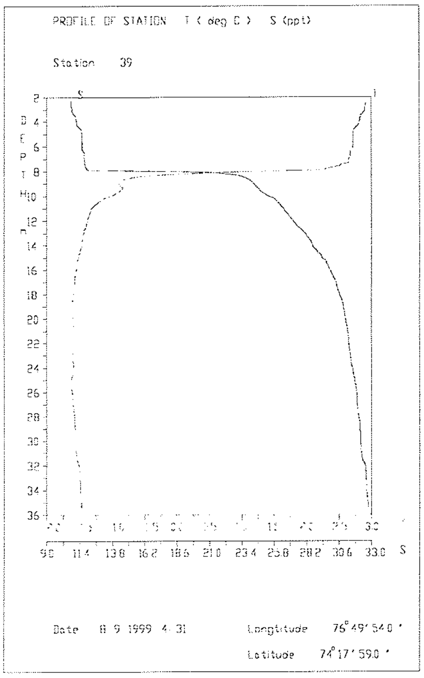

PROFILE OF STATION T (deg C) S (ppt)
Station 34
Date 6. 9 1999 15 1
Longtitude 79° 2' 30.0 '
Latitude 73° 43' 0.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 35
DEPTH m
11.0 13.3 15.6 17.9 20.2 22.5 24.8 27.1 29.4 31.7 34.0 S
Date 6 9 1999 18 42
Longtitude 78° 20' 6.0 '
Latitude 74° 18' 0.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 36
DEPTH m
8.0 10.5 13.0 15.5 18.0 20.5 23.0 25.5 28.0 30.5 33.0 S
Date 7 9 1999 6 48
Longtitude 73° 56' 45.0 '
Latitude 74° 30' 20.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 37
DEPTH m
8.0 10.5 13.0 15.5 18.0 20.5 23.0 25.5 28.0 30.5 33.0 S
Date 7 9 1999 9 20
Longtitude 74° 20' 0.0 '
Latitude 74° 18' 0.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 38
DEPTH m
10.0 12.3 14.6 16.9 19.2 21.5 23.8 26.1 28.4 30.7 33.0 S
Date 7 9 1999 15 17
Longtitude 75° 36' 15.0 '
Latitude 74° 14' 59.0 '


PROFILE OF STATION T (deg C) S (ppt)
Station 39
DEPTH m
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
9.0 11.4 13.8 16.2 18.6 21.0 23.4 25.8 28.2 30.6 33.0 S
Date 8 9 1999 4 31
Longitude 76°49'54.0 "
Latitude 74°17'59.0 "

10.3 Lithological core description

Geological Core Descriptions

Legend:

Lithology

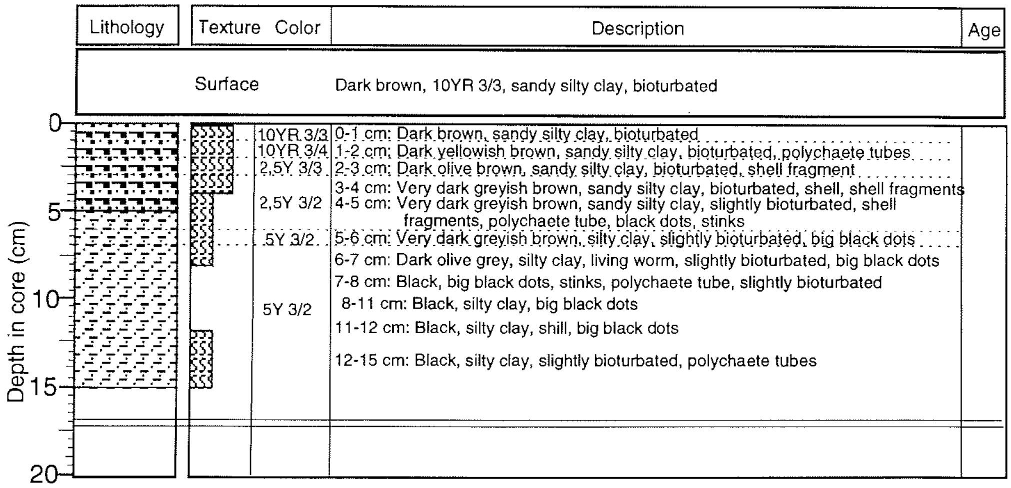
- clay
- silty clay
- sandy silty clay
- sand
- sandy clay
- clayey sand

Structure

- bioturbation
- sharp boundary
- gradational boundary
- transition zone

BP99-01/05 (MUC) Kara Sea **Boris Petrov '99**

Recovery: 0.17 m 74°29.8' N 73°59.6' E Water depth: 30 m



BP99-02/05 (MUC) | Kara Sea | **Boris Petrov '99**

Recovery: 0.20 m | 74°30' N 75°55.6' E | Water depth: 34.5 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, sandy silty clay, one shell fragment	
		2.5Y 3/3	0-1 cm: Dark olive brown, sandy silty clay, one shell fragment	
		10YR 3/4	1-2 cm: dark yellowish brown, sandy silty clay, polychaete, small shell fragment	
		10YR 3/2	2-3 cm: Very dark greyish brown, sandy silty clay	
		5Y 3/2	3-4 cm: Dark olive grey, sandy silty clay, polychaete 4-5 cm: Dark olive grey, sandy silty clay, shell fragments, polychaete	
		5Y 2.5/2	5-6 cm: Black, sandy silty clay, black spots, less sandy 6-7 cm: Black, sandy silty clay, shell fragments, polychaete tube, less sandy	
		5Y 3/2	7-8 cm: Dark olive grey, sandy silty clay, shell fragments, black spots, polychaete tube	
		5Y 2.5/1	8-9 cm: Black, sandy silty clay, black spots	
		5Y 3/1	9-10 cm: Very dark grey, sandy silty clay, black spots	
		5Y 2.5/1	10-11 cm: Black, silty clay, black spots, shell fragments 11-12 cm: Black, silty clay, black spots 12-13 cm: Black, silty clay, black spots, bioturbated 13-14 cm: Black, silty clay, black spots, bioturbated, polychaete tube 14-18 cm: Black, silty clay, black spots	

Depth in core (cm): 0, 5, 10, 15, 20, 25

BP99-03/05 (MUC) | Yenisei Estuary | **Boris Petrov '99**

Recovery: 0.28 m | 73°59.9' N 80°0.6' E | Water depth: 36.2 m

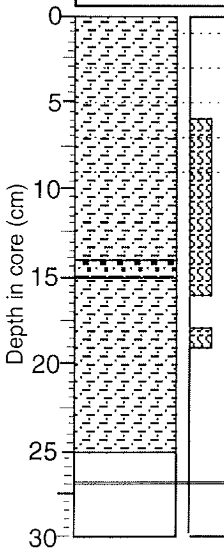
Lithology	Texture	Color	Description	Age
	Surface		Dark yellowish brown, 10YR 3/4, silty clay, bioturbated, polychaete tube	
		10YR 3/4	0-2 cm: Dark yellowish brown, 10YR 3/4, silty clay, bioturbated, polychaete tube	
		5Y 3/2	2-6 cm: Dark olive grey, silty clay, bioturbated, black dots	
		5Y 3/1	6-7 cm: Very dark grey, silty clay, bioturbated, black dots	
		5Y 3/2	7-10 cm: Dark olive grey, silty clay, bioturbated, black dots	
		5Y 3/1	10-11 cm: Very dark grey, silty clay, bioturbated, big black dots	
		5Y 3/2	11-12 cm: Dark olive grey, silty clay, bioturbated, big black dots	
		5Y 3/1	12-13 cm: Very dark grey, silty clay, bioturbated, big black dots	
		5Y 2.5/2	13-19 cm: Black, silty clay, bioturbated, big black dots 19-24 cm: Black, silty clay, big black dots 24-25 cm: Black, silty clay, big black dots, bivalve, shell fragments	

Depth in core (cm): 0, 5, 10, 15, 20, 25, 30

BP99-04/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.27 m 73°24.9' N 79°40.5' E Water depth: 32.3 m

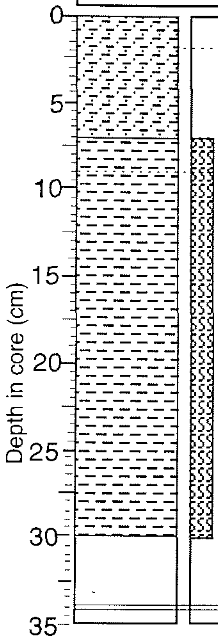
Lithology	Texture	Color	Description	Age
	Surface		Dark brown, 7.5YR 3/4, slightly silty clay	
		7.5YR 3/4	0-1 cm: Dark brown, slightly silty clay	
		10YR 3/4	1-3 cm: Dark yellowish brown, slightly silty clay	
		2.5Y 3/3	3-5 cm: Dark olive brown, silty clay	
		2.5Y 3/2	5-6 cm: Very dark greyish brown, silty clay 6-7 cm: Very dark greyish brown, silty clay, bioturbated	
		5Y 3/2	7-9 cm: Dark olive grey, silty clay, bioturbated	
		5Y 3/1	9-14 cm: Very dark grey, silty clay, bioturbated, black dots 14-15 cm: Very dark grey, sandy silty clay, bioturbated 15-16 cm: Very dark grey, silty clay, bioturbated, shell fragments 16-17 cm: Very dark grey, silty clay, black dots 17-18 cm: Very dark grey, silty clay, black dots, clay lense 18-20 cm: Very dark grey, silty clay, bioturbated, shell fragments 20-25 cm: Very dark grey, silty clay, black dots	



BP99-08/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.34 m 72°55.8' N 79°59.4' E Water depth: 21.2 m

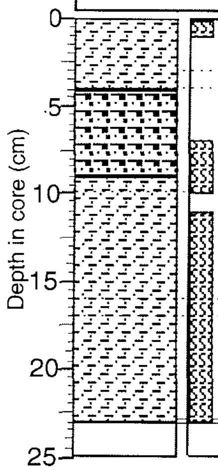
Lithology	Texture	Color	Description	Age
	Surface		Dark brown, 10YR 3/3, slightly silty clay	
		10YR 3/3	0-2 cm: Dark brown, slightly silty clay	
		2.5Y 3/3	2-6 cm: Dark olive brown, slightly silty clay 6-7 cm: Dark olive brown, slightly silty clay, bioturbated 7-9 cm: Dark olive brown, clay, bioturbated	
		5Y 3/2	9-14 cm: Dark olive, clay, bioturbated, black dots 14-15 cm: Dark olive, clay, bioturbated, black dots, shill 15-30 cm: Dark olive, clay, bioturbated, black dots	



BP99-11/05 (MUC) Yenisei Estuary **Boris Petrov '99**

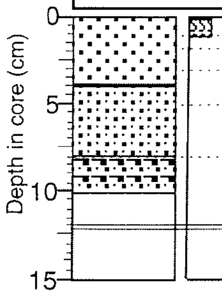
Recovery: 0.23 m 73°46.4' N 79°59.2' E Water depth: 40.6 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, silty clay, bioturbated	
		2.5Y 3/3	0-1 cm: Dark olive brown, silty clay, bioturbated 1-3 cm: Dark olive brown, silty clay	
		5Y 3/2	3-4 cm: Dark olive grey, silty clay	
		5Y 2.5/2	4--6 cm: Black, sandy silty clay 6-7 cm: Black, sandy silty clay, black dots 7-8 cm: Black, sandy silty clay, black dots, bioturbated 8-9 cm: Black, sandy silty clay, black dots, bioturbated, shell fragments 9-10 cm: Black, silty clay, black dots, bioturbated, shell fragments, polychaete tube	
		5Y 3/1	10-11 cm: Very dark grey, silty clay, black dots 11-12 cm: Very dark grey, silty clay, black dots, bioturbated, shell fragments 12-14 cm: Very dark grey, silty clay, black dots, bioturbated 14-15 cm: Very dark grey, silty clay, black dots, bioturbated, shell fragments 15-16 cm: Very dark grey, silty clay, black dots, bioturbated	
		5Y 2.5/2	16-17 cm: Black, silty clay, black dots, bioturbated, shell fragments	
		5Y 2.5/1	17-18 cm: Black, silty clay, black dots, bioturbated, shell fragments, polychaete 18-19 cm: Black, silty clay, black dots, bioturbated, shell fragments 19-20 cm: Black, silty clay, black dots, bioturbated 20-23 cm: Black, silty clay, black dots, bioturbated, shell fragments	



BP99-12/05 (MUC) Yenisei Estuary **Boris Petrov '99**

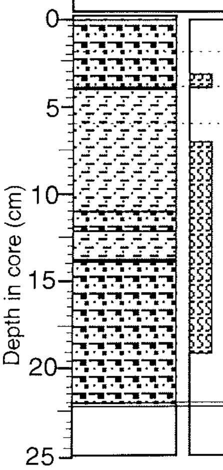
Recovery: 0.12 m 73°45.6' N 78°28.8' E Water depth: 25 m



Lithology	Texture	Color	Description	Age
Surface			Dark brown, 10YR 3/3, sand, polychaete tubes, bioturbated	
		10YR 3/3	0-1 cm: Dark brown, sand, polychaete tubes, bioturbated	
		10YR 3/3	1-2 cm: Very dark greyish brown, sand, crustacea	
		2.5Y 4/3	2-3 cm: Olive brown, sand 3-4 cm: Dark greyish brown, sand, polychaete	
		2.5Y 4/3	4-5 cm: Dark greyish brown, sandy silt	
		5Y 4/2	5-6 cm: Olive grey, sandy silt, shell fragments 6-8 cm: Olive grey, sandy silt, black dots	
		5Y 3/2	8-10 cm: Dark olive grey, sandy silty clay, black dots	

BP99-13/05 (MUC) Kara Sea **Boris Petrov '99**

Recovery: 0.22 m 74°29.8' N 78°0.0' E Water depth: 35.5 m

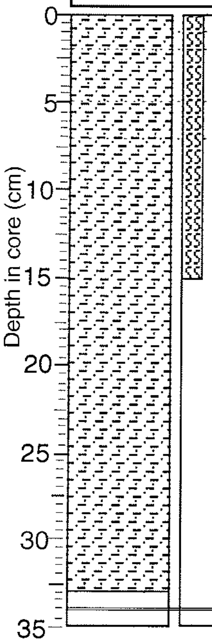


Lithology	Texture	Color	Description	Age
Surface			Dark olive brown, 2.5Y 3/3, sandy silty clay	
		2.5Y 3/3	0-2 cm: Dark olive brown, sandy silty clay	
		5Y 4/3	2-3 cm: Olive, sandy silty clay 3-4 cm: Olive, sandy silty clay, bioturbated	
		5Y 4/1	4-6 cm: Dark grey, silty clay	
		5Y 3/1	6-8 cm: Very dark grey, silty clay 8-11 cm: Very dark grey, silty clay, black dots 11-12 cm: Very dark grey, sandy silty clay, black dots 12-14 cm: Very dark grey, silty clay, black dots, bioturbated 14-16 cm: Very dark grey, sandy silty clay, black dots, bioturbated 16-18 cm: Very dark grey, sandy silty clay, black dots, bioturbated, shell fragments 18-19 cm: Very dark grey, sandy silty clay, black dots, bioturbated 19-22 cm: Very dark grey, sandy silty clay, black dots, shell fragments	

BP99-17/05 (MUC) Ob Estuary **Boris Petrov '99**

Recovery: 0.34 m 72°51.4' N 76°56.4' E Water depth: 19 m

Lithology	Texture	Color	Description	Age
	Surface		Dark brown, 10YR 3/3, silty clay, bioturbated	
		10YR 3/3	0-1 cm: Dark brown, silty clay, bioturbated	
		2.5Y 3/3	1-2 cm: Dark olive brown, silty clay, bioturbated	
		2.5Y 4/3	2-5 cm: Olive brown, silty clay, bioturbated	
		5Y 4/2	5-7 cm: Olive grey, silty clay, bioturbated	
		5Y 3/1	7-8 cm: Very dark grey, silty clay, bioturbated, small black dots	
			8-9 cm: Very dark grey, silty clay, bioturbated, black dots, polychaete	
			9-15 cm: Very dark grey, silty clay, bioturbated, black dots	
			15-16 cm: Very dark grey, silty clay, black dots	
			17-23 cm: Very dark grey, silty clay, black dots, rigide	
			23-24 cm: Very dark grey, silty clay, black dots, rigide, bivalve	
			24-33 cm: Very dark grey, silty clay, black dots, rigide	

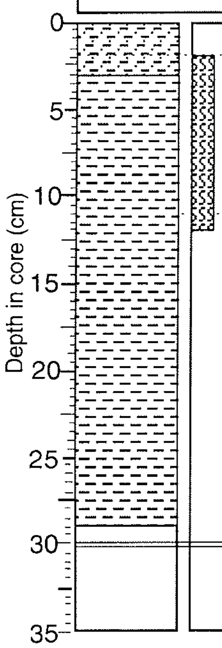


BP99-18/05 (MUC) Recovery: 0.30 m

Ob Estuary 72°20' N 74°0' E

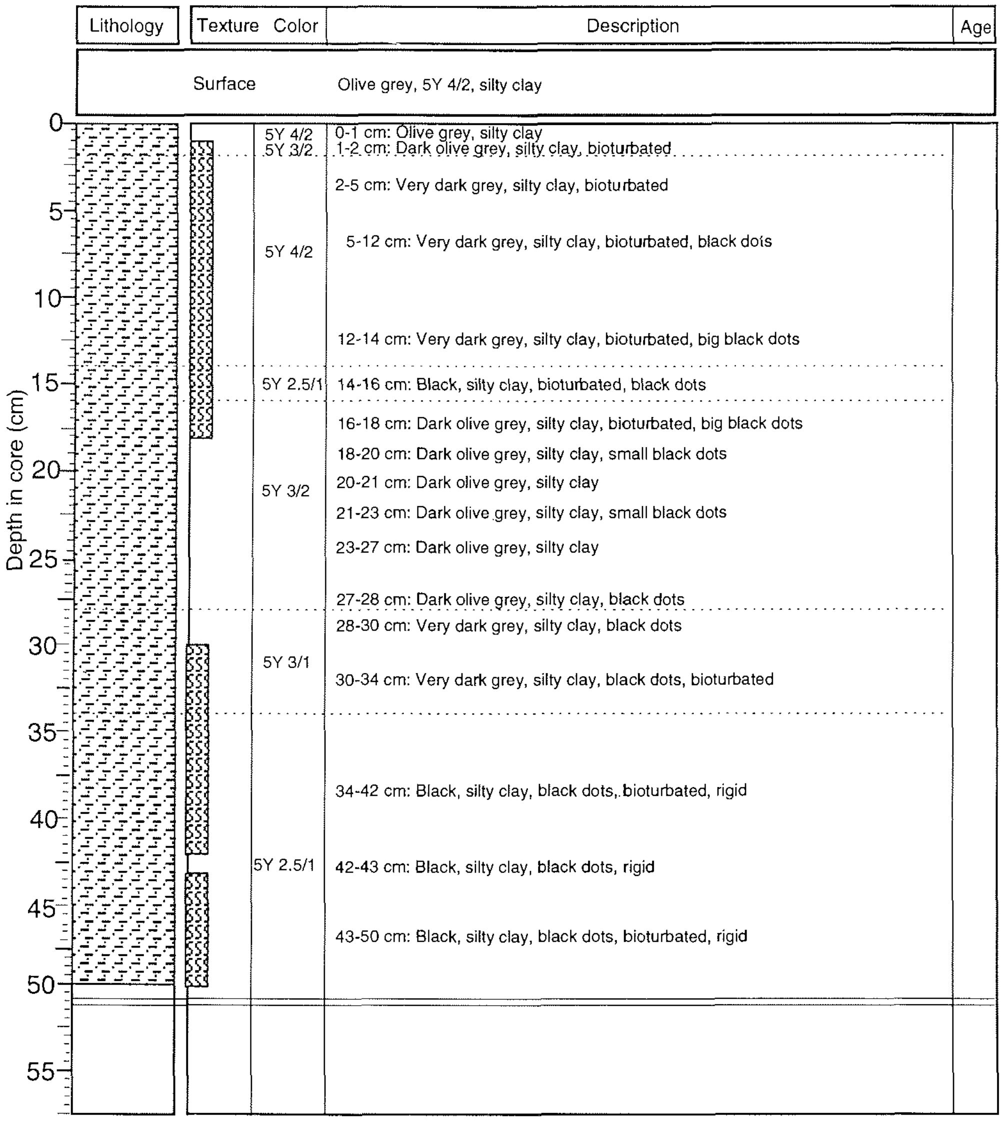
Boris Petrov '99 Water depth: 10.8 m

Depth	Color	Description
Surface		Dark olive brown, 2.5Y 3/3, silty clay
	2.5Y 3/3	0-2 cm: Dark olive brown, silty clay
	2.5Y 3/2	2-3 cm: Very dark greyish brown, silty clay, bioturbated
		3-7 cm: Very dark greyish brown, clay, bioturbated
		7-11 cm: Very dark greyish brown, clay, bioturbated, black dots
	5Y 3/1	11-12 cm: Very dark grey , clay, bioturbated, black dots
		12-29 cm: Very dark grey , clay, black dots



BP99-19/06 (MUC) Ob Estuary **Boris Petrov '99**

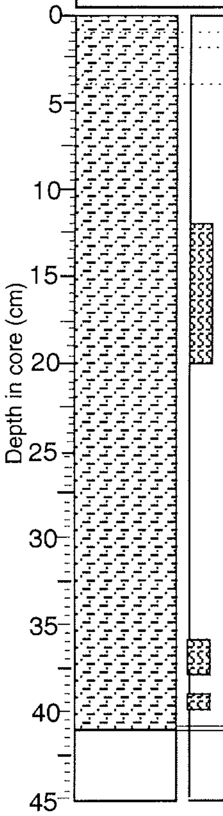
Recovery: 0.51 m 72°11.3' N 74°11.1' E Water depth: 9.3 m



BP99-20/04 (MUC) Ob Estuary **Boris Petrov '99**

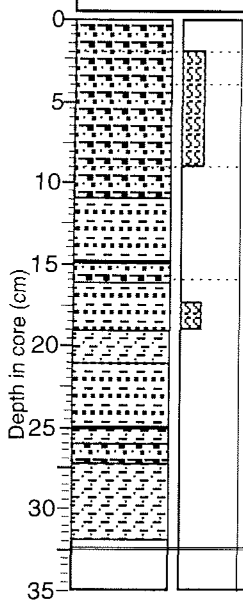
Recovery: 0.41 m 72°30.8' N 74°43.9' E Water depth: 11.8 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, silty clay	
		2.5Y 3/3	0-1 cm: Dark olive brown, silty clay	
		2.5Y 3/2	1-2 cm: Very dark greyish brown, silty clay	
		2.5Y 3/1	2-4 cm: Very dark grey, silty clay	
		5Y 3/2	4-10 cm: Dark olive grey, silty clay, bioturbated	
			10-12 cm: Dark olive grey, silty clay, bioturbated, black dots	
			12-13 cm: Dark olive grey, silty clay, bioturbated, black dots, polychaete tube	
			13-14 cm: Dark olive grey, silty clay, bioturbated, black dots	
			14-15 cm: Dark olive grey, silty clay, bioturbated, black dots, polychaete tube	
			15-16 cm: Dark olive grey, silty clay, bioturbated, small black dots, polychaete tube	
			16-17 cm: Dark olive grey, silty clay, bioturbated, black dots	
			17-19 cm: Dark olive grey, silty clay, bioturbated, black dots, polychaete tube	
			19-20 cm: Dark olive grey, silty clay, bioturbated, black dots	
			20-30 cm: Dark olive grey, silty clay, black dots	
			30-33 cm: Dark olive grey, silty clay, big black dots	
			33-35 cm: Dark olive grey, silty clay, black dots	
			36-38 cm: Dark olive grey, silty clay, bioturbated, black dots	
			38-39 cm: Dark olive grey, silty clay, black dots, shell fragment	
			39-40 cm: Dark olive grey, silty clay, bioturbated, black dots	
			40-41 cm: Dark olive grey, silty clay, black dots, shell fragment	



BP99-24/05 (MUC) Ob Estuary **Boris Petrov '99**

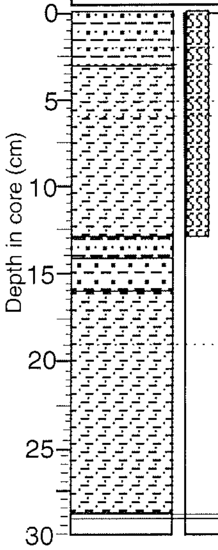
Recovery: 0.32.5 m 73°26' N 74°52.3' E Water depth: 15.5 m



Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, sandy silty clay	
		2.5Y 3/3	0-1 cm: Dark olive brown, sandy silty clay 1-2 cm: Dark olive brown, sandy silty clay, bioturbated, polychaete tube	
		2.5Y 3/2	2-3 cm: Very dark greyish brown, sandy silty clay, bioturbated, polychaete tube 3-4 cm: Very dark greyish brown, sandy silty clay, bioturbated, living worm ("Neftis")	
		5Y 3/2	*4-6 cm: Dark olive grey, sandy silty clay, bioturbated* 6-9 cm: Dark olive grey, sandy silty clay, bioturbated, black dots, living polychaete	
		5Y 3/1	9-11 cm: Very dark grey, sandy silty clay, black dots 11-15 cm: Very dark grey, clayey sand, black dots, shell fragments 15-16 cm: Very dark grey, sandy silty clay, black dots, shell fragments	
		5Y 2.5/2	16-17 cm: Black, clayey sand, shell fragments 17-19 cm: Black, clayey sand, bioturbated 19-21 cm: Black, silty clay 21-23 cm: Black, clayey sand 23-24 cm: Black, clayey sand, shell fragments 24-25 cm: Black, clayey sand 25-26 cm: Black, silty clay 26-27 cm: Black, sandy silty clay 27-32 cm: Black, silty clay	

BP99-25/05 (MUC) Kara Sea **Boris Petrov '99**

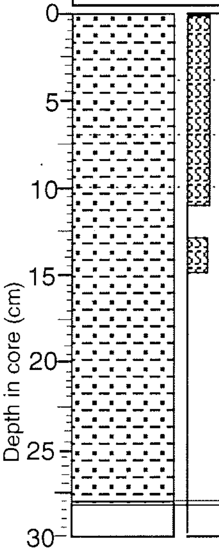
Recovery: 0.29 m 74°00.1' N 73°59.8' E Water depth: 21.9 m



Lithology	Texture	Color	Description	Age
	Surface		Olive brown, 2.5Y 4/4, sandy silty clay, bioturbated	
		2.5Y 4/4	0-1 cm: Olive brown, sandy silty clay, bioturbated 1-2 cm: Olive brown, sandy silty clay, bioturbated, shell fragment	
		5y 3/2	2-3 cm: Dark olive grey, sandy silty clay, bioturbated, shell fragment	
		5y 3/1	3-5 cm: Very dark grey, silty clay, bioturbated	
		5y 3/2	5-6 cm: Dark olive grey, silty clay, bioturbated	
		5y 3/1	6-9 cm: Very dark grey, silty clay, bioturbated 9-11 cm: Very dark grey, silty clay, bioturbated, black dots 11-13 cm: Very dark grey, silty clay, bioturbated, black dots 13-14 cm: Very dark grey, sandy silty clay, black dots 14-15 cm: Very dark grey, sandy clay, black dots 15-16 cm: Very dark grey, sandy clay, black dots, shell fragment 16-17 cm: Very dark grey, silty clay, black dots, shell fragment 17-19 cm: Very dark grey, silty clay, black dots	
		2.5y 2/0	19-29 cm: Black, silty clay	

BP99-28/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.28 m 73°25.4' N 78°48.7' E Water depth: 18.8 m

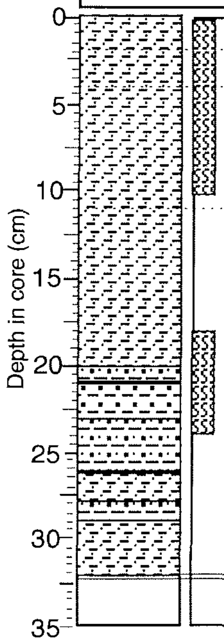


Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, sandy clay, bioturbated, living polychaete	
		2.5Y 3/3	0-4 cm: Dark olive brown, sandy clay, bioturbated, polychaete tube	
		2.5Y 3/2	4-7 cm: Very dark greyish brown, sandy clay, bioturbated	
		5Y 3/2	7-8 cm: Dark olive grey, sandy clay, bioturbated, shell fragments 8-9 cm: Dark olive grey, sandy clay, bioturbated, shell fragments, living worm 9-10 cm: Dark olive grey, sandy clay, bioturbated, black dots, living worm	
		5Y 3/1	10-11 cm: Very dark grey, sandy clay, bioturbated, black dots, living worm 11-13 cm: Very dark grey, sandy clay, black dots 13-15 cm: Very dark grey, sandy clay, black dots, living worm 15-17 cm: Very dark grey, sandy clay, black dots 17-18 cm: Very dark grey, sandy clay, black dots, gastropode 18-28 cm: Very dark grey, sandy clay, black dots	

BP99-29/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.32 m 73°5.5' N 78°30.8' E Water depth: 12.2 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, silty clay, bioturbated	

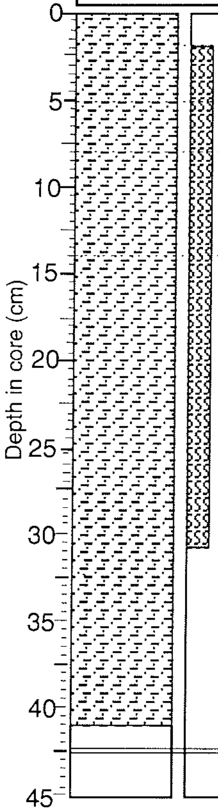


Color	Description
2.5Y 3/3	0-1 cm: Olive brown, silty clay, bioturbated 1-2 cm: Olive brown, silty clay, bioturbated, polychaete tube
2.5Y 3/2	2-4 cm: Dark olive grey, silty clay, bioturbated, polychaete tube
2.5Y 3/1	4-5 cm: Very dark grey, silty clay, bioturbated, polychaete tube 5-6 cm: Very dark grey, silty clay, bioturbated, black dots 6-8 cm: Very dark grey, silty clay, bioturbated, black dots, living worm 8-10 cm: Very dark grey, silty clay, bioturbated, black dots 10-11 cm: Very dark grey, silty clay, black dots
5Y 2.5/1	11-18 cm: Black, silty clay, black dots 18-20 cm: Black, silty clay, black dots, polychaete tube 20-21 cm: Black, sandy silty clay, black dots, polychaete tube 21-22 cm: Black, clay sand, shell fragments 22-23 cm: Black, clay sand, black dots, shell fragments 23-24 cm: Black, sandy silty clay, black dots, polychaete tube, shell fragments 24-26 cm: Black, sandy silty clay, black dots 26-28 cm: Black, silty clay, black dots 28-29 cm: Black, sandy silty clay, black dots 29-32 cm: Black, silty clay, black dots

BP99-30/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.42.5 m 72°27.5 N 79°18' E Water depth: 9.2 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, silty clay	
		2.5Y 3/3	0-2 cm: Dark olive brown, silty clay	
		2.5Y 3/2	2-3 cm: Very dark greyish brown, silty clay, bioturbated, polychaete tube 3-5 cm: Very dark greyish brown, silty clay, bioturbated	
		5Y 3/2	5-8 cm: Dark olive grey, silty clay, bioturbated	
		5Y 3/2	8-10 cm: Very dark grey, silty clay, bioturbated 10-11 cm: Very dark grey, silty clay, bioturbated, living worm 11-14 cm: Very dark grey, silty clay, bioturbated, black dots	
		5Y 3/1	14-18 cm: Black, silty clay, bioturbated, black dots 18-19 cm: Black, silty clay, bioturbated, black dots, smells like H_2S 19-21 cm: Black, silty clay, bioturbated, black dots, smells like H_2S, polychaete tube 21-31 cm: Black, silty clay, bioturbated, black dots, smells like H_2S 31-41 cm: Black, silty clay, black dots, smells like H_2S	



BP99-31/05 (MUC) Yenisei Estuary **Boris Petrov '99**

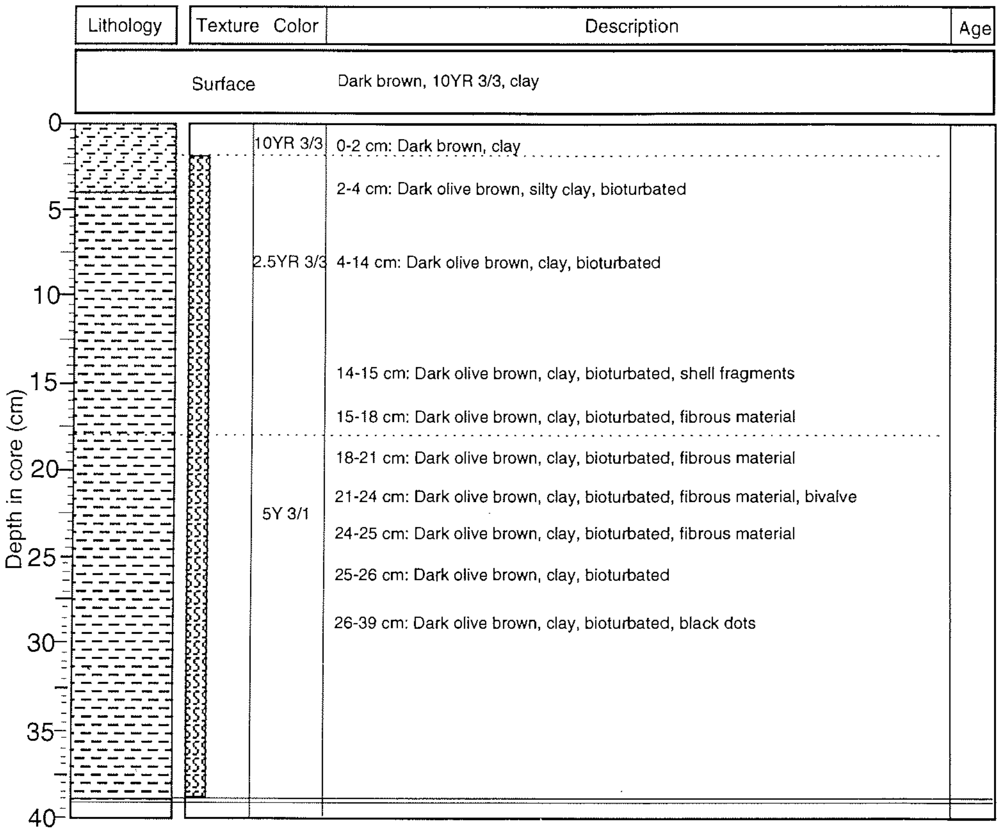
Recovery: 0.34 m 72°29.2' N 79°45.7' E Water depth: 12.4 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, silty clay, bioturbated	
		2.5Y 3/3	0-2 cm: Dark olive brown, silty clay, bioturbated	
		5Y 3/2	2-3 cm: Dark olive grey, silty clay, bioturbated, polychaete tube 3-4 cm: Dark olive grey, silty clay, bioturbated	
		5Y 3/1	4-7 cm: Very dark grey, silty clay, bioturbated, black dots	
		5Y 2.5/1	7-8 cm: Black, silty clay 8-10 cm: Black, silty clay, bioturbated 10-30 cm: Black, slightly silty clay 30-31 cm: Black, slightly silty clay, shell fragments 31-33 cm: Black, slightly silty clay	

Depth in core (cm): 0, 5, 10, 15, 20, 25, 30, 35

BP99-32/05 (MUC) Yenisei Estuary **Boris Petrov '99**

Recovery: 0.39 m 73°08.1' N 79°57.2' E Water depth: 22.9 m

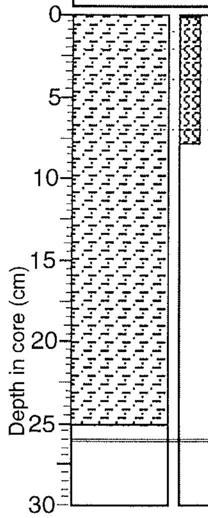


BP99-35/05 (MUC) Kara Sea **Boris Petrov '99**

Recovery: 0.26 m 74°18.1' N 78°20' E Water depth: 29 m

Lithology | Texture Color | Description | Age

Surface: Dark olive brown, 2.5Y 3/3, sandy silty clay, bioturbated



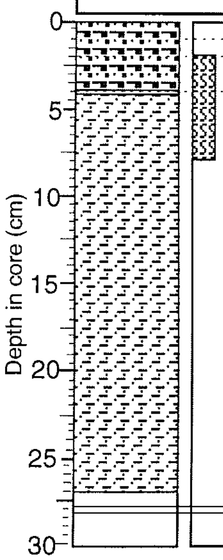
Color	Description
2.5Y 3/3	0-1 cm: Dark olive brown, sandy silty clay, bioturbated
2.5Y 4/2	1-2 cm: Olive brown, sandy silty clay, bioturbated, polychaete tube
5Y 4/2	2-4 cm: Olive grey, sandy silty clay, bioturbated, polychaete tube
5Y 4/1	4-5 cm: Dark grey, sandy silty clay, bioturbated, polychaete tube, black dots 5-7 cm: Dark grey, sandy silty clay, bioturbated, polychaete tube, black dots, shell fragments, living worm (Nermertini)
5Y 3/1	7-8 cm: Very dark grey, sandy silty clay, bioturbated, polychaete tube, black dots, shell fragments, living worm (Nermertini) 8-9 cm: Very dark grey, sandy silty clay, black dots, shell fragments 9-15 cm: Very dark grey, sandy silty clay, black dots 15-16 cm: Very dark grey, sandy silty clay, black dots, polychaete tube, shell fragments 16-17 cm: Very dark grey, sandy silty clay, black dots, polychaete tube 17-19 cm: Very dark grey, sandy silty clay, black dots 19-22 cm: Very dark grey, sandy silty clay, black dots, polychaete tube 22-23 cm: Very dark grey, sandy silty clay, black dots 23-24 cm: Very dark grey, sandy silty clay 24-25 cm: Very dark grey, sandy silty clay, shell fragments

BP99-38/05 (MUC) Kara Sea **Boris Petrov '99**

Recovery: 0.28 m 74°15' N 75°36.3' E Water depth: 26.8 m

Lithology | Texture Color | Description | Age

Surface: Olive grey, 5Y 4/2, sandy silty clay

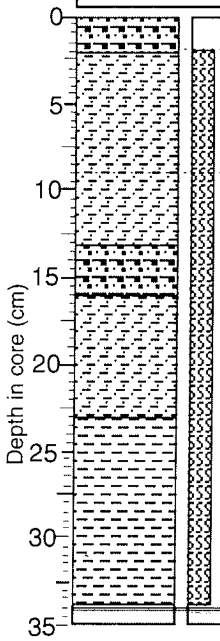


Color	Description
5Y 4/2	0-1 cm: Olive grey, sandy silty clay
2.5Y 4/3	1-2 cm: Olive brown, sandy silty clay
5Y 4/2	2-3 cm: Olive grey, sandy silty clay, bioturbated, shell fragments 3-4 cm: Olive grey, sandy silty clay, bioturbated
5Y 3/1	4-5 cm: Very dark grey, silty clay, bioturbated, living worm, black dots 5-8 cm: Very dark grey, silty clay, bioturbated, black dots 8-9 cm: Very dark grey, silty clay, black dots 9-12 cm: Very dark grey, silty clay, black dots, rigid 12-15 cm: Very dark grey, silty clay, black dots, rigid, shell fragments 15-17 cm: Very dark grey, silty clay, black dots, rigid 17-19 cm: Very dark grey, silty clay, black dots, rigid, shell fragments 19-20 cm: Very dark grey, silty clay, black dots, rigid 20-21 cm: Very dark grey, silty clay, black dots, rigid, shell fragments 21-22 cm: Very dark grey, silty clay, black dots, rigid 22-24 cm: Very dark grey, silty clay, black dots, rigid, shell fragments 24-27 cm: Very dark grey, silty clay, black dots, rigid

BP99-39/05 (MUC) Kara Sea **Boris Petrov '99**

Recovery: 0.35 m 74°17.9' N 76°49.9' E Water depth: 33.3 m

Lithology	Texture	Color	Description	Age
	Surface		Dark olive brown, 2.5Y 3/3, sandy silty clay	
		2.5Y 3/3	0-2 cm: Dark olive brown, sandy silty clay	
		5Y 4/2	2-6 cm: Olive grey, silty clay, bioturbated 6-9 cm: Olive grey, silty clay, bioturbated, black dots	
		5Y 4/2	9-13 cm: Dark olive grey, silty clay, bioturbated, black dots 13-15 cm: Dark olive grey, sandy silty clay, bioturbated, black dots 15-16 cm: Dark olive grey, sandy silty clay, bioturbated, black dots, bivalve 16-22 cm: Dark olive grey, silty clay, bioturbated, black dots 22-23 cm: Dark olive grey, silty clay, bioturbated, black dots, shell fragments 23-24 cm: Dark olive grey, clay, bioturbated, black dots, shell fragments 24-25 cm: Dark olive grey, clay, bioturbated, black dots, shell fragments, polychaete tube 25-27 cm: Dark olive grey, clay, bioturbated, black dots, shell fragments 27-34 cm: Dark olive grey, clay, bioturbated, black dots	



10.4 Summary table of planned investigations by participating institutes

Table 10-4:
Summary of biological, geochemical, and geological studies performed at Russian and German institutes on water and sediment samples obtained during the "Akademik Boris Petrov" Kara Sea Expedition 1999

	Institute	Methods	Parameter
1. Water samples			
Sea (river) water	GEOKHI	Classical chemical analyses	Nutrients (PO4, NO3, NO2, SiO2), alkalinity, pH, chlorinity
Sea water	GEOKHI	GC	Concentration and distribution of CH4 and C2-C6 homologues
Dissolved organic matter	IFBM-AWI	HTC, HPLC, GC/MS, IRMS, CHN, NMR	DOC, DON; C, N; Amino acids, lignin phenols; structure
Carbon and silica cycle	IFBM	CN, HPLC, MS, Photometry	POC, PON, CaCO3, Opal, aminoacids, carbohydrates; ∂15N
Particulate organic matter	AWI	GC, GC/MS	Biomarkers (n-alkanes, fatty acids, sterols, hopanoids etc.
Particulate organic matter	GEOKHI	CNS, MS	POC, PON; stable carbon and nitrogen isotopes
Particulate organic matter	GEOKHI	Radiochemistry	137-Cs and other radianuclides
Geochemistry	GEOMAR	MS	Stable inorganic carbon and oxygen isotopes
Geochemistry	GEOKHI	MS	Stable inorganic carbon isotopes
Phytoplankton	GEOKHI	MS	Stable carbon and nitrogen isotopes
Phytoplankton	MMBI	Microscopy, statistical analysis	Abundances, species composition, community structure
Zooplankton	AWI	Microscopy, REM, statistical analysis	Abundances, biomass, species composition, community structure

2. Sediments	Institute	Methods	Parameter
Benthos ecology	AWI	Microscopy, statistical analysis	Abundances, biomass, species composition, community structure
Benthos	GEOKHI	Gamma-spectrometry	Total radioactivity
Sedimentology/Mineralogy	AWI	XRD	Bulk and clay minerology
Organic geochemistry	AWI	CNS, Rock-Eval, GC, GC/MS; Microscopy	TOC, N, S; C/N, HI, OI; Biomarkers, ∂13C of biomarkers; Macerals
Organic geochemistry	IFBM	CN, HPLC, MS, Photometry	POC, PON, CaCO3, Opal, aminoacids, carbohydrates; ∂15N
Organic geochemistry	GEOKHI	CNS, Rock-Eval, GC, GC/MS	C, N, S; pyrolysis parameter; lignin; stable carbon and nitrogen isotopes
Hydrocarbon gases	GEOKHI	GC, GC/MS	Concentration and distribution of hydrocarbon gases; stable isotopes CH4
Pore-water chemistry	GEOKHI	classical chemistry analyses	Nutrients (PO4, NO3, NO2, SiO2), alkalinity, pH, chlorinity
Radio-geochemistry	GEOKHI	Radiochemistry, gamma-spectrometry	137-Cs, 90-Sr, 239-Pu, 240-Pu, 210-Pb
Radio-geochemistry	IGEM	Radiochemistry, gamma-spectrometry	137-Cs, 90-Sr, 239-Pu, 240-Pu, 210-Pb
Micropaleontology	AWI	Microscopy	Palynomorphs, diatoms, benthic foraminifers; pollen stratigraphy
Geochemistry	GEOMAR	MS	Stable inorganic carbon and oxygen isotopes
Inorganic geochemistry	AWI	RFA	Major and minor elements
Inorganic geochemistry	GEOKHI	XRS	Heavy elements
Dating of sediment cores	AWI	AMS 14C	Chronology; flux rates

10.5 Participants

10.5 Participants

Country and Institutions

Germany

AWI
Alfred Wegener Institute for Polar and Marine Research
P.O.Box 120161
27515 Bremerhaven

IFBM
Institute of Biogeochemistry and Marine Chemistry
University of Hamburg
Grabenstr. 27
20357 Hamburg

GEOMAR
Research Center for Marine Geosciences
University of Kiel
Wischhofstr.1-3
24148 Kiel

Russia

GEOKHI
Vernadsky Institute of Geochemistry and Analytical Chemistry
Russian Academy of Sciences
19, Kosygin Street
117975 Moscow

IGEM
Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry
Russian Academy of Sciences
35, Staromonetnyi per
Moscow, 109017

IORAS
P.P. Shirshov Institute of Oceanology,
Atlantic Branch
Russian Academy of Sciences
1, Mira Prospect
Kaliningrad, 23600

MMBI
Murmansk Marine Biological Institute
Russian Academy of Sciences
17, Vladimirskaya Street
Murmansk, 183019

Research Participants

Name	Discipline	Institution
Stepanets, Oleg	Chief of Expedition	GEOKHI
Stein, Ruediger	Co-chief Scientist (Geology)	AWI
Amon, Rainer	Organic Geochemistry	IFBM-AWI
Arndt, Carolin	Biology	AWI
Bogacheva, Margarita	Organic Geochemistry	GEOKHI
Borisov, Alexandr	Radio-Geochemistry	GEOKHI
Boucsein, Bettina	Geology	AWI
Deubel, Hendrik	Biology	AWI
Fetzer, Ingo	Biology	AWI
Hefter, Jens	Organic Geochemistry	AWI
Khorshev, Victor	Engineer	GEOKHI
Kluev, Evgeny	Chemistry	GEOKHI
Kodina, Lyudmila	Organic Geochemistry	GEOKHI
Köhler, Gert-Hayo	Organic Geochemistry	IFBM
Komarevskiy, Vasiliy	Radio-Geochemistry	GEOKHI
Kraus, Matthias	Geology	AWI
Larionov, Viktor	Biology	MMBI
Lau, Nina	Geology	GEOMAR
Ligaev, Alexandr	Radio-Geochemistry	GEOKHI
Miroshnikov, Alexey	Geology	IGEM
Neumann, Kirsten	Organic Geochemistry	IFBM
Osadchiy, Nikolay	Engineer	GEOKHI
Pribylova, Tatyana	Organic Geochemistry	GEOKHI
Prusakov, Boris	Computer Center Engineer	GEOKHI
Schoster, Frank	Geology	AWI
Shmelkov, Boris	Oceanography	GEOKHI
Simstich, Johannes	Geology	GEOMAR
Sizov, Yevgeniy	Engineer	GEOKHI
Solovjeva, Galina	Radio-Geochemistry	GEOKHI
Stefantphsev, Leonid	Oceanography	GEOKHI
Sukhoruk, Vladimir	Marine Chemistry	IORAS
Testov, Stas	Radiochemistry	GEOKHI
Tokarev, Victor	Organic Geochemistry	GEOKHI
Unger, Daniela	Organic Geochemistry	IFBM
Vlasova, Lyudmila	Organic Geochemistry	GEOKHI
Weiel, Dominik	Geology	AWI

Ships Crew

Kondratev Victor	Captain
Dmitrenko Petr	Chief mate
Moiseev Alexey	2nd Mate
Vaulin Alexandr	2nd Mate
Pasechnik Dmitriy	3rd Mate
Shalimov Yuriy	Mate
Krytin Alexey	Chief Radio
Reutzkiy Anatoliy	Doctor
Latko Alexandr	Scientific Engineer
Sivkov Vadim	Chief Engineer
Kuryshev Victor	2nd Engineer
Osminin Anatoliy	3rd Engineer
Tsentner Boris	4th Engineer
Drozdov Fedor	Electric Engineer
Ganoshenko Anatoliy	2nd Electric Engineer
Markovskiy Vladimir	Boatswain
Orlov Sergey	Seaman
Levkin Vladimir	Seaman
Teryokhin Alexandr	Seaman
Nesterchuk Yuriy	Seaman
Domrachev Alexey	Seaman
Privalov Andrey	Seaman
Petrov Oleg	Seaman
Vtorov Andrey	Seaman
Slepchenko Vladimir	Repair Engineer
Zaytsev Anatoliy	Motorman
Fil Vladimir	Motorman
Shpakovskiy Yuriy	Motorman
Yarokhno Andrey	Motorman
Titova Angelina	Stewardess
Ilyina Vera	Stewardess
Shorova Natalya	Stewardess
Demyanovich Galina	Stewardess
Dolmatova Irina	Stewardess
Razumovskaya Irina	Cook
Zolotaryova Svetlana	Cook