Scientific Cruise Report of the joint Russian-German Kara Sea Expedition in 2002 with RV "Akademik Boris Petrov"

Wissenschaftlicher Fahrtbericht über die russisch-deutsche Karasee-Expedition 2002 mit FS "Akademik Boris Petrov"

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Scientific Cruise Report of the joint Russian-German Kara Sea Expedition 2002 with RV "Akademik Boris Petrov"

Wissenschaftlicher Fahrtbericht über die russisch-deutsche Karasee-Expedition 2002 mit FS "Akademik Boris Petrov"

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1. Introduction

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Within the framework of the Russian-German project on "The nature of continental run-off from the Siberian rivers and its behavior in the Adjacent Arctic Basin (Siberian River Run-Off – SIRRO)" and based on the results of the former four expeditions in 1997, 1999, 2000, and 2001 (Matthiessen and Stepanets 1998, Stein and Stepanets 2000, 2001, 2002) a fifth expedition with RV "Akademik Boris Petrov" into the Kara Sea was carried out into the inner Kara Sea and the Ob Estuary (Fig 2-1). Aims of the project and also of this expedition are the understanding of the oceanographical, biological, geochemical, and geological processes in the inner Kara Sea and the Ob Estuary (Fig. 1-1; Stein et al. 2003 and further references therein). In order to fulfill these aims, two moorings are recovered, and additional oceanographical, biological and geochemical data are collected in the begin of autumn.

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

(1) to characterize the supply of the Ob River 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 river supply 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, and
(4) to study the dispersal and distribution pattern of contaminants.

The research institutes involved in this expedition were from the Russian side the Vernadsky Institute of Geochemistry and Analytical Chemistry (GEOKHI) Moscow, the Arctic and Antarctic Research Institute (AARI) in St. Petersburg, the Murmansk Marine Biological Institute (MMBI), and the Moscow State University, 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.

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. In addition, some results from studies of the 1997, 1999, and 2000 material are also presented.

and his crew for their untiring and able support during work onboard RV "Akademik Boris Petrov".

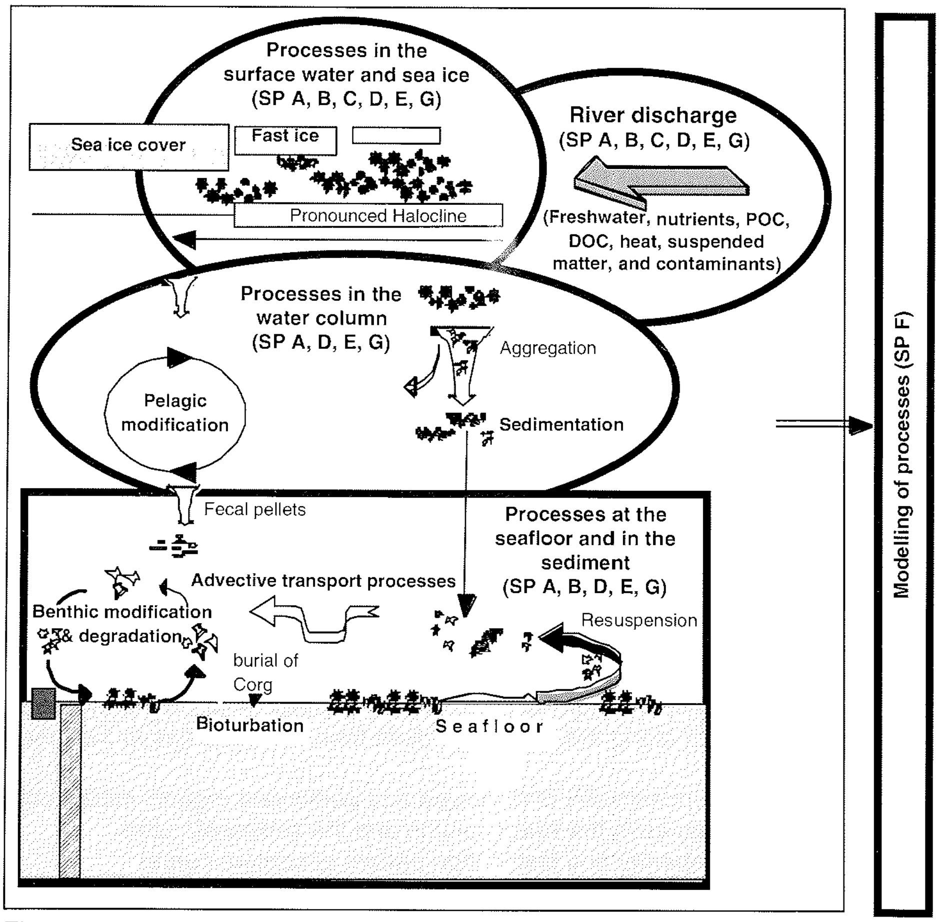

Figure 1-1: Major processes related to river discharge, its distribution, freshwater transformation and sedimentary documentation in the Kara Sea. A to G indicate subprojects (SP) of the multidisciplinary SIRRO project involved in studying the various processes (Fütterer and Galimov 2003; Stein et al. 2003).

2. Itinerary

F. Schoster[1] and M. Levitan[2]

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In the evening of September 26, 2002, the German participants arrived in Murmansk to embark onto RV "Akademik Boris Petrov". Almost all of the Russian participants of the expedition were already onboard, the rest came one day later. After loading the equipment onto RV "Akademik Boris Petrov" we left Murmansk in the afternoon of September 30, 2002, with 35 crew members and 20 German and Russian scientists. We headed eastwards in order to pass the Kara Gate between Novaya Zemlya and Vaigach. After passing the Kara Gate the course of RV "Akademik Boris Petrov" changed to north-east to the position of the northern sediment trap.

On October 04, 2002, our first position was reached and, despite of the new-ice covering, the mooring was recovered successfully. Because of the ice, coming from the north, we moved as fast as possible to the second mooring in the Yenisei Estuary. Unfortunately, the weather became bad. So the sediment trap couldn't be recovered at that day. On October 06, 2002, the weather was better and we recovered the second sediment trap. After repairing of the sediment trap and an additional station westwards of the Sverdrup Island the sediment trap was deployed again (Fig. 2-1, Fig. 2-2).

The scientific program was continued in the Ob Estuary on October 08, 2002. The station work began with CTD measurements, followed by water sampling based on the CTD-data. Surface water is sampled by buckets and pump, and plankton nets are used by the biologists in order to collect data about the diversity of plankton With box-corer, multi-corer and Van Veen grab surface and near surface sediments are sampled. In order to get information about the benthic biota we used a benthos dredge. The scientific program was finished with our last station in the mouth of the Ob River on October 10, 2002. Then RV "Akademik Boris Petrov" moved westwards back to Murmansk, which we arrived on October 13, 2002.

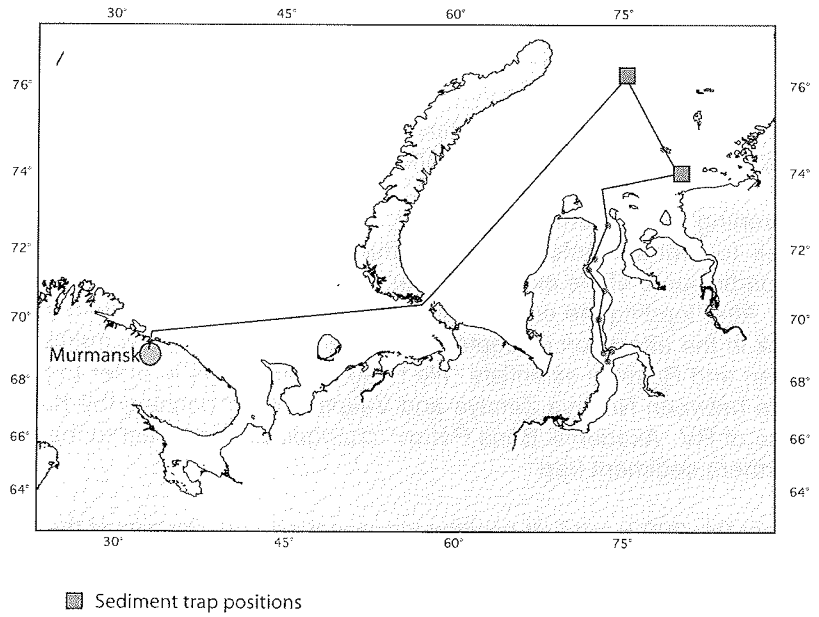
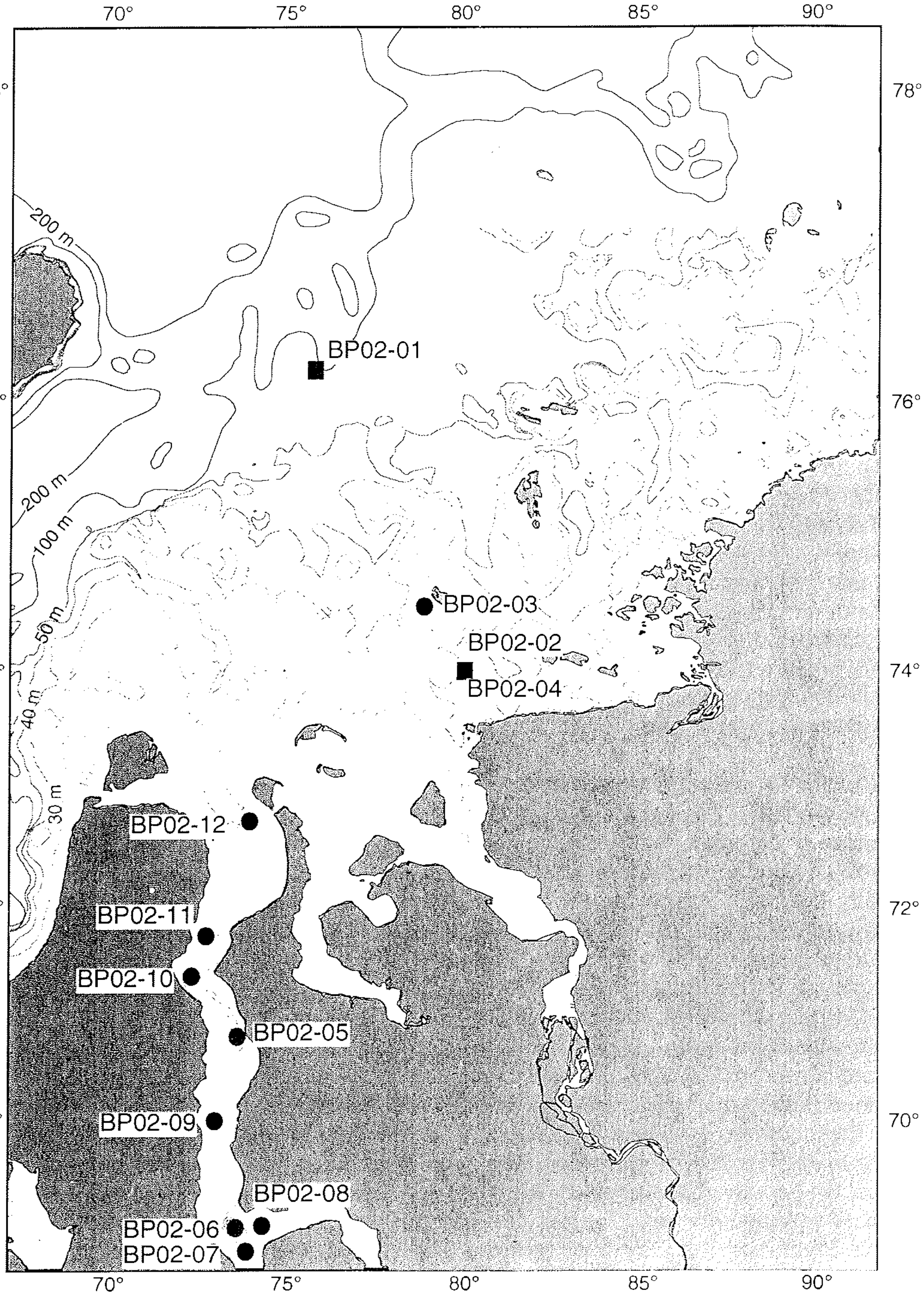


Figure 2-1: Cruise track of Kara Sea Expedition 2002 with RV "Akademik Boris Petrov"



● Stations of Expedition „Boris Petrov 2002"

■ Sediment traps (BP02-01: Sediment Trap Recovery; BP02-02, BP02-04: Sediment Trap Recovery and Deployment)

Figure 2-2: Sample sites and positions of sediment traps of „Boris Petrov"-Expedition 2002

3. Meteorological Data and Ice Conditions

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During the Kara Sea Expedition 2002 with RV "Akademik Boris Petrov", the meteorological data was taken at each station from the bord computer screen. Table 3-1 shows the surface water temperature, the air temperature, the wind speed and the wind direction. Due to the late seasonal start in the end of September 2002,the ice conditions were important. For some days the distribution of the sea ice in the Kara Sea is presented in Figures 3-1 (http:/www.sea-ice.de, Kaleschke et al. 2001).

According to the late time of the expedition the air temperatures were below 0°C (Table 3-1). In earlier expeditions in this working area the air temperatures were between 3 and 8 °C in August/September 1999, for example (Stein 2000). The water temperature is changing from - 0.75 in the central, marine Kara Sea to a maximum of +3 in the Ob River (Table 3-1). From October 04 to October 09, northwesterly, westerly and southwesterly winds with speeds between 2 and 14 m/s occurred, except October 05 with stormy weather and wind speeds up to 22 m/s. During October 09, the wind was changing to northeasterly direction with speeds between 5 and 7 m/s.

In order to get oceanographic data and biological and geochemical samples during another season in the Kara Sea, the expedition started at the end of the northern summer. At that time ice conditions in the Kara Sea could be problematic, and therefore, observing the sea-ice extension was important. A daily update of the sea-ice conditions was reported on the website http://www.seaice.de. On August 05, the sea ice was melting (Figure 3-1a). During the summer the Kara Sea south of 78 °N is mainly ice-free (Figure 3-1b-c). At the end of the short summer, the sea ice was moving to the south (Figure 3-1 d-g). In the winter the whole Kara Sea is sea-ice covered (Figure 3-1h). In this expedition newly formed sea ice (pancake ice) were recorded in the central Kara Sea on October 04, which can also be recognised in the sea-ice concentration map (Figure 3-1e, northern sediment trap position). To days later at the southern sediment trap posititon, small fields of newly formed sea ice occurred. The sea-ice concentration map showed low ice concentrations north, east and south of this position (Figure 3-1f). Between October 07 and October 09, RV "Akademik Boris Petrov" moved from the mouth of the Ob River to the Taz River and the way back without any sea-ice observes. So the sea-ice concentrations in the Ob River and probably also the Yenisei River are artifacts from the satellite observings or the calculations with the algorithms (Figures 3-1).

Table 3-1: Meteorological data recorded at the stations of the Kara Sea Expedition 2002 with RV "Akademik Boris Petrov" (Air: Air Temperature, Water: Water Temperature)

Station	Date	Time [UTC]	Latitude °N	Longitude °E	Air [°C]	Water [°C]	Salinity [psu]	Wind Speed [m/s]	Wind Direction
BP02-01A	2002-10-04	6:00	76°13,08	75°43,97	-3	-0,75	26,2	9,1	110°
BP02-01B	2002-10-04	10:00	76°13,08	75°43,97	-2,5	-0,6	26,2	8,9	98°
	2002-10-04	16:30	76°16,37	75°43,02	-2,9	-0,46	26,2	13,9	103°
BP02-02A	2002-10-06	4:30	74°00,07	80°19,87	-2,1	+0,32	11,5	11,5	85°
BP02-02B	2002-10-06	5:25	73°59,58	80°19,53	-2,1	+0,32	11,5	11,5	85°
	2002-10-06	9:30	73°59,28	80°02,80	-1,2	+0,1	11,5	12,3	77°
BP02-03	2002-10-06	15:30	74°34,69	78°52,53	-0,6	-0,23	n.d.	10,9	88°
BP02-04	2002-10-07	2:00	74°00,06	80°19,90	-1,8	-0,21	n.d.	12,6	85°
BP02-05	2002-10-08	4:23	70°49,84	73°43,70	-2,8	+3,19	0	13,9	43°
BP02-06	2002-10-08	4:00	68°54,91	73°39,94	-0,7	+2,29	0	10,4	109°
BP02-07	2002-10-08	17:00	68°40,07	73°59,74	-0,8	+2,55	0	5,6	82°
BP02-08	2002-10-08	19:16	68°58,08	74°22,03	-1,0	+2,53	0	6,2	63°
BP02-09	2002-10-09	2:13	69°58,70	73°11,35	-1,4	+2,81	0	2,2	113°
BP02-10	2002-10-09	10:15	71°26,81	72°17,13	-2,5	+3,03	0	5,4	307°
BP02-11	2002-10-09	12:45	71°45,05	72°48,63	-2,1	+2,79	0	6,4	280°
BP02-12	2002-10-09	18:05	72°40,40	73°59,80	-0,7	+1,52	8,2	7,1	267°

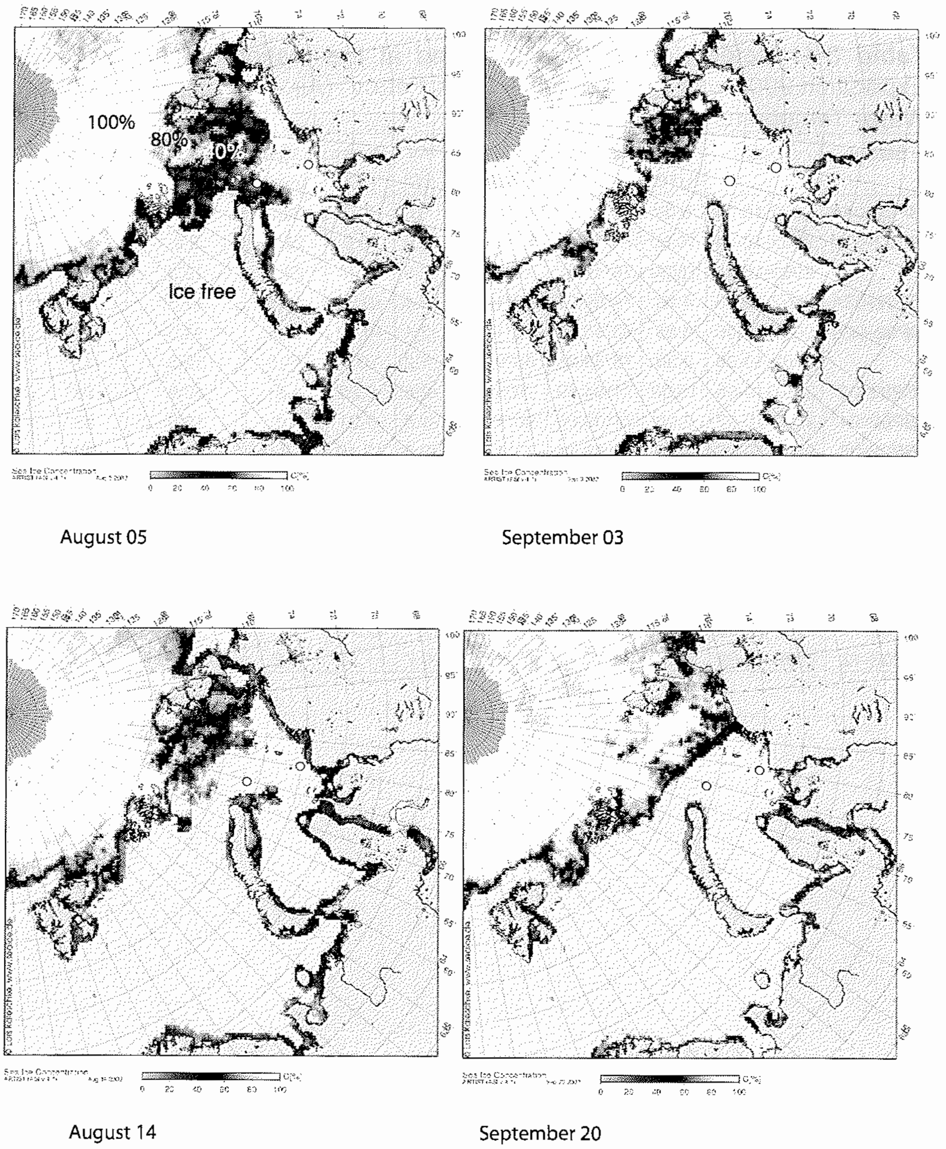

Figure 3-1 a - d: Ice conditions in the Kara Sea from August 05, 2002 until September 20, 2002 (Source (in colour): http://www.seaice.de; due to maps are printed in black and white, examples of ice concentrations (100%, 80%, 40%, ice free) are given in Figure 3-1a; dots are the sites of the sediment traps).

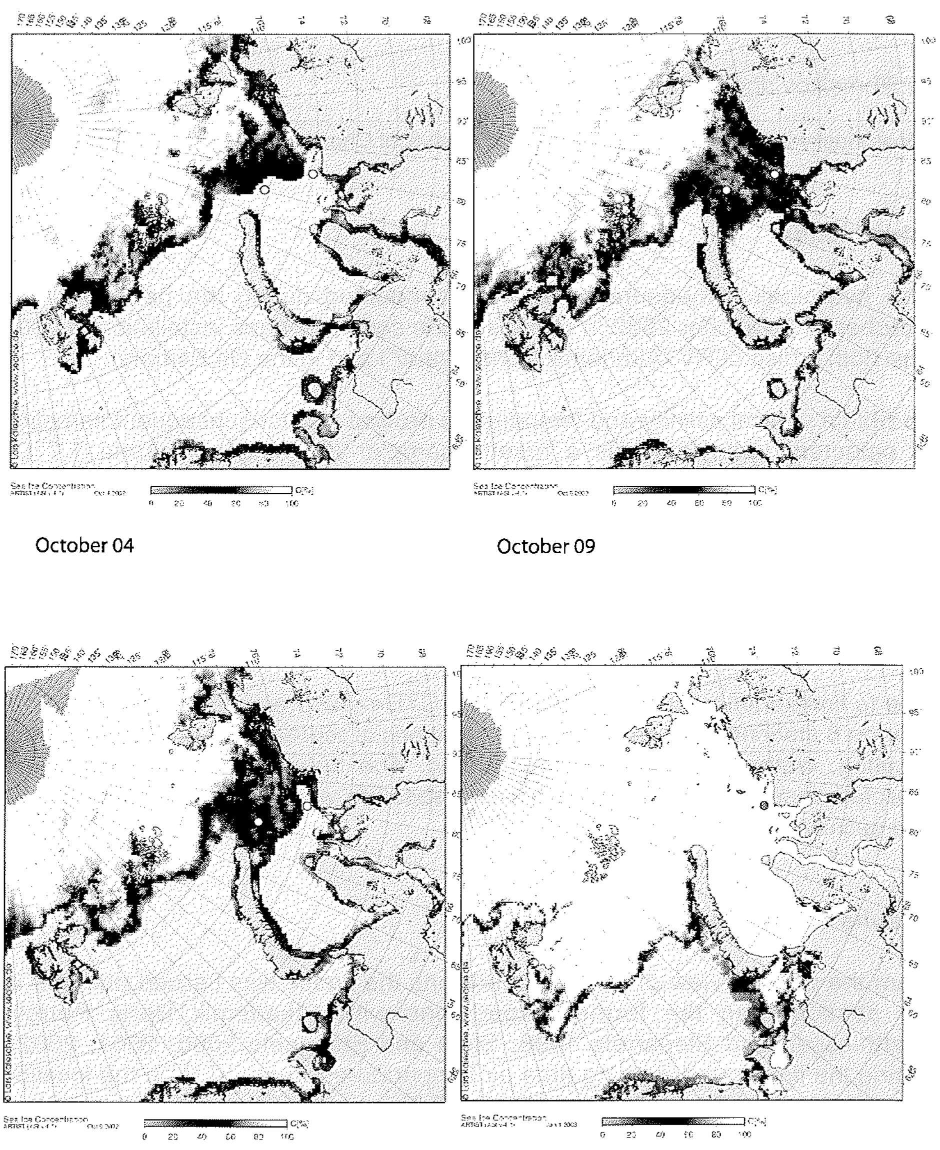

Figure 3-1 e - h: Ice conditions in the Kara Sea from October 04, 2002 until January 01, 2003 (Source (in colour): http://www.seaice.de; due to maps are printed in black and white, examples of ice concentrations (100%, 80%, 40%, ice free) are given in Figure 3-1a; dots are the sites of the sediment traps).

4. Hydrological investigations in the Kara Sea during cruise 2002

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Introduction

The hydrological measurements were conducted during the period from 4 October till 9 October 2002 in regions of the sediment traps installation in 2001 (the 36th cruise of RV "Akademik Boris Petrov") and in the Ob Estuary.

To obtain vertical salinity and temperature profiles and for subsequent sampling of selected depth intervals a rosette sampler (22 bottles, volume 1.7 L), including CTD-probe "MARK-3B" of the "EG and G OCEAN PRODUCTS" company was used. The probe is suitable for measurements of electrical conductivity, temperature and pressure up to depths of 6000 m. The measurement precision for temperature in the range from -32°C up to + 32°C is ±0.005°C, for electrical conductivity in the range from 1 up to 65 mmho is ±0.005 mmho, and for pressure in the range from 0 up to 320 db is ±0.1 db.

Due to limited time during the expedition, CTD-measurements were carried out only on 6 stations. The arrangement of stations is represented on Fig. 4-1. After profiling, water sampling was conducted. The horizons for sampling were selected based on the CTD-profiles and absolute values of water temperature and salinity.

Results and discussion

From the point of view of climatic conditions the cruise was carried out later in the season than the former expeditions with "Akademik Boris Petrov" (Matthiessen and Stepanets 1998, Stein and Stepanets 2000, 2001, 2002). During the time in the working area air temperatures were < 0°C, in the location of station 1 some ice fields were observed. This leads to convection processes, which in most cases can be determined by CTD-measurements throughout the vertical hydrological structure of the water column.

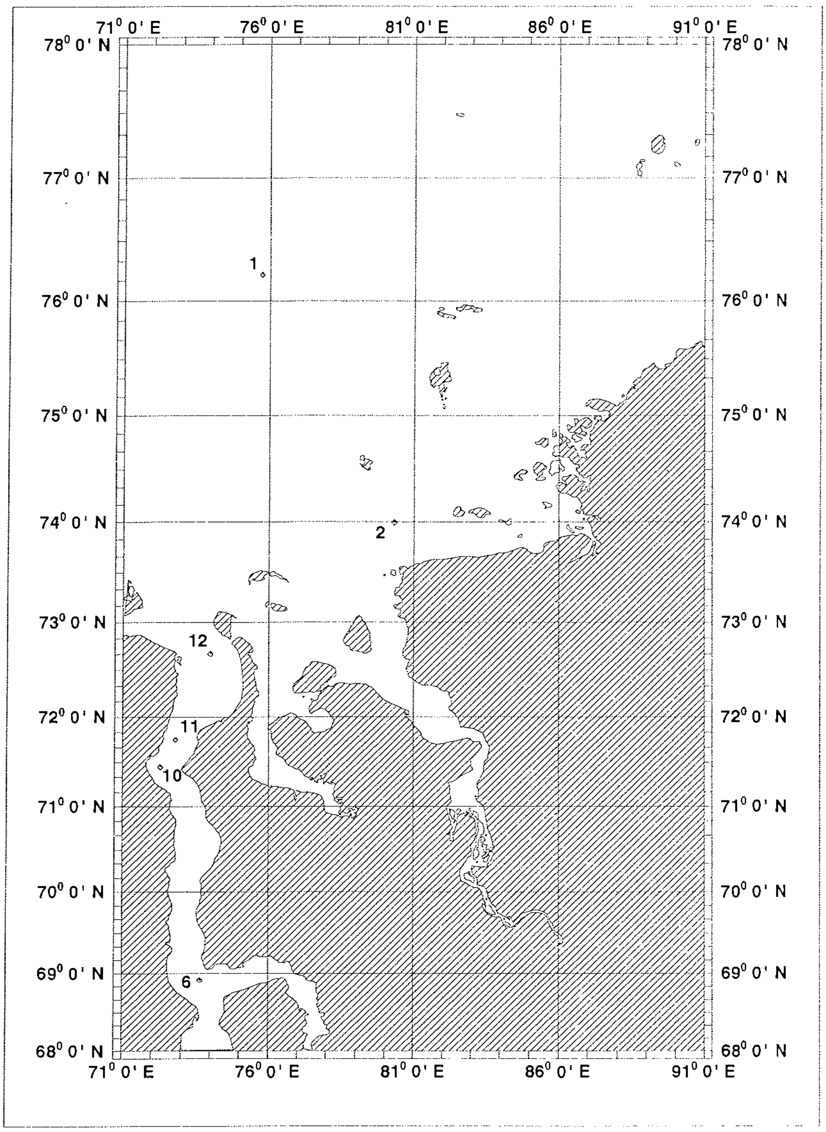

Figure 4-1: Hydrophysical stations on the Kara Sea Expedition 2002 with RV "Akademik Boris Petrov".

On Fig. 4-2 a and b, the vertical profiles of temperature and salinity on stations BP02-01 and BP02-02, (regions of installation of sediment traps in August-September 2001, stations BP01-61 and BP01-26, accordingly) are represented. The distribution of temperature vs. depth at station BP02-01 was practically homogeneous with small fluctuations as a result of a strong convection in the water column. The salinity is increased from 27 ppt up to 34 ppt in subbottom layer, beginning from a depth of ~ 15 m. At the more southern station BP02-02

(Fig. 4-2b), near to the Yenisei Gulf the vertical structure of temperature and salinity is characteristic for estuaries. The vertical gradient of temperature in pycnocline layer for this station was equal to ~ 0.7 °C per 1m (~ 2 °_ per 1m at station BP01-26). The pycnocline depth (~ 8 m) and the vertical salinity gradient in pycnocline layer (~ 6 ppt per 1m) were close to values obtained in 2001.

Temperature in the upper layer on both stations (BP02-01 and BP02-02) was below than multiyear mean values obtained from the historical data, available for us. The salinity in the upper layer was close to multiyear mean values.

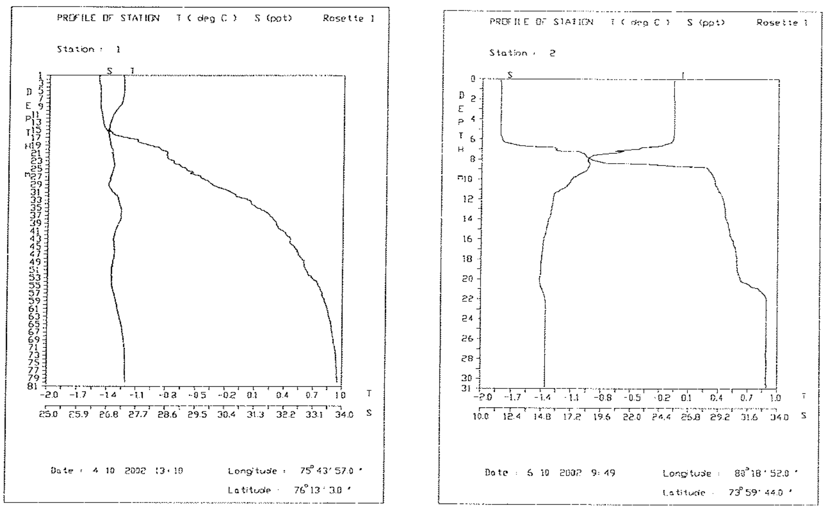

Figure 4-2: CTD profiles on stations BP02-01 (a) and BP02-02 (b).

The profiles of temperature and salinity of stations 6, 10, and 11 in the Ob Estuary show homogeneous distribution of riverine fresh water with temperatures values from 0.1 °C up to 2.4 °C (Fig. 4-3 a-c). At station BP02-12 (Fig. 4-3d) a practically homogeneous distribution of temperature throughout the whole water column can be recognized. In water depths from 7 - 9 m at station BP02-12 the salinity is increasing (Fig. 4-3d). The vertical gradient of salinity was equal to 9 ppt per 1 m. Temperature in the upper layer on stations 6, 10, 11, and 12 was below than multiyear mean values. From profiles, represented on Fig. 4-3 a, b, c, and d, it is obvious that in the investigated period the boundary between fresh and saline water in the Ob Gulf both near bottom and at surface was located between stations BP02-11 (71° 45' N) and BP02-12 (72° 40' N). This is in good agreement with the mean multiyear salinity distribution. Unfortunately, due to limited time during the expedition it was not possible to make additional stations in region of saline water penetration in the Ob Gulf.

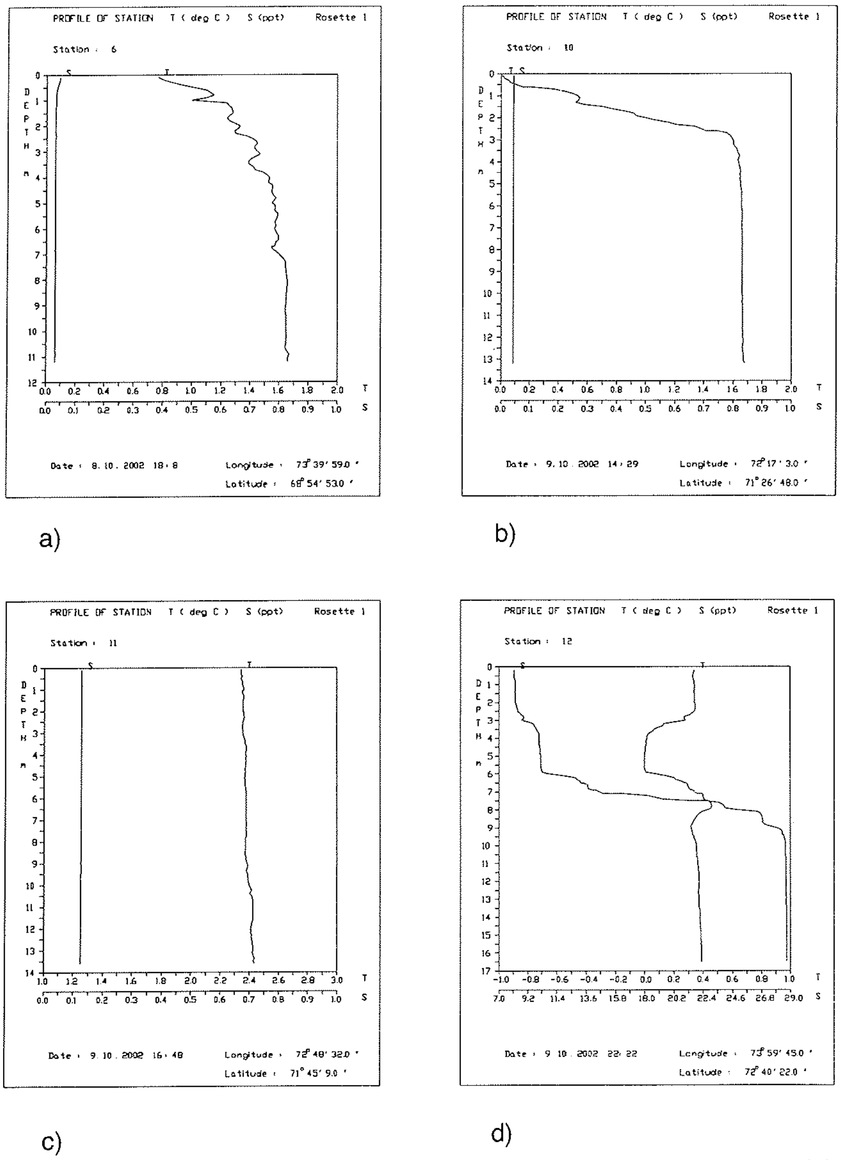

Fig. 4-3: CTD profiles on stations BP02-06 (a), BP02-10 (b), BP02-11 (c) and BP02-12 (d).

5. Sediment Trap Investigations in the Kara Sea

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Introduction

Transport processes and cycling of organic and lithogenic components within the transition zone between riverine and marine water masses play a major role in global biogeochemical cycles. Aim of this study is to investigate the seasonal variation of the transport and cycling of particulate matter in the water column and its transfer to the sediment-water interface and its subsequent incorporation into the sedimentary record. Moored time-series sediment traps are a powerful tool to obtain sinking particulate matter fluxes from the water column, which can be quantitatively and qualitatively investigated.

Sediment trap investigations were carried out at two stations (Fig. 5-1) and have provided the first long-term particle flux record from the Kara Sea. Detailed analyses of bulk composition and organic compounds will provide information on the sources, alteration, transport paths as well as transport processes of the organic matter. These investigations will be carried out within the SIRRO Russian-German cooperation and are closely linked to the biological and geological investigations. Moreover, sediment trap experiments will contribute to the carbon and nitrogen budgets of the Kara Sea and thus will elucidate its relevance for arctic environments.

Sampling

The two mooring systems, which had been deployed during the cruise of RV "Akademik Boris Petrov" in 2001, could be recovered. However, only one of the traps had sampled. The other trap could not sample due to corrosion and water inflow into the electronics housing. The electronics was severely damaged so that this trap could not be redeployed. Such a severe corrosion has not been experienced in the various trap experiments carried out previously by the Hamburg working group and will be discussed in detail with the manufacturer.

Recovery of Mooring KARA 01

During the "Akademik Boris Petrov"-Cruise 2001 a sediment trap mooring was deployed in the open Kara Sea at 94 m water depth (Gebhardt et al. 2002). The mooring was retrieved at 76°12.08 N 75°45.3 E at the BP01-61a site. The mooring was recovered in a good shape through a patchy sea ice cover.

The HYDROBIOS MST-12 sediment trap was recovered at Bottle 11 (instead of "open hole"). A detailed check showed that the electronic units (i.e., timer unit and battery housing) were not completely water-tight and therefore filled with seawater. Nonetheless, KARA 01 sampled a period of more than 11 months

Bremerhaven and IfBM Hamburg. An AANDERAA current meter moored just below the sediment trap provided a full-year record about water temperature, current speed/direction, and turbidity. Current speed ranged between 0.5 and 46 cm s^{-1} with a maximum in late October to early November and a mean velocity of 6.98 cm s^{-1}. Temperature ranged over the complete year between -1.4 and -0.4°C with a mean value of -1.15°C. Detailed analysis of the current meter data will be done by a German-Russian research cooperation.

Due to the severe damage of the electronic system we were not able to re-deploy the sediment trap at the KARA 01station.

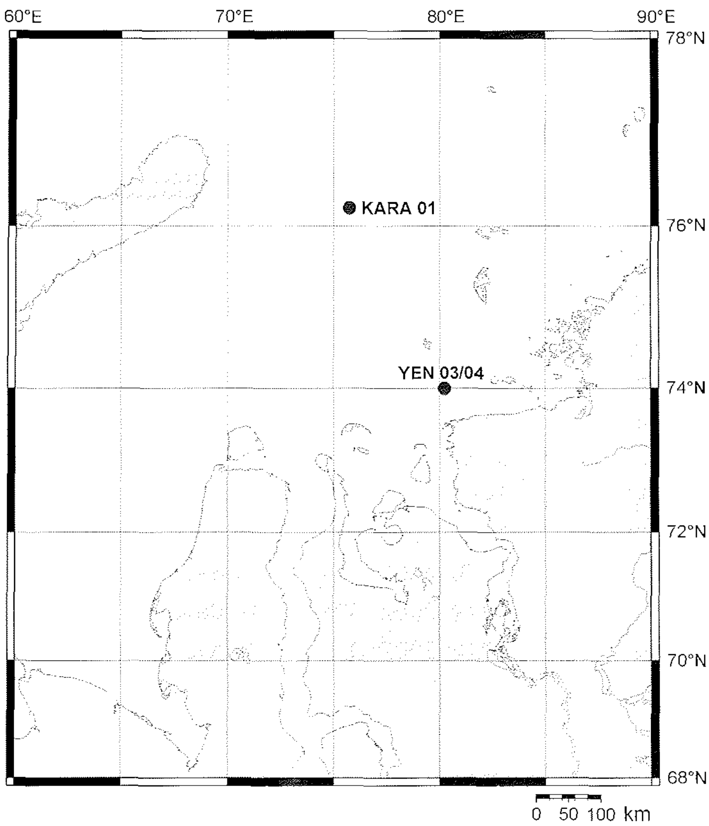


Figure 5-1: Positions of sediment trap moorings deployed in the Kara Sea

Recovery of Mooring YEN 03

During the "Akademik Boris Petrov" Cruise 2001 a sediment trap mooring was deployed in the Yenisey river mouth, where former sediment trap investigations had been carried out within the SIRRO project (Unger et al. 2001; Gebhardt et al. 2002). Unfortunately, the battery housing of the HYDROBIOS MST-24 sediment trap was not water-tight either (this problem had occurred during BP-01), so that the cups did not rotate at all. Nonetheless, the AANDERAA current al. 2002). Unfortunately, the battery housing of the HYDROBIOS MST-24 sediment trap was not water-tight either (this problem had occurred during BP-01), so that the cups did not rotate at all. Nonetheless, the AANDERAA current meter moored just below the sediment trap provided a record for temperature and current speed/direction for a time period between 23. Aug. 2001 and 23. Apr. 2002. It was intended to obtain a full-year record; however, it seemed that the battery pack broke apart in late April 2002. A detailed investigation of the potential reasons behind this unexpected problem will be done by the technical support of AANDERAA. The temperature varied between -1.34 and 0.43°C with an average value of -1.18°C. The current speed ranged between 0.5 and 50 cm s^{-1} with a mean of 8.83 cm s^{-1}. Detailed analysis of the current meter data will be done by a German-Russian research cooperation.

Tab. 5-1: Rotation scheme for KARA 01

Cup No.	Start of Interval	Duration	Recovery Status
Cup 01	04.09.2001 00:00	17 days	done
Cup 02	21.09.2001 00:00	42 days	done
Cup 03	02.11.2001 00:00	56 days	done
Cup 04	28.12.2001 00:00	56 days	done
Cup 05	22.02.2002 00:00	56 days	done
Cup 06	19.04.2002 00.00	42 days	done
Cup 07	31.05.2002 00:00	14 days	done
Cup 08	14.06.2002 00:00	14 days	done
Cup 09	28.06.2002 00:00	28 days	done
Cup 10	26.07.2002 00:00	14 days	done
Cup 11	09.08.2002 00:00	14 days	active
Cup 12	23.08.2002 00:00	7 days	waiting

Deployment of Mooring YEN 04

A sediment trap mooring was carried out at the YEN 03 station in order to extend and to intensify the measurements of settling particulate matter in the Yenisey river mouth.

The defective battery housing from YEN 03 was exchanged. The trap was programmed according to the rotation scheme in Tab. 5-2. Just below the sediment trap the current meter from KARA 01 was installed in order to measure temperature, current speed/direction, and turbidity. Detailed description and information is provided in Fig. 5-2 and Tab. 5-3. All trap cups were filled with filtrated water from BP02-02 and poisoned with 35 gl^{-1} NaCl and 3.3 gl^{-1} $HgCl_2$. The YEN 04 mooring was deployed at 74°00.1145 N 80°19.4613 E on 07. Oct.

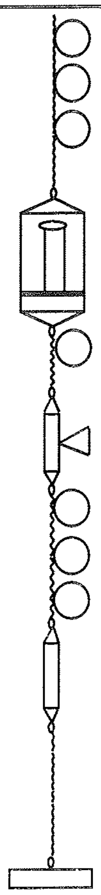
2002 at 02:07 UTC at 39.7 m water depth. Deployment took place without any complications.

Mooring System Information

Mooring-I.D.: YEN-04

Deployment Date:	07.10.02
Start:	01:10 UTC
System under water:	02:07 UTC

Deployment Position:	74°00.1145' N, 80°19.4613' E
Radio Frequency:	none
Release Code:	Enable: 1 C Release: 1 A
Water Depth:	39.7 m
Wind:	10 m/s East (89 Deg)
Temperature:	-1.7°C (Air); -0.21°C (Water)



Mooring Diagram m.a.b.	m.b.s.	Mooring Description	Deployment Time out [UTC]
19	21	Nautlius Float on chain (red)	01:45
		Nautlius Float on chain (yellow)	
		Nautlius Float on chain (red)	
		Chain 3/8' 7m	
11	29	Sediment Trap Hydrobios MST-24	01:57
		Benthos 17' Float on chain (yellow)	
		Chain 3/8' 1m	
8	32	Aanderaa Current Meter RCM 9 MKII SN 626 Current speed/direction, Temperature, Turbidity	01:59
		Benthos 17' Float on chain (yellow)	
		Benthos 17' Float on chain (yellow)	
		Benthos 17' Float on chain (yellow)	
4	36	Benthos Release 865A SN 756 (13 V) Enable Code: 1 C; Release Code 1 A Release armed: 02:01 UTC (Niko Lahajnar, Birgit Nagel)	02:04
		Chain 3/8' 2m	
0	40	Chain 3/8' 1m Anchor (1 Railroad Wheel)	02:07

Fig. 5-2: Mooring system information

Tab. 5-2: Mooring system description

Cruise ID	BP-02
Mooring ID	YEN-04, Station BP02-04
Date of Deployment	07. October 2002
Time of Deployment	02:07 UTC
Position of Anchor Drop	74°00.1145 N 80°19.4613 E
Water Depth	39.7 m
Weather Condition	Cloudy, Wind 10 m/s from East (89 Deg) Temperature (Air): -1.7°C; Temperature (Water): -0.21°C
Topfloat:	none (no radio, no flash-light)
Sediment Trap:	HYDROBIOS Multisediment-Trap MST-24 (24 Cup-Version) Batteries: 3 Photocells CR123A 3 V (Battery-Check: 9.74 V) Funnel: 570 mm height; 120 mm diameter Cups: 250 ml PE Cup-Fillings: filtrated Deep-Water from BP-02 Station 02 Additives: 35 g/l NaCl; 3.3 g/l $HgCl_2$ Deployment: open hole
Current Meter:	AANDERAA RCM 9 MKII SN 626 Sensors: Current Speed, Current Direction, Temperature, Turbidity Battery: Model 3614 9V, 15Ah (Battery Check: 9.63 V) Data Storage Unit: 2990 E Channel 7 Temperature Range: arctic (-3.01 to +5.92 °C) Recording Interval: 60 min Special Remark: Burst Mode
Acoustic Release:	BENTHOS 865A SN 756 13 Volt Battery Pack 13 V (Battery Check: 14.46 / 14.46 V) Enable Code: 1 C Release Code: 1 A

Tab. 5-3: Rotation scheme for YEN 04

Cup No.	Start of Interval [UTC]	Duration
Cup 01	07.10.2002 12:00	6.5 days (156 h)
Cup 02	14.10.2002 00:00	7 days (168 h)
Cup 03	21.10.2002 00:00	7 days (168 h)
Cup 04	28.10.2002 00:00	7 days (168 h)
Cup 05	04.11.2002 00:00	14 days (336 h)
Cup 06	18.11.2002 00:00	14 days (336 h)
Cup 07	02.12.2002 00:00	14 days (336 h)
Cup 08	16.12.2002 00:00	14 days (336 h)
Cup 09	30.12.2002 00:00	56 days (1344 h)
Cup 10	24.02.2003 00:00	56 days (1344 h)
Cup 11	21.04.2003 00:00	28 days (672 h)
Cup 12	19.05.2003 00:00	14 days (336 h)
Cup 13	02.06.2003 00:00	14 days (336 h)
Cup 14	16.06.2003 00:00	14 days (336 h)
Cup 15	30.06.2003 00:00	14 days (336 h)
Cup 16	14.07.2003 00:00	14 days (336 h)
Cup 17	28.07.2003 00:00	14 days (336 h)
Cup 18	11.08.2003 00:00	14 days (336 h)
Cup 19	25.08.2003 00:00	14 days (336 h)
Cup 20	08.09.2003 00:00	7 days (168 h)
Cup 21	15.09.2003 00:00	7 days (168 h)
Cup 22	22.09.2003 00:00	7 days (168 h)
Cup 23	29.09.2003 00:00	7 days (168 h)
Cup 24	06.10.2003 00:00	14 days (336 h)

6. Marine Biology

6.1 Phytoplankton investigations

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Materials and methods

Water sampling for the investigations of qualitative and quantitative phytoplankton composition was carried out on 5 stations (BP02-01, BP02-02, BP02-06, BP02-10, and BP02-12). Samples were collected on several standard layers: from the surface layer (with a zinc plated bucket), from the layer of the density change (if such layer exists) and from the near bottom layer (with a sampler of the «Rosette» system, parallel to the hydrological sampling). Definite stations and layers of sampling are presented in Table 6-1. 11 samples were collected all in all (0.5-1 l volume each), which were concentrated by a standard method of inverse-flaw filtration and fixed with solution of 40 %-formaldehyde (final concentration is 1-2 %) for the subsequent microscopic investigation.

Besides, on 4 stations phytoplankton sampling was carried out for the analysis of the carbon isotopic composition. These samples (from the water layer 0 – 10 m) were immediately looked under the light microscope Micmed-2 at the magnification ×400-800, which allowed to obtain preliminary data on the qualitative composition of plankton phytocenoses, i.e. dominating species, and to give the estimation of the seasonal stages of phytoplankton development in different parts of the investigated area.

Short characteristics of the communities

Station BP02-01: "Classic" early spring complex of plankton micro-algae, typical in the given period to all Arctic Seas. It consists almost exclusively of the oceanic species – large diatoms of genus *Chaetoceros* and the largest genera of *Dinophyta*: *Ceratium* and *Protoeridinium*.

Station BP02-02: Qualitative composition is nearer to that at the first station, but much poorer. Other properties of the community degradation are also observed: according to preliminary estimation the concentration of organisms is an order of magnitude lower, a large amount of the cells were dead, and cells with destroyed chromatophores were also seen.

Station BP02-06: A typical complex of freshwater and estuarine species peculiar to the Ob bay basin during the whole vegetation period, with a dominance of diatomic genus *Melosira* and non-identified species of the filament green algae. But in comparison to the investigation materials obtained in previous years, conducted in the summer season, the part of the blue-green algae and especially of the species *Aphanizomenon flos-aquae* increased sharply in the community.

Station BP02-12: The Composition of dominant species was the same as that on the previous station, but the relative amount of blue-green algae lowered significantly. Besides, oceanic forms of genera *Chaetoceros* and *Ceratium* are registered in large amounts. comparable to the first station (BP02-01). Evidently, the "pressure" of the freshwater , typical of the mouth part of the Ob bay, weakens during the autumn period, and we can observe the presence of a typically sea pelagic micro algal flora in this area.

Table 6-1:Total characteristics of the stations, amount of the works fulfilled and the major identified representatives of microphytoplankton in the samples collected during the cruise of RV "Akademik Boris Petrov" into the Kara Sea (04 – 09 October 2002; dominating species are distinguished in bold type).

Station BP02-	Date	Time [UTC]	Latitude °N	Longitude °E	W.d. [m]	S. d. [m]	Species
1	04.10.02	10:00	76°13,55	75°43,96	90	0 80	***Chaetoceros decipiens*** ***C. borealis*** ***C. convolutus*** ***Ceratium arcticum*** *C. longipes* *P. depressum*
2	06.10.02	5:30	73°59,75	80°18,53	37	0 9	***Chaetoceros decipiens*** ***Ceratium arcticum*** *C. longipes* *Navicula vanhoeffenii*
6	08.10.02	4:00	68°54,91	73°39,94	15	0 9	***Melosira granulata*** ***M. varians*** ***Aphanizomenon flos-aquae*** *Anabaena sp.* *Microcystis aeruginosa* *Chlorophyta spp.*
10	09.10.02	11:00	71°26,81	72°17,13	19	0 12	-
12	09.10.02	18:00	72°40,40	73°59,80	21,50	0 8 15	***Melosira granulata*** ***M. varians*** ***Ceratium arcticum*** *Chaetoceros decipiens* *Chlorophyta spp.*

6.2. Resting eggs as possible overwintering strategy of neritic calaniod copepods in the Kara Sea

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Introduction

To endure adverse conditions several neritic calanoid copepods produce resting eggs (Marcus 1996). These eggs sink to the sea floor waiting for improving environmental conditions. If conditions are adequate for the eggs development or a certain, genetically fixed time passed they are going to hatch.

Calanoid copepods play an important role in the Kara Sea ecosystem. For the Kara Sea zooplankton is dominated by calanoid copepods in terms of abundance as well as biomass (Vinogradov et al. 1995, Fetzer et al. 2002).

Various environmental factors of the Kara Sea show a high variability. Salinity, for example, decreases with the amount of freshwater discharge of the rivers Yenisei and Ob. Especially salinity of surface waters changes drastically with the highest rates during winter and early spring and the lowest rates during late summer (Pawlov and Pfirman 1995).

These facts lead to an interesting question: Are there species in the Kara Sea that also use resting eggs as a strategy to endure unfavourable environmental conditions?

Methods

Samples were obtained at 4 stations additionally to samples of last year's cruises of RV "Akademik Boris Petrov".

Sediment sampling was performed with a Multicorer equipped with perspex tubes of 6 cm diameter. Usually 3 cores per station were taken. The soft top layer of each cores' sediment was filled into a 500 ml Kautex bottle. Two bottles were preserved in 5 % borax buffered formalin for later identification and counting of copepod eggs. The third bottle was filled up with 0,2 µm filtered seawater and stored in an incubator at 0°C and DD until return to Bremerhaven.

A 55 µm plankton net was used at every station. The samples were screened for possible copepod eggs, which were sorted and placed in the incubator at LD 20:4. Unfortunately no nauplius larvae hatched from the eggs during the experimental period.

Table 6-2: Sampling stations during Kara Sea Expedition 2002 (muc = multicorer, pn = plancton net).

Station	Date	Time [UTC]	Latitude [°N]	Longitude [°E]	Depth [m]	# of device taken
BP02-01b	2002-10-04	16:30	76°16.37	75°43.02	85,0	2 muc
		10:00	76°13.08	75°43.97	85,5	1 pl
BP02-02b	2002-10-06	09:30	73°59.28	80°02.80	32.1	2 muc
		5:25	73°59.58	80°19.53	32,2	1 pl
BP02-06	2002-10-08	04:00	68°54.91	73°39.94	10,4	2 muc, 1pl
BP02-12	2002-10-09	18:05	72°40.40	73°59.80	16,6	1 muc, 1pl

6.3. Complementary sampling for macrobenthic studies of the estuaries of Ob and Yenisei and the central Kara Sea

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Introduction

Within the SIRRO project biological studies are an important part of understanding the flow of organic matter into the Kara Sea. Therefore, the macrozoobenthos of the estuaries of Ob and Yenisei as well as the southern part of the Kara Sea has been studied in detail during former expeditions. In the course of this cruise samples were taken to close gaps of data received from the previous cruise with RV "Akademik Boris Petrov" in 2002.

Methods

Since there was a lack of data of epibenthos a dredge with a frame size of 150 x 50 cm was used. 5 samples were taken at 4 stations (Table 6-3). The macrofauna was separated from the sediment by using 500 µm screens and preserved 5 % borax buffered formalin for subsequent examination. Species that occurred in large quantities were deep-frozen for later biochemical investigations.

Table 6-3: Dredge sampling stations during the Kara Sea Expedition 2002

Station	Date	Time [UTC]	Latitude [°N]	Longitude [°E]	Depth [m]	# dredges taken
BP02-01b	2002-10-04	16:30	76°16.37	75°43.02	85,0	1
BP02-02b	2002-10-06	09:30	73°59.28	80°02.80	32.1	1
BP02-03	2002-10-06	15:30	74°34.69	78°52.53	32,7	2
BP02-12	2002-10-09	18:05	72°40.40	73°59.80	16,6	1

7. Marine Geology

7.1. Geological sampling program

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One of the main objectives of this short expedition of RV "Akademik Boris Petrov" in 2002 was the recovering of the two moorings. So the sediment sampling program during these seven days was strictly reduced compared to the expeditions in the years 1997, 1999, 2000 and 2001 (Matthiessen and Stepanets 1999, Stein and Stepanets 2000, 2001, 2002). Surface and near surface samples were taken by Van-Veen-Grab, Multicorer, and giant box corer. The working area reached ca. from 72° E until 80° E and from 76° N down to 68° N. After recovering the moorings water and sediment samples were taken in the central and southern Kara Sea mainly without anchoring. Changes in the position due to drifting were documented in the stationlist (Annex 10.1). In the Ob Estuary water and sediment sampling were done after anchoring. In the southern region of the working area the samples were taken along the salinity gradient from the outer estuary of Ob down to the fresh water endmember. In general, the water column and the sediments were 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. After the water sampling the geological sampling started generally with Van-Veen-Grab, Giant Box Corer, and Multicorer in order to take samples from the surface and near-surface sediments.

Van-Veen-Grab

The Van-Veen-Grab is of light weight, and therefore, needs less time to get a small amount of surface sediment. It was used 6 times successfully.

Giant Box Corer

The Giant Box Corer (weight of ca. 500 kg; volume of sample 50*50*60 cm; manufactured by Fa. Wuttke, Henstedt-Ulzburg, Germany) was successfully used 2 times on 2 stations. The box cores were sampled for the following investigations:

surface sediments

- stable isotope analysis of benthic calcareous organisms (Geomar)
10*10 from the upper 1 cm (100 cm^3) fixed with bengal-rose-methanol-solution
10*10 from the upper 5 mm (50 cm^3)
- benthic foraminifera and stable isotopes (Shirshov-Institute)

1-3 times 10*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)

profiles (tubes 120 mm in diameter)

- 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 7 times on 6 stations, and usually recovered undisturbed surface sediments and overlying bottom water. Two multicorer were empty due to technical problems.

surface sediments

- Copepodes (Juveniles) (AWI-Biology)
3-4 tubes, 30 – 80 cm^3
- Phyto-zoo-plankton (AWI-Biology)
2-3 tubes, 20 – 60 cm^3
- stable isotope analysis of benthic calcareous organisms (Geomar)
1-3 tubes, 10 – 60 cm^3, from the upper 1 cm fixed with bengal-rose-methanol-solution to stain living organisms
- clay minerals, grain-size composition (AWI-Geology)
1 tube, 10 – 20 cm^3
- palynology (AWI-Geology)
1 tube, 10 – 20 cm^3
- biomarkers and $\delta^{13}C$ of specific biomarkers (AWI-Geology)
1 tube, 10 – 20 cm^3, stayed frozen at –20°C
- organic geochemical bulk parameter (TOC, C/N, Rock Eval pyrolysis, $CaCO_3$), inorganic geochemistry (AWI-Geology); 1 tube, 10 – 20 cm^3

profiles
- organic geochemical analysis (C_{org}/N, carbonate, biogenic silica (Opal), carbohydrates, amino acids) (IfBM)
1 tube, samples (20 cm^3) from the upper 3 cm, stored frozen at –20°C, tube sampled at 5 cm intervals and additionally at lithological changes, stored at –20°C
- organic geochemistry (Vernadsky-Institute)
- heavy minerals, lithology (Vernadsky-Institute)

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

7.2. Composition of fraction >125 µm from surface sediments (on BP01 and BP02 data)

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Introduction

In our former paper (Levitan 2002) it was proved that composition of sand (and gravel) fractions is of great importance as facies indicator for the eastern Kara Sea. Regretfully, there was a number of technical mistakes in figures and tables. That's why here we are forced to give a correct version of Fig. 6.14 and Table 6.6 (Levitan 2002). Some new data obtained during the SIRRO RV "Akademik Boris Petrov" cruise (2002) will be added and used for compilation of new maps.

Facts and methods

Main methods of the study have been described earlier (Levitan 2002). Here we would like to mention that distribution of non-biogenic grains is much better expressed on the biogenic-free basis (biogenic matter in this case means amount of biogenic remains in fraction >125 µm in relative percents). New version of our raw data on BP01 cruise is given in Table 7-1. Data on composition of fraction >125 µm from surface sediments of BP02 cruise are represented in Table 7-2.

Preliminary results

First of all, we should mention that our new results (Table 7-2) fit well with former data on taphocoenoses of surface-layer sediments (Levitan 2002, Fig. 6.15) and – such way – we will not describe this pattern once more. Relationships between main components of sand fractions – rock fragments, biogenic remains and minerals – are shown at Fig. 7-1 (new version of former Fig. 6.14 from Levitan 2002).

It's important to note that rock fragments have a different lithology (petrography) for different areas of studied region. For example, rock fragments from Taz River and south Ob Estuary are represented by light pinky-brown siltstones, and majority of rock fragments on the Ob-Yenisei Shoal are composed from dark shales or black schists.

It was described earlier (Lisitsin et al., 2000) an example of coarser rock fragments. This event was considered as related to sea ice transportation of coarse rock fragments, but – in case of sand fraction – this mechanism of rock fragment distribution is not the unique one. Also we should keep in mind local sources which contribute the material via bottom erosion (edaphogenic mechanism) and coastal abrasion.

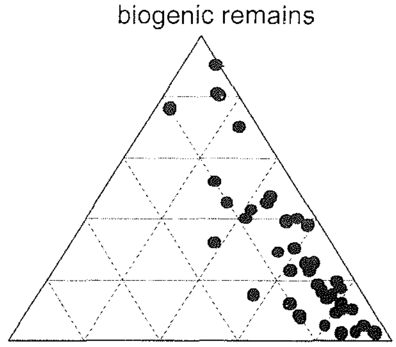

Figure 7-1: Composition of fraction >125 μm from the eastern Kara Sea surface sediments (BP01 data, rel. %).

Distribution pattern of rock fragments on biogenic-free base is shown at Fig. 7-2. Two main areas of enhanced amount can be revealed: in Ob and Yenisei estuaries and on the northern and north-western parts of Ob-Yenisei Shoal break. In first case there is a typical picture of alluvial composition with very weak differentiation of sand fraction. But the reason of second maximum is still under discussion. It can not be related to sea-ice transportation because this zone isn't characterized by distribution of specific warm water masses and – such way – there is no reason for increased sea-ice melting. Another idea ties the distribution of rock fragments with existence of jet-streams in the surface waters - see for example description made by S.I.Muyakshin in the paper (Levitan et al. 1996). The current speed is enough, indeed, for transportation of sand grains, but there is a definite gap between rock sources on surrounding land and area of rock fragments accumulation, so the question is: how these grains have been transportated from the source areas to the area of jet-stream activity? Third idea points at near-bottom hydrodynamic activity. Indeed, near shoal break enhanced level of hydrodynamics at the bottom waters should exist, but what about the source of rock fragments? According to seismoacoustic data (Niessen and Dittmers 2002), highly dissected glaciogenic relief along the break and northward exists in this area, and we suppose that in principle it can serve as a source of rock fragments. Enhanced near-bottom hydrodynamic activity (in form of bottom currents) and/or jet-streams could transport this material for relatively short distance.

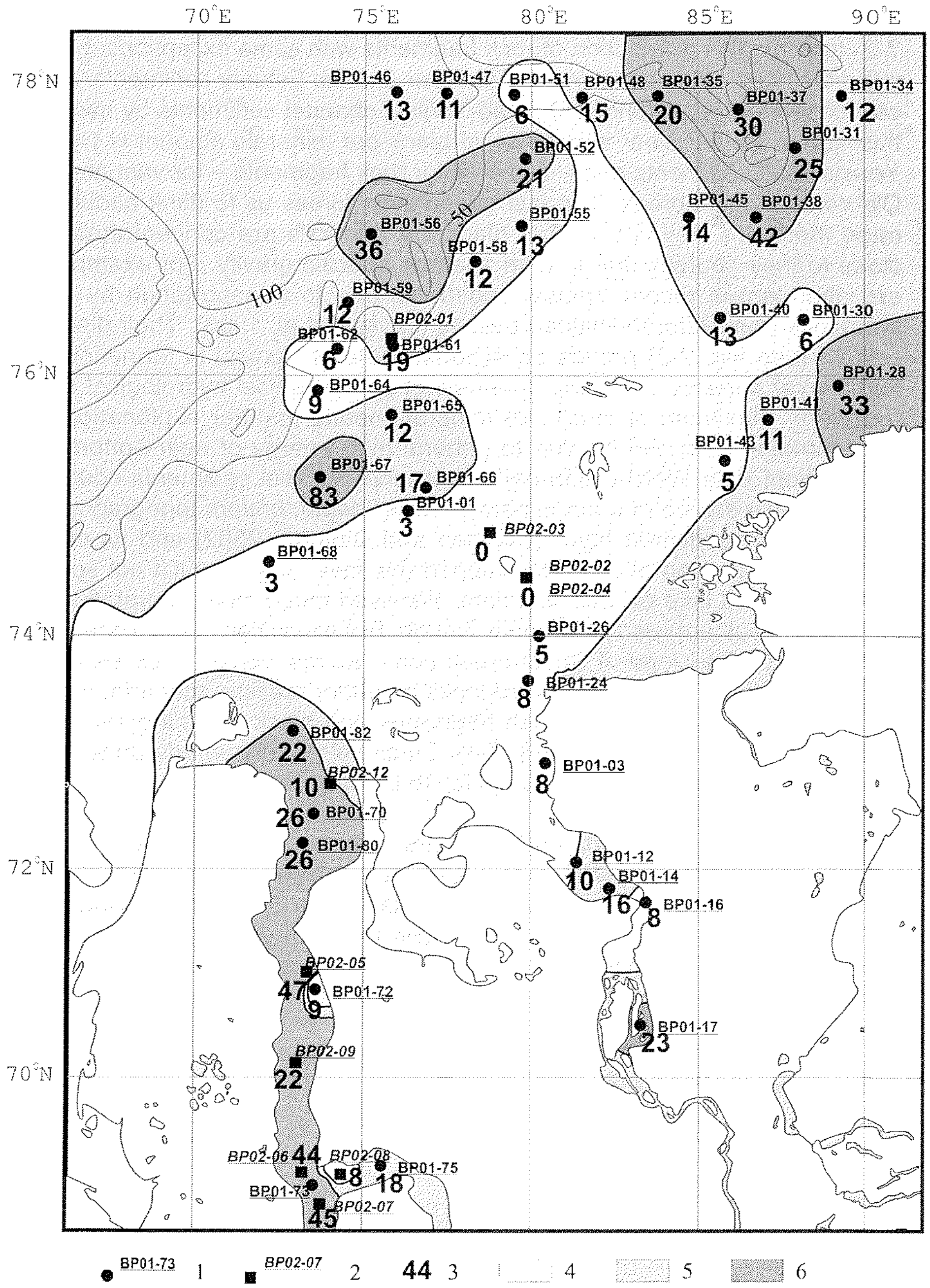

Figure 7-2: Distribution of rock fragments in fraction >125 µm. 1 – BP01 stations; 2 – BP02 stations; 3 – amount of rock fragments (biogenic-free, rel %); 4 - <10 rel. %; 5 – 10-20 rel. %; 6 - >20 rel. %.

Distribution pattern of black ore minerals on biogenic-free basis is shown at Fig. 7-3. It resembles distribution of rock fragments with some exceptions: black ore minerals practically absent in the Taz River and Ob Estuary sediments, and one can observe an enrichment of paleo-Yenisei channel sediments by minerals of this group. Rather clear increasing of black ore minerals amount is typical for Yenisei Gulf sediments and – same as for rock fragments – for vast area along Ob-Yenisei Shoal break. The last observation forces us to think about source once more. It's well known that black ore minerals are concentrated mainly close to their sources due to high average specific gravity. For example, they are abundant in recent Yenisei sediments due to transportation by its right tributaries from Putoran-Plateau basalts (Levitan et al. 1996). Their distribution pattern (see Fig. 7-3) proves an important role of Yenisei in formation of nefeloid layer currents along the channels of paleo-Yenisei hydrological net. But "northern" maximum of black ore minerals needs another explanation. Their concentration here can be due to general high energy of near-bottom water, and ancient (late Weichselian-early Holocene) Yenisei sediments could serve as a possible source of such minerals. Water depth, bottom topography, structure of upper sediment layer (Niessen and Dittmers 2002) and its chemical composition (Levitan et al. 2002) support this idea. Just now it's not so clear if an ice-dammed lake existed that time. We need much more information about the upper (southern) part of Voronin Trough. But exposition of old Yenisei fluvial sediments on the slope of Shoal break and – as thin veneer – on several outcrops of glacigenic relief northward looks as rather realistic scenario. In this relation coupled distribution of rock fragments and black ore minerals looks as additional prove of this idea (Fig. 7-4). Small field of disrupted connection between these two parameters belongs to Ob Estuary sediments.

Minerals (first of all – quartz and feldspars) play an important role in composition of sand fractions (see Fig. 7-1). Our new data on composition of fraction >125 µm from surface sediments of the eastern Kara Sea support earlier observation (Levitan et al. 1998) about two main forms of quartz: colourless, transparent and angular from the one hand, and milk-like, semi-opaque and rounded, from another. So, the study of bulk quartz distribution has no sense.

We would like to thank the crew of RV "Akademik Boris Petrov" for fruitful cooperation. This is grant RFBR # 02-05-64017.

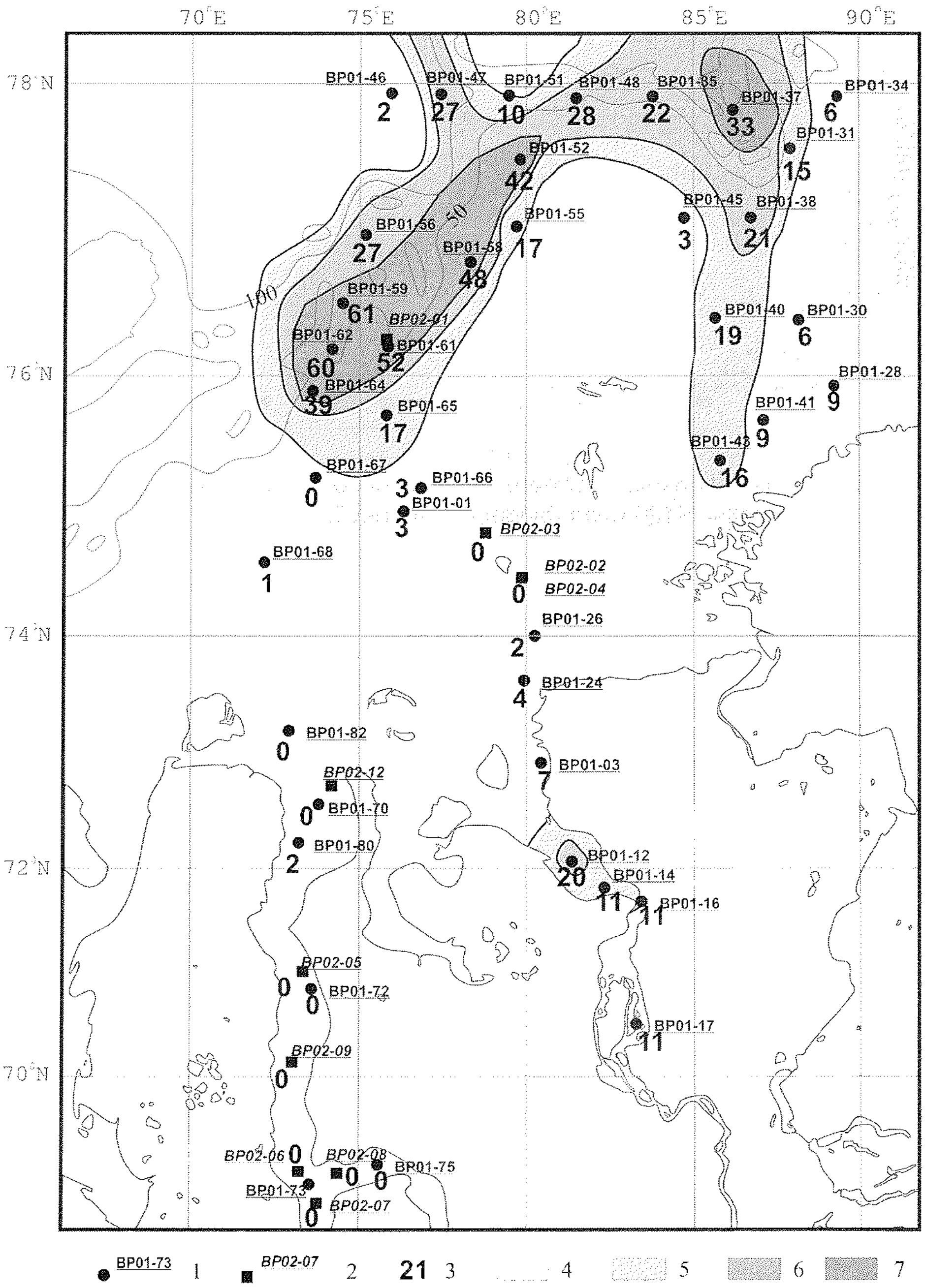

Figure 7-3: Distribution of black ore minerals in fraction>125 mkm. 1 – BP01 stations; 2 – BP02 stations; 3 – amount of black ore minerals (biogenic-free, rel. %); 4 - <10 rel. %; 5 – 10-20 rel. %; 6 – 20-30 rel. %; 7 - >30 rel.%.

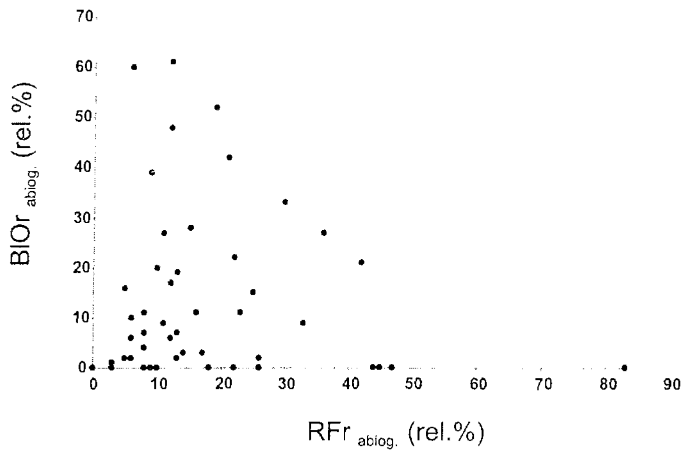

Figure 7-4: Relationship between amounts of rock fragments and black ore minerals in fraction >125 mkm (biogenic-free, rel. %).

Table 7-1: Composition of fraction >125 µm (rel. %) from BP01 surface-layer sediments

NN	station	biogenic remains								minerals						rock fragments	RFr abiog.	BIOr abiog.
			mollusks															
		polychaets	bivalves	mollusk clutchs	ostracods	benthic foraminifers	sponges spicules	plant remains	total	quartz	feld spars	black ore minerals	colored minerals	mica	total			
1	1	1	0	0	tr	1	tr	0	2	60	30	0	2	2	95	3	3	0
2	3	0	0	0	0	0	0	40	40	35	15	4	tr	tr	55	5	8	7
3	12	0	0	0	0	0	0	90	90	3	2	2	1	1	9	1	10	20
4	14	2	0	0	0	0	1	2	5	25	20	10	20	5	80	15	16	11
5	16	0	0	5	0	0	0	7	12	45	20	10	5	1	81	7	8	11
6	17	0	0	5	0	0	0	7	12	35	20	10	2	1	68	20	23	11
7	24	0	0	0	0	1	0	2	3	50	31	4	2	2	89	8	8	4
8	26	0	0	2	1	2	0	0	5	48	37	2	2	1	90	5	5	2
9	28	0	1	5	2	5	2	0	15	28	18	8	2	1	57	28	33	9
10	30	3	4	0	1	1	1	0	10	40	36	5	4	tr	85	5	6	6
11	31	80	tr	0	0	tr	0	0	80	6	4	3	1	1	15	5	25	15
12	34	2	tr	0	0	tr	0	0	2	45	34	6	1	tr	86	12	12	6
13	35	1	2	0	tr	5	0	0	8	30	20	20	2	tr	72	20	22	22
14	37	35	5	0	tr	tr	0	0	40	10	9	20	3	0	42	18	30	33
15	38	50	2	0	tr	tr	0	0	52	10	7	10	tr	0	28	20	42	21
16	40	5	10	5	tr	3	0	0	23	29	20	15	2	1	67	10	13	19
17	41	2	5	0	tr	2	0	0	9	39	30	8	2	3	81	10	11	9
18	43	0	30	0	5	1	2	0	38	26	20	10	2	1	59	3	5	16
19	45	25	5	0	0	tr	0	0	30	30	25	2	3	0	60	10	14	3
20	46	1	1	0	1	36	0	0	39	34	19	1	tr	0	53	8	13	2
21	47	tr	8	0	5	12	0	0	25	24	20	20	3	0	67	8	11	27
22	48	2	3	0	2	35	4	1	47	18	10	15	4	tr	45	8	15	28
23	51	1	1	0	1	16	0	0	19	34	30	8	4	0	76	5	6	10
24	52	1	10	0	10	5	3	0	29	15	7	30	3	1	56	15	21	42
25	55	tr	10	5	6	4	tr	0	25	32	25	5	3	0	65	10	13	7
26	56	20	10	0	tr	15	0	0	45	10	5	15	5	0	35	20	36	27
27	58	2	3	0	5	5	1	0	16	18	10	40	6	0	74	10	12	48
28	59	tr	8	0	4	4	2	0	18	10	9	50	2	1	72	10	12	61
29	61	2	10	5	1	5	0	0	23	10	8	40	4	0	62	15	19	52
30	62	1	5	0	4	6	1	0	17	14	10	50	3	1	78	5	6	60
31	64	tr	4	0	tr	6	0	0	10	24	20	35	3	0	82	8	9	39
32	65	tr	5	2	0	7	tr	0	14	35	20	15	5	1	76	10	12	17
33	66	0	0	60	4	5	1	0	70	10	7	1	5	2	25	5	17	3
34	67	49	10	15	1	tr	1	0	76	2	2	0	0	0	4	20	83	0
35	68	2	tr	0	0	1	0	0	3	50	37	1	4	2	94	3	3	1
36	70	80	tr	0	0	1	0	0	81	7	7	tr	0	tr	14	5	26	0
37	72a	0	0	0	0	0	0	15	15	50	23	0	3	1	77	8	9	0
38	73	tr	0	tr	2	0	0	30	32	20	14	0	2	2	38	30	44	0
39	75	0	0	3	0	0	0	42	45	22	20	0	2	1	45	10	18	0
40	80	35	tr	0	0	0	0	8	43	26	10	1	5	0	42	15	26	2
41	82	3	tr	tr	0	2	0	2	7	40	30	0	3	1	73	20	22	0

Table 7-2: Composititon of fraction >125μm (rel. %) fromBP02 surface layer sediments.

NN	station	biogenic remains														minerals								rock fragments	RFr abiog.	BIOr abiog.
			mollusks				foraminifers													mica						
								benthic																		
		polychaets	bivalves	gastropods	mollusk clutchs	ostracods	planktic	agglutinated	calcareous	diatoms	spicules	radiolarians	plant remains	spores and pollen	total	quartz	feldspars	black ore minerals	colored minerals	muscovite	biotite	others	total			
1	BP02-01MC	4	-	-	-	-	-	8	-	-	2	-	-	-	14	44	10	15	3	2	-	2	78	10	12	17
2	BP02-02BC	1	4	-	-	?	-	2	4	-	+	-	-	+	11	50	24	2	4	3	1	+	84	5	6	2
3	BP02-03MC	-	100	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	0	0
4	BP02-05MC	10		-	?	-	-	-	-	-	-	-	5	-	15	30	12	-	3	+	-	-	45	40	47	0
5	BP02-06MC	1		-	-	4	-	-	-	-	-	-	40	12	57	12	4	-	+	1	-	8	24	20	47	0
6	BP02-07Gr	4		-	-	-	-	-	-	-	-	-	6	4	14	25	16	-	4	1	1	-	47	39	45	0
7	BP02-08Gr	+	6	-	-	1	-	-	-	-	-	-	4	3	14	55	23	-	1	+	-	-	79	7	8	0
8	BP02-09Gr	3		-	-	1	-	-	-	-	-	-	5	1	10	40	26	-	2	2	+	-	70	20	22	0
9	BP02-12Gr	20		-	-	-	-	-	-	-	-	-	1	+	21	40	24	-	5	3	-	-	71	8	10	0

7.3. Sediment types of surface sediments

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Introduction

Sediment types and clay minerals are important components of the facies analysis. A number of publications were devoted to description of sediment types (Kulikov 1961, Gurevich 1995, Levitan et al. 1996, and others) and clay minerals (Gurevich 1995, Nürnberg et al. 1995, Shelekhova et al. 1995, Levitan et al. 1996, Gorbunova 1997, Wahsner et al. 1999, Müller and Stein 1999, Steinke 2002) of surface-layer sediments of the Kara Sea. Different methods of clay minerals study give different values of their amount in the sediments (for example, see discussion in Müller and Stein 1999). Also there was no information about clay minerals in the Taz River and their influence on the sediment composition northward from merge of Ob and Taz Rivers. That's why we studied clay minerals from surface sediments obtained during BP02 cruise.

Facts and methods

Sediment types of surface sediments have been determined by means of smear-slides examination (Table 7-3). Clay fractions less than 1 µm were prepared for X-ray diffraction. As an internal standard we used quartz with peak 4.25 Å. The mixture of clay fraction with quartz was dispersed and sucked on a glassy plate to get high orientation of clay minerals. For study of clay minerals we used vaporization by ethyleneglycol, treatment by warm HCl, heating at 600^0 C during 1.5 hour, vaporization by dimethylsulphoxide. Samples were measured between $2\text{-}40^0\,2\theta$ with a step size 2, 1, and $0.5^0\,2\theta$/min for different ranges. The measurements were carried out with a DRON-3.0 goniometer using CoKα radiation. The following peaks were used to identify clay minerals: 17 Å for smectite, 10 Å and 5 Å for illite, and 7 Å for kaolinite plus chlorite. To differentiate kaolinite and chlorite we used intensity ratios of the 3.58 Å-kaolinite peak and the 3.54 Å-chlorite peak, identified by slow scan. Also we used for this purpose vaporization by dimethylsulphoxide and treatment by warm HCl. Relative clay-mineral contents were calculated by using empirical factors after Biscaye (1965). All results are listed in Table 7-4. Distribution of clay minerals, smectite/illite and chlorite/kaolinite ratios is shown in Fig. 7-6.

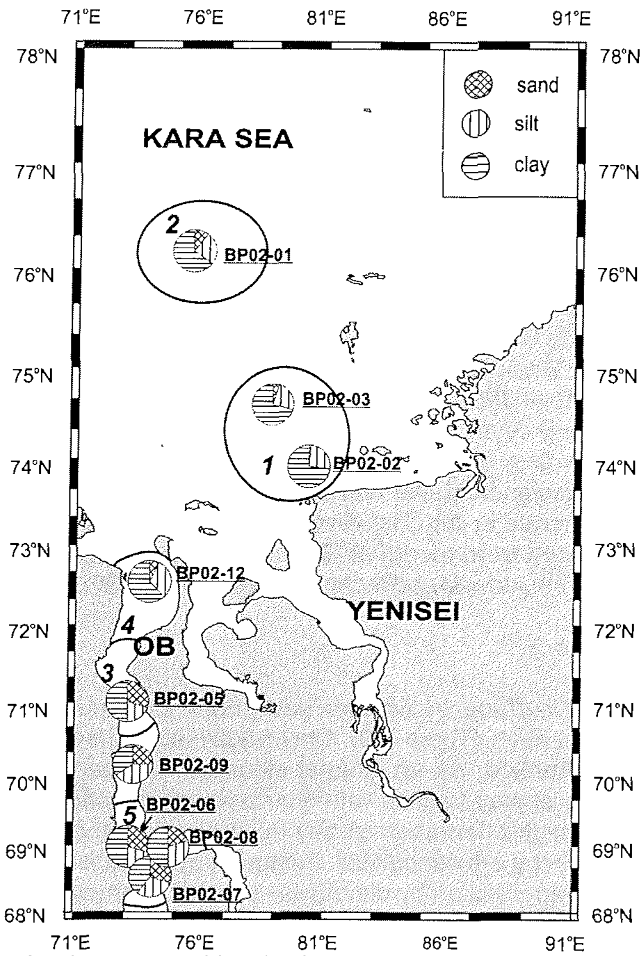

Figure 7-3: Grain-size composition (weight %) of BP02 surface sediments. See the text for explanation of numbers.

Results and discussion

Distribution of grain-size composition of surface sediments is shown in Fig. 7-3. As a result of smear-slide examination we can reveal following sediment types:

1. Silty clay with sand is typical for St. BP02-01, which is located in the area of Ob-Yenisei Shoal break in the north-western part of the studied region.
2. Clay is typical for one of paleo-Yenisei channel in the southern Kara Sea (St. BP02-02, 03).
3. Mixtite (Gurevich 1995) – mixed sediment with more or less equal amount of sand, silt and clay – is developed in the middle part of Ob Estuary (St. BP02-05).
4. Diatomaceous sandy silty clays characterize area of Ob and Taz Rivers merge (St. BP02-06, 07, 08).
5. Sandy clayey silt is located in the middle part of Ob Estuary (St. BP02-09).

6. Silty clay is typical for mixing zone of sea and fresh water in the northern part of Ob Estuary (BP02-12).

In general, fluvial sediments have relatively coarse composition. Coarseness depends mainly on hydrodynamics and – the second cause – on component composition. Diatomaceous sediments (with fresh-water diatoms *Melosira sp.*) are typical for merging of Taz and Ob rivers. Small admixture of fresh-water diatoms also was reported for Ob' marginal filter. Same results were obtained for Yenisei marginal filter (Mukhina and Yushina 1999). These data fit well with results of Nürnberg (1996) concerning opal distribution in study area. Of course, here we should keep in mind that in smear-slides we evaluate ***area*** percents, and opal concentrations are expressed in weight percents.

Five clay mineral assemblages are revealed in study sediments (Table 7-4, Fig. 7-6):

1. Chlorite-smectite-illite assemblage is typical for St. BP02-01, 08 (Sm/Ill ratio is 0.4-0.5).
2. Illite-smectite assemblage is reported for St. BP02-02, 03, 07, 12 (Sm/Ill ratio varies from 1.2 to 2.0).
3. Smectite-illite assemblage characterizes St. BP02-05 (Sm/Ill ratio is 0.6).
4. Chlorite-illite-smectite assemblage is developed in St. BP02-09 (Sm/Ill ratio is 1.4).
5. Kaolinite-chlorite-smectite-illite assemblage is typical for St. BP02-06 (Sm/Ill ratio is 0.9).

Sediments of Taz River are enriched by illite and – up to some degree – by chlorite, here we observe the highest chlorite/kaolinite ratio (2.5). Mixing of Taz and Ob waters gave a strong enrichment by chlorite. If we compare clay mineral distribution along the Ob Estuary from south to north we can find that since St. BP02-06 northward amount of chlorite and chlorite/kaolinite ratio is decreasing; smectite has the same behavior as smectite/illite ratio; illite has the same behavior as kaolinite. Behavior of chlorite can be explained by differentiation downstream, and behavior of illite and smectite by hydrodynamic regime. By increasing of hydrodynamic activity illite (and kaolinite) accumulation is favoured and by decreasing smectite accumulation. Difference of BP02-01 sediments, from the one hand, and BP02-02, 03 sediments, from the other hand, is due to their belonging to two different facies zones of the Kara Sea (Levitan et al. 1996). Enrichment of BP02-02 and 03 sediments by smectite can be explained by the influence of Yenisei. If we compare clay minerals of Ob sediments (before the mixing with Taz River – BP02-07) and Yenisei influenced sediments (BP02-02, 03), we will find that Ob sediments have much less smectite, higher illite and kaolinite, same chlorite; lesser smectite/illite, illite/kaolinite, chlorite/kaolinite ratios, higher illite/chlorite ratio. Such way, clay minerals demonstrate the difference in source areas for three studied rivers: Yenisei, Ob and Taz. Even same clay assemblages of Ob marginal filter and Yenisei influenced sediments with same Sm/Ill ratio have different other ratios: Ill/Chl, Ill/Kaol, Chl/Kaol.

We are grateful to crew and our German colleagues for their help in sampling procedures. This is the RFBR grant # 02-05-64017.

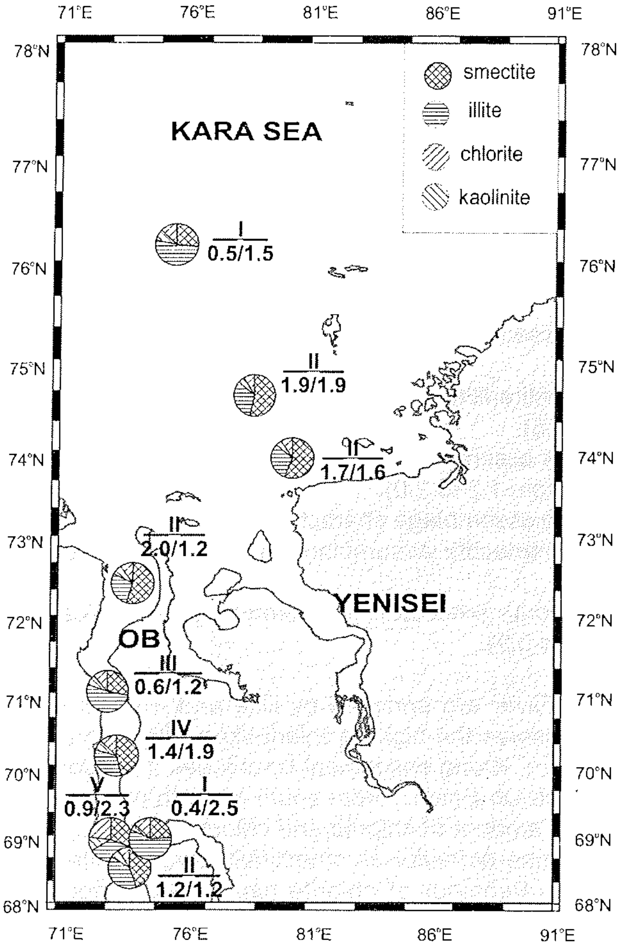

Figure 7-4: Clay-mineral assemblages (rel. %) of BP02 surface sediments. Rome numbers – assemblage types. In denominator: left fraction – Sm/Ill ratio, right fraction – Chl/Kaol ratio.

Table 7-3: Smear-slide composition of BP02 sediments (rel. %).

NN	Station	Depth, cm	grain size			minerals								rock fragments	Fe-clayey aggregates	biogenic remains						lithology
			sand	silt	clay	quartz	feldspar	heavy mineral: colored	heavy mineral: opaque	clay	mica: muscovite	mica: biotite	volcanic glass			forams	diatoms	sponge spicules	silicoflaggelats	spores & pollens	plant remains	
1	BP02-01BC	01	10	25	65	25	5	4	1	54	-	+	+	+	10	+	+	1	-	-	-	silty clay with sand
2		11	5	20	75	15	5	5	<1	55	+	-	+	+	20	+	+	+	-	-	-	clay
3		15	20	20	60	27	5	8	-	51	-	+	+	+	5	4	+	+	-	-	-	sandy silty clay
4	BP02-02BC	01	5	25	70	20	5	4	<1	55	1	-	+	+	15	+	<1	+	-	-	-	clay
5		03	5	20	75	14	5	5	-	60	1	-	+	+	15	+	<1	-	-	-	-	clay
6		20	10	30	60	24	8	6	-	45	1	1	+	+	14	1	<1	-	-	-	-	silty clay with sand
7	BP02-03MC	01	1	25	74	15	6	2	-	54	3	-	+	+	20	-	+	+	-	-	+	clay
8		03	5	25	70	19	8	2	+	65	1	-	+	+	5	-	+	-	-	-	-	clay
9		07	25	25	50	22	18	10	-	35	<1	-	+	+	15	-	+	-	-	-	-	sandy silty clay
10		15	30	30	40	30	20	9	-	29	1	-	+	+	10	-	1	-	-	-	-	sandy silty clay
11	BP02-05MC	03 (lense)	30	20	50	27	13	5	-	45	3	2	+	+	5	-	+	-	-	-	-	silty sandy clay
12		05 (burrow)	20	40	40	30	15	10	-	35	3	2	+	+	5	-	+	-	+	-	-	sandy clayey silt
13		06	20	50	30	30	10	15	-	35	5	-	+	+	5	-	+	+	+	-	-	sandy clayey silt
14	BP02-06MC	01	30	30	40	20	15	5	-	40	+	-	+	+	<1	+	20	-	-	-	-	diatomaceous sandy silty clay
15		02	25	30	45	20	10	5	-	40	+	-	+	+	5	-	20	-	-	-	-	diatomaceous sandy silty clay
16		04	20	30	50	20	10	5	-	45	-	+	+	+	5	-	15	-	-	-	-	diatomaceous sandy silty clay
17		40	20	30	50	20	9	5	-	45	1	+	+	+	5	-	15	+	-	-	-	diatomaceous sandy silty clay
18	BP02-07Gr	01	20	30	50	15	10	5	-	49	+	-	+	+	1	-	20	+	-	-	-	diatomaceous sandy silty clay
19	BP02-08Gr	01	30	20	50	15	10	4	-	49	1	-	+	+	1	-	20	-	-	-	-	diatomaceous silty sandy clay
20	BP02-09Gr	01	25	40	35	30	19	10	+	34	1	+	+	+	1	-	5	+	-	-	-	sandy clayey silt
21	BP02-12Gr	01	8	30	62	20	10	5	+	60	+	+	+	+	2	-	3	-	-	-	-	silty clay
22		10	25	25	50	29	10	9	+	45	1	+	+	+	5	-	1	-	-	-	-	sandy silty clay

Table 7-4: Clay minerals in BP02 surface sediments (fr. <1 μm, rel. %).

NN	Cruise	Station	Smectite	Illite	Chlorite	Kaolinite	Sm/ILL	IL/Chl	IL/Kaol	Ch/Kaol	assemblages
1	BP02	01 BC	26,4	52,5	12,7	8,3	0,5	4,1	6,3	1,5	I - chlorite-smectite-illite
2	BP02	02 BC	56,2	30,4	8,7	4,7	1,9	3,5	6,4	1,9	II - illite-smectite
3	BP02	03 MC	54,0	31,9	8,6	5,5	1,7	3,7	5,8	1,6	II - illite-smectite
4	BP02	05MC	28,3	51,4	11,2	9,1	0,6	4,6	5,6	1,2	III - smectite-illite
5	BP02	06 MC	31,1	35,2	23,5	10,2	0,9	1,5	3,4	2,3	V - kaolinite-chlorite-smectite-illite
6	BP02	07 Grab	44,9	38,8	8,9	7,4	1,2	4,4	5,2	1,2	II - illite-smectite
7	BP02	08 Grab	23,6	58,7	12,7	5,1	0,4	4,6	11,6	2,5	I - chlorite-smectite-illite
8	BP02	09 Grab	46,3	32,5	13,8	7,4	1,4	2,4	4,4	1,9	IV - chlorite-illite-smectite
9	BP02	12 Grab	55,1	27,8	9,5	7,7	2,0	2,9	3,6	1,2	II - illite-smectite
		min	23,6	27,8	8,6	4,7	0,4	1,5	3,4	1,2	
		max	56,2	58,7	23,5	10,2	2,0	4,6	11,6	2,5	
		mean	40,6	39,9	12,2	7,3	1,2	3,5	5,8	1,7	
		standard deviation	13,29	11,31	4,69	1,87	0,61	1,08	2,42	0,47	

7.4. Lithology of sediment cores

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Introduction

Lithostratigraphy of sediment cores reflects changes in source provinces, sedimentation environment and diagenetic transformations. Lithostratigraphy of the southern Kara Sea sediment cores was described in Levitan et al. 1994, Kosheleva and Yashin 1998, and in cruise reports of RV "Akademik Boris Petrov" (Matthiessen et al. 1999, Stein and Stepanets 2000, 2001, 2002). Special attention has been paid to diagenetic transformations of sediments downcore (Kodina et al. 2001). Most of these studies described long sediment cores retrieved by gravity corers. Much less is known about lithostratigraphy of short sediment cores obtained by means of multicorers, box corers and grab samplers. In this contribution we will try to fill this gap up to some degree.

Facts and methods

During 38-th cruise of RV "Akademik Boris Petrov" (2002) we obtained 9 sediment cores (for location of geological stations see Krupskaya and Levitan, this volume). Lithological description of sediment cores, preparation and examination of smear-slides from sediments have been done on board. Results of smear-slides examination are represented in Table 7-3 from paper (Krupskaya and Levitan, this volume). For lithological descriptions see Annex 10.2 "Core descriptions" (this volume). Regretfully, we have no data about the age of studied sediment cores.

Preliminary results

We revealed 10 types of sediment layers based on color, consistence, grain-size composition, texture, organic remains, component composition, etc.:

1. Dark olive-brown liquid silty clay with sand admixture; 1a – same with shell debris and plant remains.
2. Patchy (from brown to gray) soft silty clay with sand, bioturbated.
3. Dark olive-gray dense silty clay with sand, bioturbated, with polychaets and hydrotroilite spots; 3a –gray to dark gray dense silty clay with sand, bioturbated, with bivalves and spots of hydrotroilite; 3b – olive-gray to dark olive-gray dense sandy silty clay and silty sandy clay, bioturbated, with shell debris and hydrotroilite spots.
4. Dark olive-brown liquid sand with gravel, includes tubes of polychaets.
5. Dark olive-brown liquid silty clay with diatoms (up to 5%).

6. Dark gray dense sandy silty clay with diatoms (up to 5%) and polychaets, bioturbated. Spots of hydrotroilite. Sometimes lenses of sandy clay.
7. Dark olive-brown liquid diatom (up to 20%) silty clay with rare bivalves.
8. Dark olive-gray diatom (up to 20%) silty clay with admixture of sand. Thin layers of clay and lenses of fine sand.
9. Dark olive-brown liquid clayey silt with diatoms (up to 5%).
10. Dark olive-gray fine silty sands with diatoms (up to 5%).

Correlation scheme of sediment cores is shown in Figure 7-5.

Discussion

We believe that there are several groups of sediment cores (Fig. 7-5). First group includes sediment cores BP02-01, 02 and 03 which are located in the southern Kara Sea. Main differencies between types 1, 1a, 2, 3, 3a and 3b (color and consistence changes) are due to diagenesis. Practically all these types are represented by same lithology (silty clay with sand) and – such way – one doesn't observe any significant paleoenvironmental change during the time of accumulation of listed sediment cores. Second group consists of sediment cores BP02-06, 07 and 08 which are located in the area, where Ob and Taz Rivers merge. Here differencies between types 7 and 8 are due to diagenesis as well, and also there was no paleoenvironmental change. Major lithology is diatom silty clay. Paleoenvironmental changes are obvious for sediment cores BP02-05, 09 and 12, but in this group BP02-05 demonstrate coarsening upward, and BP02-09 and 12 fining upward. It seems that all these changes can be explained by changes in hydrodynamic activity – increased in the region of BP02-05, and diminished in regions of BP02-09 and 12, respectively. Of course, we need strong age control of mentioned sediment cores (by means of radionuclides or ^{14}C) for better understanding of sedimentation history during the last stage of Holocene.

We are grateful to our German colleagues and crew for possibility of sampling and lithological description. This is RFBR grant # 02-05-64017.

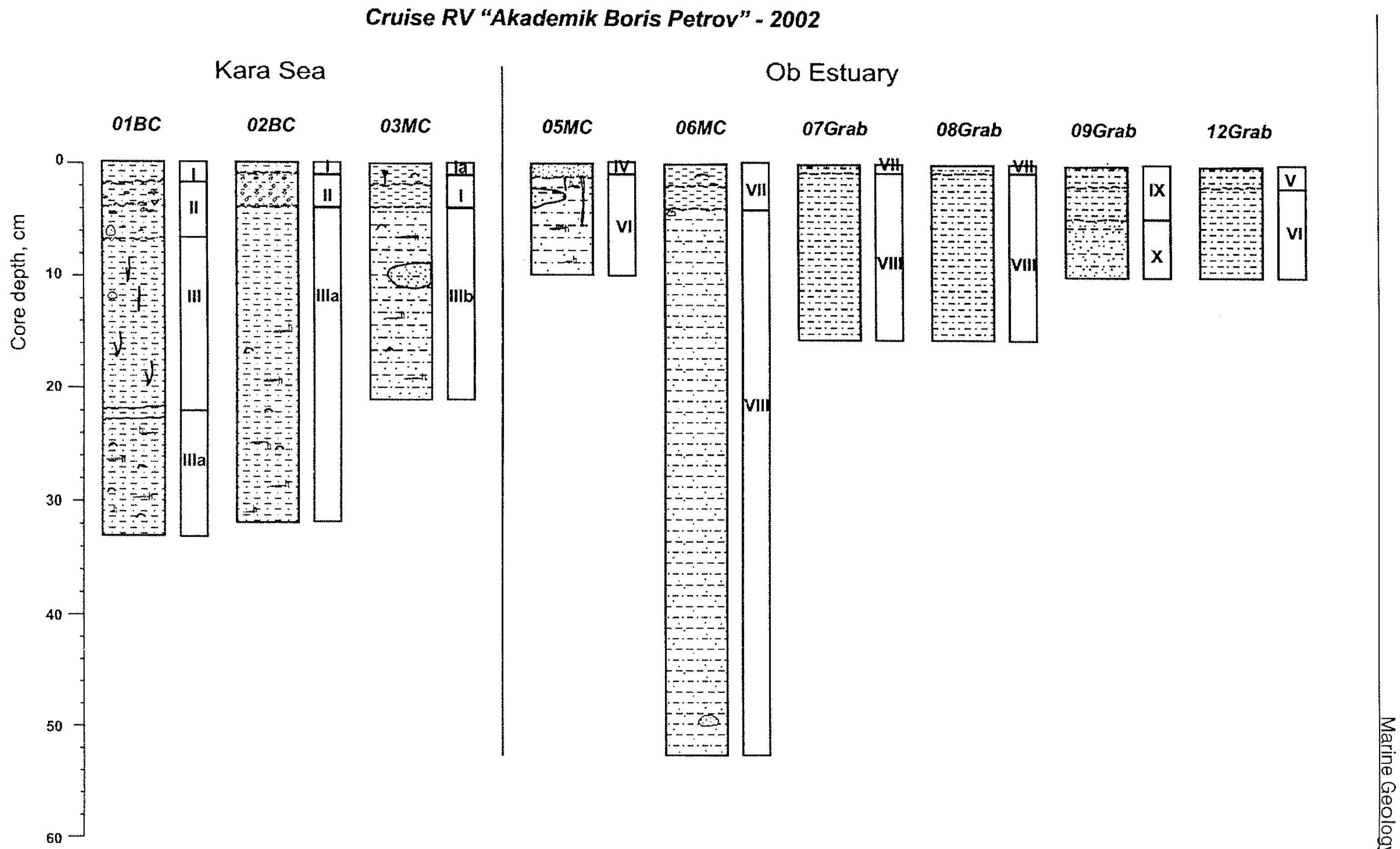

Figure 7-5: Types of BP02 sediment cross-sections. Rome numbers – layer types (see text for explanation). Lithological legend is given in Annex 10.2 "Core descriptions".

8. Geochemistry

8.1. Geochemical sampling of suspended and sedimentary particulate matter

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Geochemistry of carbon and silica

Suspended particulate matter samples were taken in order to obtain information about the source and cycling of suspended matter. The results will add to the record obtained during previous cruises (BP-97, BP-99, BP-00, BP-01) as it covers a time period not investigated so far. Surface water samples were taken with a bucket, deep-water samples were taken with the CTD rosette. Samples were filtrated onto pre-weighed and pre-combusted (450°C overnight) WHATMAN GF/F filters (47 mm, pore size ca. 0.7 µm) and onto pre-weighed WHATMAN polycarbonate filters (47 mm, pore size 0.4 µm), respectively. All samples were dried onboard at 40°C for at least 24 hours.

Surface sediments (0-1 cm) were taken from Multicorer tubes, stored in small plastic cups and immediately frozen at -20°C onboard in a refrigerator. For sampling overview refer to Tab. 8-1.

Tab. 8-1: Samples collected during Cruise BP-02

Station	Salinity [‰]	Surface Water	Deep Water	Surface Sediment
BP02-01a	26.2	x	x	x
BP02-02b	11.5	x	x	x
BP02-05	0.0	x		x
BP02-06	0.0	x		x
BP02-07	0.0	x		
BP02-08	0.0	x		
BP02-09	0.0	x		
BP02-10	0.0	x		
BP02-11	0.0	x		
BP02-12	8.2	x	x	

Geochemistry of particulate organic matter in the water column and sediments of the Ob and Yenisei estuaries and the inner Kara Sea

Major objectives are the characterization and quantification of particulate organic matter accumulated in the Ob Estuary and the adjacent Kara Sea. 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 characterize and identify the different sources of the particulate and sedimentary organic carbon pool (see Fahl et al. 2003, Stein et al. 2003).

14 water samples at 10 stations were obtained either by use of a Niskin rosette water sampler or a water bucket. 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 8-2. In marine areas, three water depths were sampled at each of the selected stations: surface water, the pycnoclyne (mixed-water) layer and near-bottom water. In the Ob River, salinity was zero, and therefore, only a surface water sample was taken. 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 LBC and MUC stations (see Annex 10.1, station list) surface samples were taken for future organic-geochemical investigations. The sediment samples were stored frozen (-20°C) and under light-protection in precleaned 100 ml glass-bottles.

Table 8-2: Station with sampling of particulate organic matter out of the water column.

Station	Sample-depth(m)	Salinity(PSU)	Volume(l)	sampler
BP02-01 B	surface	26,2	4	bucket
	60		2,5	CTD
BP02-02 B	surface	11,5	1	bucket
	9		3	CTD
	26		0,5	CTD
BP02-05	surface	0	0,5	bucket
BP02-06	surface	0	0,69	bucket
BP02-07	surface	0	0,46	bucket
BP02-08	surface	0	0,4	bucket
BP02-09	surface	0	0,2	bucket
BP02-10	surface	0	0,2	bucket
BP02-11	surface	0	0,2	bucket
BP02-12	surface	8,2	0,5	bucket
	15		0,5	CTD

Variability of element concentrations in sediments of the Kara Sea and Ob River

The variability of element concentrations in sediments of the Kara Sea and the Ob River is quite high (Lukashin et al. 1999, Schoster et al. 2000). The Ob and Yenisei rivers transport huge amounts of terrigenous material from their sources to the estuaries and into the Kara Sea. Both rivers have large, but different catchment areas. The Ob River mainly drains the Siberian Lowland and the Altai Mountains far south, the Yenisei River mainly the Putoran Mountains with its Triassic Trapp Basalts, which show a significant chemical and mineralogical composition (Churkin et al. 1981, Lightfoot et al. 1990). Therefore, the surface sediments of the Kara Sea show high smectite content and enhanced Ti/Al-, Mg/Al-, Fe/Al-, Cr/Al-, and Ni/Al-ratios compared to the continental crust composition (Taylor and McLennan 1985, Schoster et al. 2000).

Changes in the salinity lead to rapid precipitation of particulate and dissolved material in the estuaries. In this "marginal filter" area mainly fine sediments, organic material and authigenic minerals like Fe- and Mn-oxides accumulate. So we have to distinguish between variability in sediment composition based on different source rocks and variability based on grain size fractionation and chemical processes (Beeskow and Rachold 2003).

In order to understand the distribution of the elements surface sediment samples were taken additionally to the samples of the former expeditions (Matthiessen and Stepanets 1998, Stein and Stepanets 2000, 2001, 2002). Surface sediment samples for this purpose were taken by LBC and MUC at every station, in general (see Annex 10.1, station list). The samples are stored at 4°C. In the laboratory detailed geochemical analyses will be performed. The concentrations of major and minor elements for sediments will be analyzed by X-ray flourescence spectrometer (XRF).

8.2 Influence of the Ob and Yenisei rivers' discharge on main hydrochemical parameters of the Kara Sea water: evidences from the RV "Akademik Boris Petrov " expeditions of 2001 and 2002

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Ob and Yenisei provide more than 30% of the annual water discharge from the Eurasian territory into the Arctic Ocean.The largest rivers of the Kara Sea Basin are characterised by a higher concentration of total dissolved inorganic ions (100 mg/L for Yenisei and 120 mg/L for Ob) than the world river average value (89,2 mg/L, Gordeev et al. 1996, Gordeev 2000).

Material and Methods

In this paper the distribution of the major nutrients, hydrocarbon gases and other hydrochemical parameters in sea and river water obtained during the expedition 2001 (14 August-11 September) and the expedition 2002 (4-9 October) with RV "Akademik Boris Petrov" is described. The locations of stations of the expedition BP-2001 together with stations of the short expedition BP-2002 into the Kara Sea and the Ob and Yenisei rivers are shown in Fig. 8-1. For hydrological conditions during expedition 2001 refer to Shmelkov et al. (2002).

In this year 2002 the short expedition was performed one month later, during late autumn (pre-winter). Surface water temperature dropped to subzero (BP02-01, BP02- 02, Table 8-3) in the off-shore area and to lower positive temperatures (from 0,3^{0}C in the north to 3,2^{0}C in the south part of the Ob Bay) in the Ob Estuary. Water sampling was done by bucket (surface samples), rosette sampler (pycnocline and deeper near-bottom water samples) and multicorer (bottom water samples were taken immediately above sediment surface).

Total alkalinity (TAlk) was determined titrimetrically. NO_2^-, NO_3^-, PO_4^{3-}, SiO_4^- were analysed on board in filtered water samples (paper "blue-tape" filters, pore size of 1-1,5 µm) in accordance with the standard hydrochemistry methods (Methods of hydrochemical investigations in ocean, 1978). Dissolved oxygen concentrations and pH values were measured in 500 ml water samples by using the combined "Orion" electrode immediately after the rosette sampler recovery. Hydrocarbon gases were separated from the water samples (500 ml) by using an exhaustive degassing procedure and were analysed on a gas chromatograph equipped with flame-ionization detector (Korobeinik et al. 2001a).

Results

Data obtained in cruise BP-01 are listed in the Tables 8-4 and 8-5, and hydrochemical results of the expedition BP-02 are given in Table 8-3. All graphs in the paper belong to the cruise BP-01. Vertical distribution of hydrochemical parameters in the study area, including dissolved methane concentration in surface water along the quasimeridional section Ob - Kara Sea is shown in Fig. 8-2 - 8-8). Spatial nutrients and oxygen distribution in the water at pycnocline depth is presented in Fig. 8-9 and in near-bottom water in Fig. 8-10.

Dissolved oxygen concentration and water pH –values are important indicators of geochemical environment in a basin. The fresh water parts of the study area are characterised by undersaturation of surface water with oxygen (saturation < 100 %), whereas the open sea water is moderately supersaturated (100,1-109,5%, Table 8-4 and Fig. 8-2). pH-Values vary parallel to the oxygen concentrations. The lowest pH-values of 6,8-7,8 as well as oxygen content was recorded in the Ob Estuary (Fig. 8-3).

Content of main nutrients in both rivers in 2001 and 2002 (Tables 8-3 and 8-4) fit well with concentration ranges for rivers of the west Russian Arctic after Gordeev (2000): silica 107 – 164 μM, orthophosphates 2,3 μM (average value for Ob) and 0,4 μM for the Yenisei.

Comparison of the two years' data for the Ob Estuary (Fig. 8-1,Tables 8-3 and 8-4) shows a range of variations in the TAlk, orthophosphate, oxygen concentrations, and pH-values in October 2002 and September 2001 in the same localities. The data are summarized in Table 8-6. One can notice sufficient increase in oxygen and phosphate concentrations, in growth of TAlk and pH in October 2002. In spite of autumn temperature decline we could not notice yet a disturbance in structure of the water mass as a consequence of pre-winter water mixing.

The nutrients distribution pattern throughout the water depth and along both river - sea meridional sections for expedition BP-01 (Fig. 8-2 - 8-10) agree with the observed hydrological regularities. Surface boundary between fresh and saline waters in the east part of the study area (the Yenisei-Kara Sea section) was located between stations BP01-11 and BP01-19. In the Ob Bay the boundary of fresh - saline surface water was located between stations BP01-70 and BP01-82; in the near- bottom water the boundary was located between stations BP01-80 and BP01-72 (Shmelkov et al. 2002). In the expedition BP-02 in October 2002 surface boundary has moved slightly southwards and was located in the Ob Bay between stations BP02-11 and BP02-12 (72^{0}40'N and 71^{0}50'N).

Fresh-water parts of both sections are characterised by a rather uniform depth distribution of the main hydrochemical parameters. Riverine water is clearly distinguished from saline water by lower pH-values and low TAlk (Fig. 8-3 - 8-4). Comparison of the concentration data for main nutrients in river and marine parts of both meridional sections (Table 8-4) enables to follow importance of the river run-off for phosphate, nitrate, nitrite and silica supply into the off-shore area (Fig. 8-5 - 8-7).

Geochemical behaviour of dissolved nutrients changed sharply in the frontal zone. Concentration of inorganic ions (silicates, phosphates, nitrates) dropped sharply (up to 50% for phosphate) immediately behind the hydrological front (Fig. 8-5 - 8-7) and tends to decrease seawards. Oxygen concentration (and saturation degree), TAlk and pH-values increased correspondingly with salinity growth and decrease of temperature (Fig. 8-2 - 8-4). As can be seen from Fig. 8-9 and 8-10, nutrients supply kept in deeper water (pycnocline and near-bottom water).

Surface layer of the transformed river water extended as far north- and northeastwards as 78°N (Table 8-4), evidenced by the data on the specific alkalinity (TAlk/S-ratio > 730) and silica concentration >10 µM (Rusanov et al. 1979).

Concentration of methane and higher hydrocarbon homologues (ethane, ethylene, propane, propylene, butane, iso-butane, butylene, pentane) in the water column along the meridional sections river – sea is presented in Table 8-5. Total content of the higher homologues (C2-C5), and especially heavy hydrocarbons (C4 and C5), exceeds methane content, except only some fresh water stations in the southern Ob Bay (BP01-73 - BP01-78). Here, dissolved methane concentration was one order of magnitude higher than in the remaining water area.

The distribution pattern of nutrients dictated by the composition of the river discharge and the basin hydrodynamics might be disturbed by biogeochemical remineralization of labile organic compounds as well as by active nutrients uptake by phytoplankton in photosynthesis. Therefore, it is controlled by the bioproductivity and distribution pattern of the phytoplankton biomass (Larionov and Makarevich 2001).

Discussion

Active remineralisation of organic matter including biomass of the dying fresh-water plankton in pycnocline and deeper water is responsible for the highest nutrient concentrations as well as for deficient oxygen in the deeper water as a consequence of oxygen consumption by bacterial respiration. The regularities are usually more pronounced in the mixing zone.

Riverine water is clearly distinguished from saline water by lower pH-values and low TAlk. The low pH-values and TAlk in both rivers are suggested to be governed by the presence of organic acids originated from soils (humic and fulvic acids) and high molecular mass organic matter destruction in water followed by production of low molecular mass fatty acids. Humic substances are the dominating compounds of dissolved organic carbon in the Ob and Yenisei rivers accounting for 60-75% of the dissolved organic carbon (Köhler et al. 2003).

Nutrients concentration are decreasing seawards and drop sharply in surface water immediately behind the hydrological front (Table 8-4) due to coprecipitation with the dying fresh-water plankton, water suspended matter and new-formed organic and inorganic colloids. The nutrients continue to diminish because of dilution of transformed fresh water with saline water and consumption of nutrients by phytoplankton, when the transformed riverine water moves further northwards from the river mouth (Fig. 8-5 - 8-7). TAlk origins mostly of hydrocarbonate type and continues to rise further seawards (Table 8-4, Gaillardet et al. 1999).

Oxygen regime in the Kara sea in summer was influenced by the great river discharge, enhanced temperature and biogeochemical processes of photosynthesis and organic matter remineralisation. Bacterial processes of organic matter respiration are accompanied by oxygen consumption and resulted in modification of redox conditions within water masses and at bottom surface. As this takes place, pH-values and alkalinity increase, oxygen content diminishes and water saturation degree with oxygen dropped down to minimal values (Fig. 8-2 and 8-3). This geochemical situation is favorable for bacterial methanogenesis. The stable carbon isotope ratio of methane from the surface sediments at BP01-73 indicate the methane biogenic nature ($\delta^{13}C$ from –80 to –105 ‰).

Photosynthetic activity of phytoplankton microalgae is considered to be the important source of dissolved oxygen in sea water. Environmental conditions are unfavorable for photosynthesis in river water because of light attenuation due to the high water turbidity (in the Ob Bay water a Sekki-disk only could be seen until a depth of 2 m). Once the bulk of suspended material precipitated in the estuary, and water transparency increased sharply, active photosynthesis starts in the warm surface water enriched in dissolved nutrients. A round-the-clock photosynthesis operates in conditions of the polar day in the northernmost part of the study area. Silica concentrations decrease to 10-20 µM, and phosphate concentration at same stations decline to analytical zero in surface water (Table 8-4). Phytoplankton biomass maxima are in most cases located at the pycnocline (Larionov and Makarevich 2001).

Photosynthesis leads to depletion of the nutrient pool and to an increase in the surface water saturation with oxygen up to more than 100%. Wave water mixing may be an additional effective factor for oxygen supply from the cold bottom water. Oxygen degassing of the bottom water occurs when the deep cold water emerge on surface and is getting warm. Sea water became sometimes supersaturated in oxygen as high as 115% (Fig. 8-9).

In such cases, dissolved nutrient salt pool might be compensated additionally by wave stirring and mixing of the surface water with deeper saline water masses, which contain a higher content of nutrients (Fig. 8-10). The high specific alkalinity (TAlk-values >700) detected in pycnocline and near-bottom water (Table 8-4, Fig. 8-10) is evidence of an effective water mixing in the Kara sea and shallow-water estuaries.

The distribution pattern of methane in water along the meridional section Ob-Kara Sea is shown in Figure 8-8. We would like to stress that water salinity and water temperature were found to be the main parameters, which guide distribution pattern of methane concentrations along salinity gradient. Methane content decreases seawards due to decrease of solubility in saline water. As distinct from methane, no clear relation was observed between C5 concentration and water salinity (Korobeinik et al. 2001b); instead, pentane concentration is mostly correlated with the presence of suspended matter and its sedimentation in the mixing zone (Bogacheva et al. 2001).

The distribution pattern of the important hydrochemical parameters (O_2 saturation, silica and orthophosphate concentrations) enable to suggest that biogeochemical organic respiration and photosynthesis embrace the overall water body in the shallow-water area of the Kara Sea. The active photosynthesis in the warm transformed surface water together with relatively slow remineralisation of the plankton biomass and its high preservation degree in low temperature conditions (-1,5^{0}C) in the near- bottom water are thought to be an important peculiarity of the environment leading to high bioproductivity of benthos communities in the Kara Sea (Polterman et al. 1999).

Comparison of the Ob and Yenisei water hydrochemistry clearly shows that Ob water is of lower pH-values and significantly lower oxygen saturation due to higher concentration of suspended organic carbon and higher biogeochemical activity producing organic acids due to organic matter remineralisation caused with the higher temperatures in the Ob water and peculiarities of the Ob watershed environment rich in forests and swamps. According to Larionov and Makarevich (2001) overall plankton biomass of the Ob Bay was more than one order of magnitude higher than that in the Yenisei Gulf.

Comparison of the data, received in the expeditions of 1999 and 2000 (Sukhoruk and Tokarev 2000) and in 2001-2002 years (Table 8-6) demonstrate some variations in nutrient concentrations and distribution pattern relative to the role of seasons, weather conditions and phytoplankton season bloom. Temperature and wind strength, ice conditions, bioproductivity, and organic matter bacterial cycling belong to the most effective factors.

Calculations made by Gordeev (2000), have shown a negligible river input of dissolved salts in the budget of the whole Arctic Ocean and a minor role of the river discharge in the total new production in the Eurasian Arctic seas (about 10 % of the total).

Our observations as well as other new data received in the framework of the German-Russian SIRRO Project have shown that influence of the great Siberian rivers' discharge on the nature of the shelf shallow- water Kara Sea manifests itself significantly and can be expanding to biosynthesis of autochtonous bioproduction and organic carbon sedimentation.

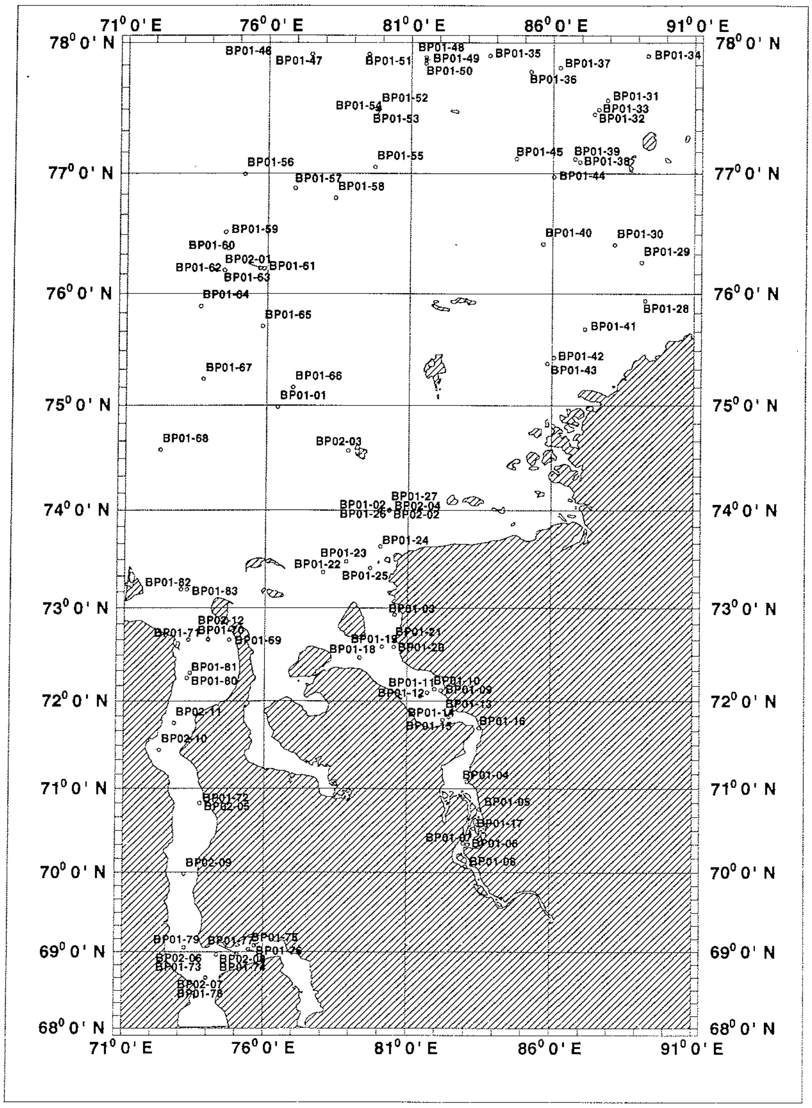
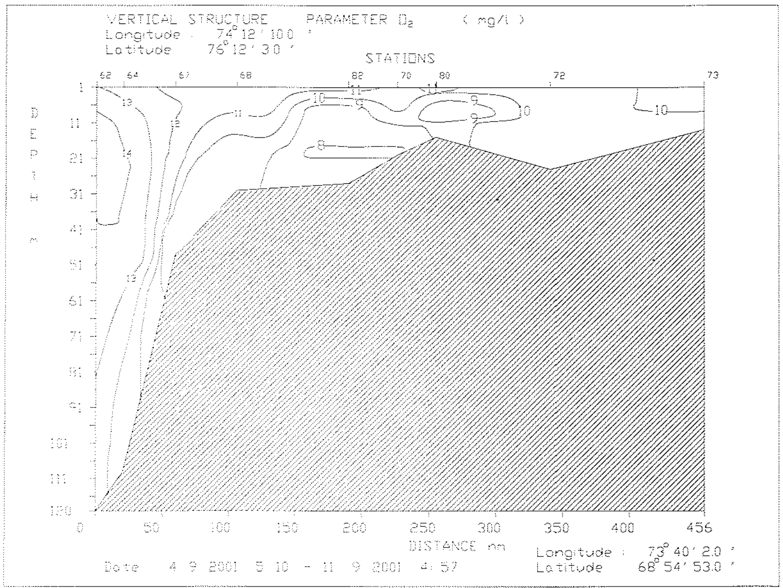
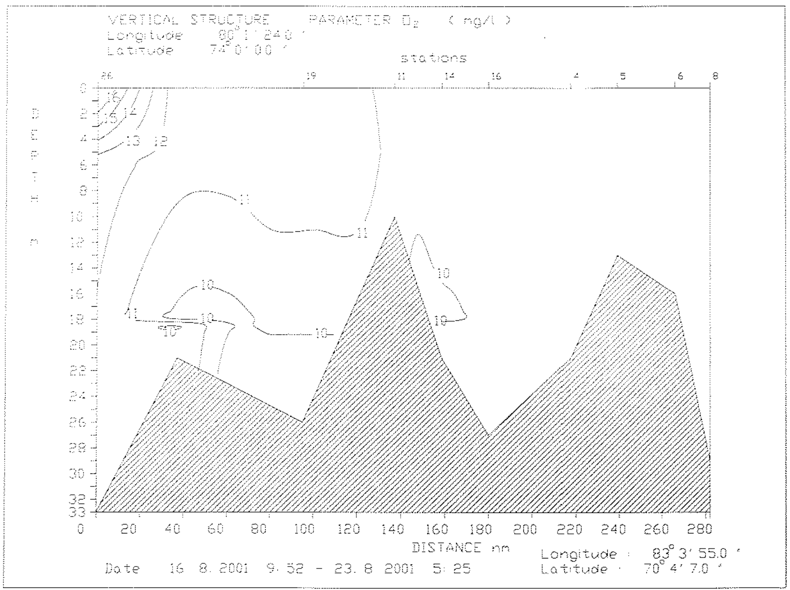


Figure 8-1: Location of sampling stations during cruise 2001 (from BP-01-01 to BP01-83) and cruise 2002 (from BP-02-01 to BP02-12) with RV "Akademik Boris Petrov".

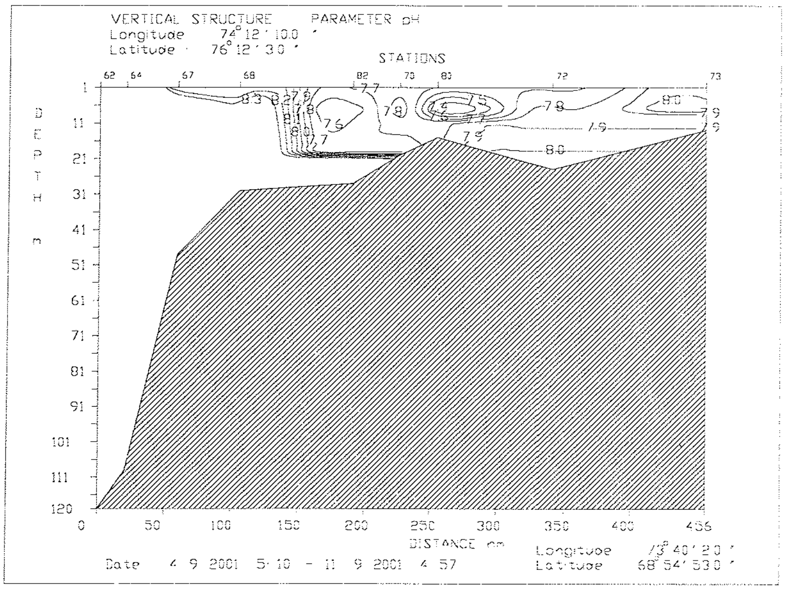


A)

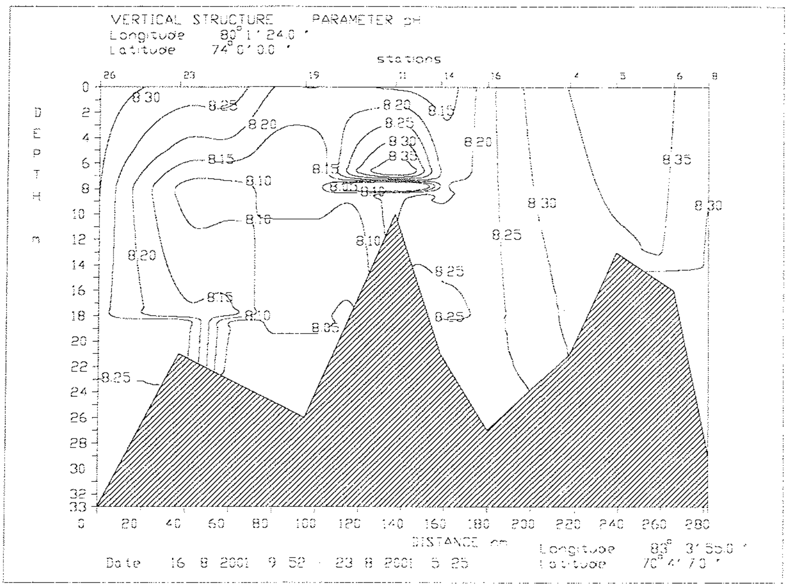


B)

Figure 8-2. Depth variations of dissolved oxygen concentration in the Kara Sea water (Cruise BP-2001) along quasimeridional sections:
A – Ob – Kara Sea (from 68°54'53"N to 76°12'03"N);
B – Yenisei – Kara Sea (from 70°04'07"N to 74°00'00"N).

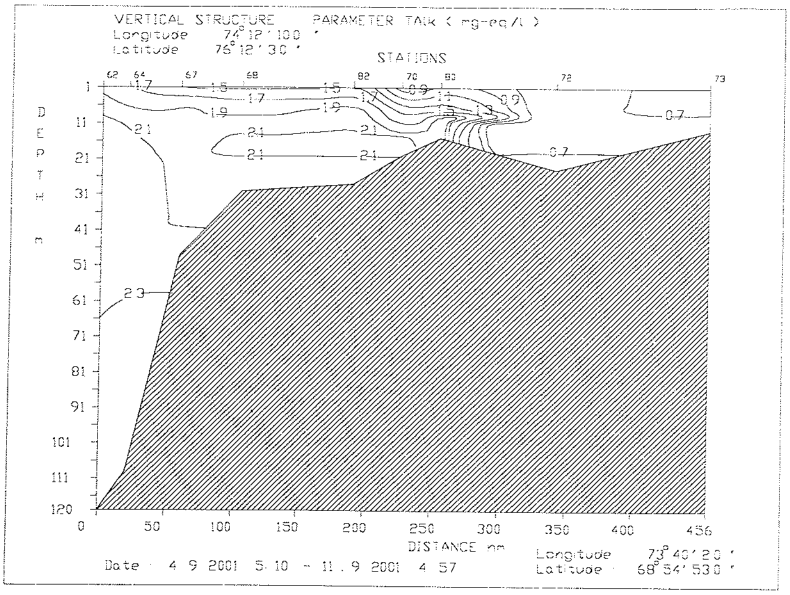


A)

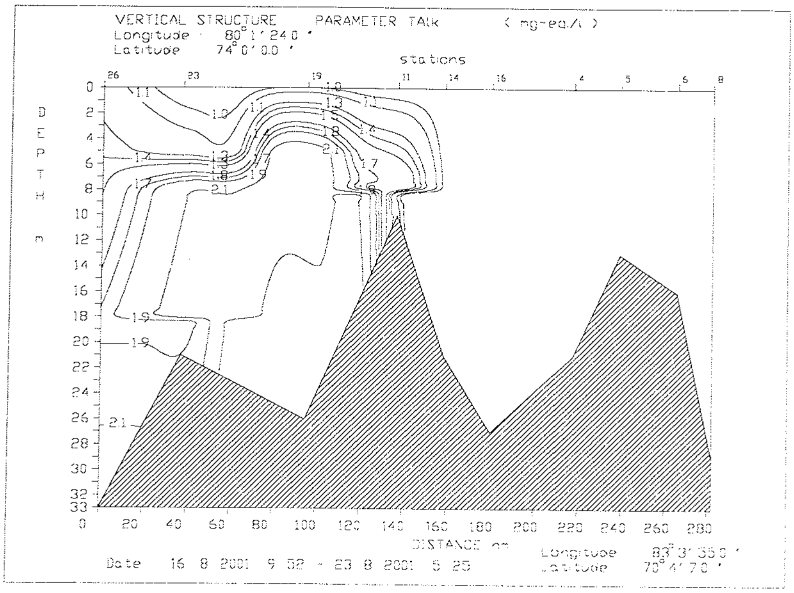


B)

Figure 8-3: Depth variations of pH-values in the Kara Sea water (For detailed explanation see Fig. 8-2).

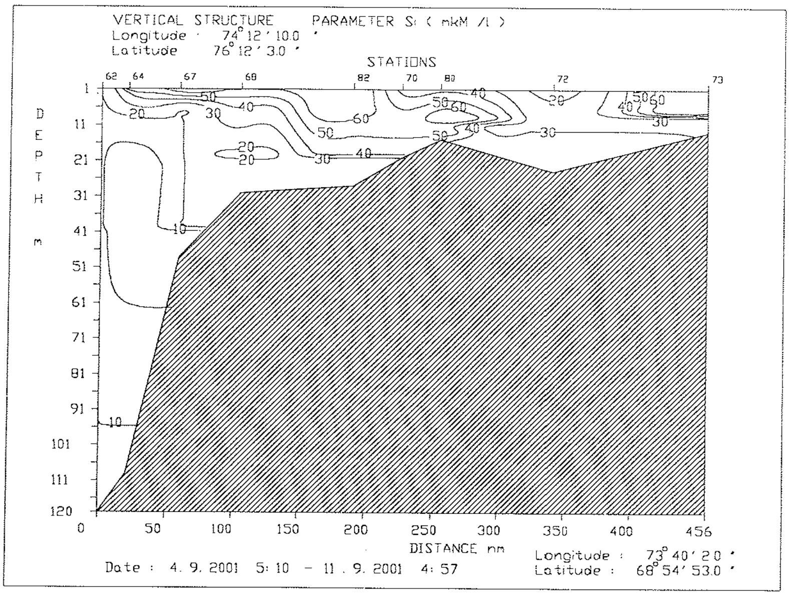


A)

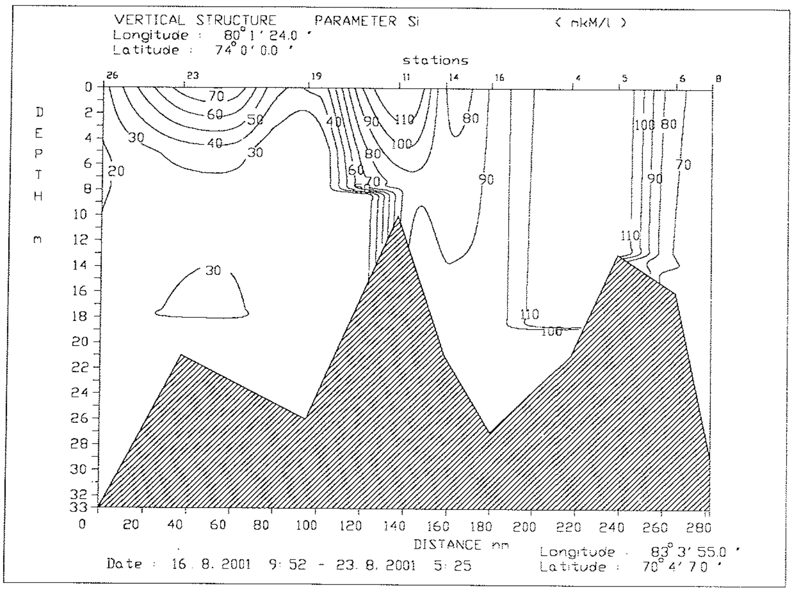


B)

Figure 8-4: Depth variations of total alkalinity (TAlk) in the Kara Sea water (For detailed explanation see Fig. 8-2).

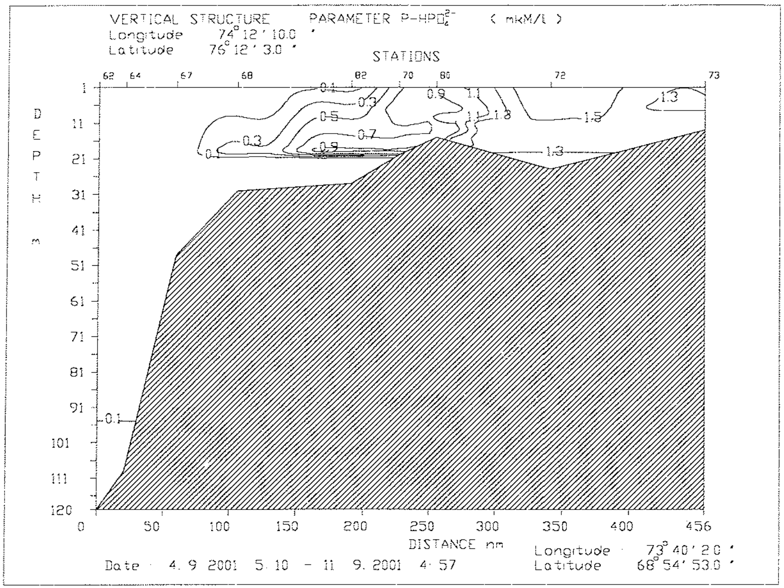


A)

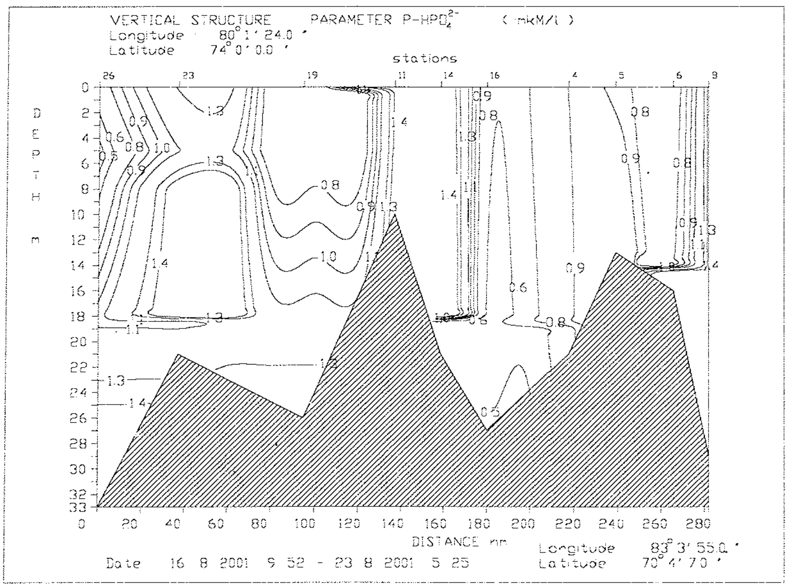


B)

Figure 8-5: Depth variations of dissolved silica concentration in the Kara Sea water (For detailed explanation see Fig. 8-2).

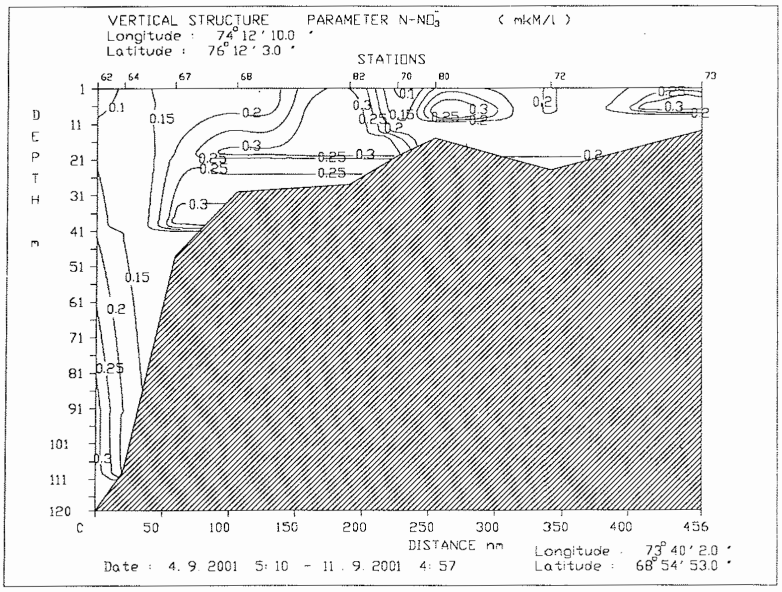


A)



B)

Figure 8-6: Depth variations of dissolved phosphate concentration in the Kara Sea water (For detail explanation see Fig.8-2).



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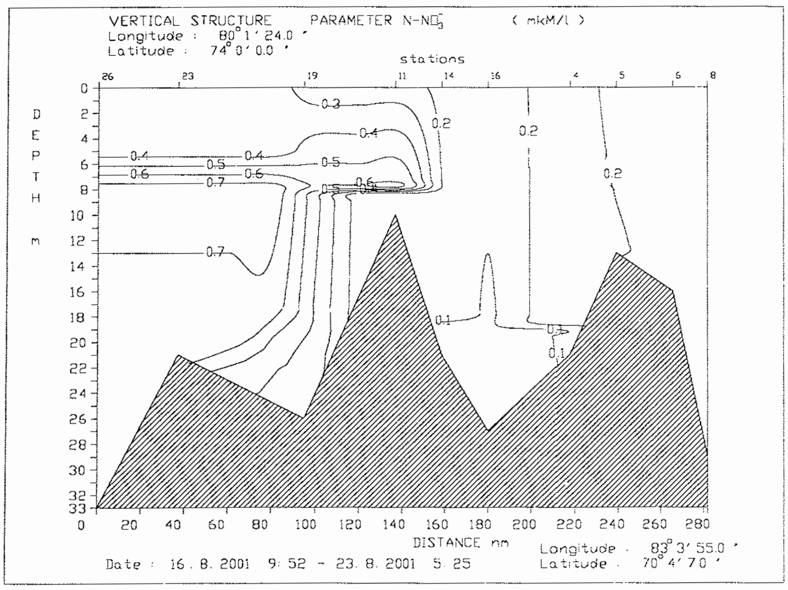


B)

Figure 8-7: Depth variations of dissolved nitrogen (nitrate) concentration in the Kara Sea water (For detail explanation see Fig. 8-2).

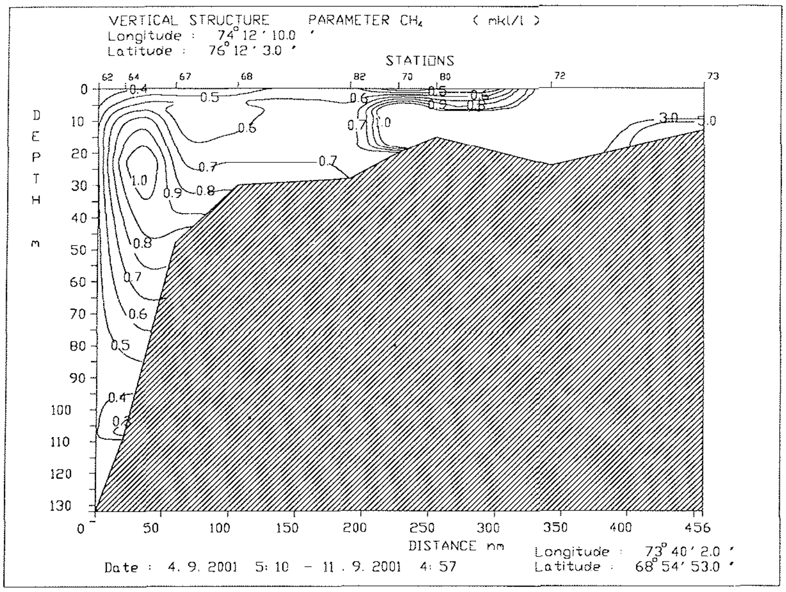
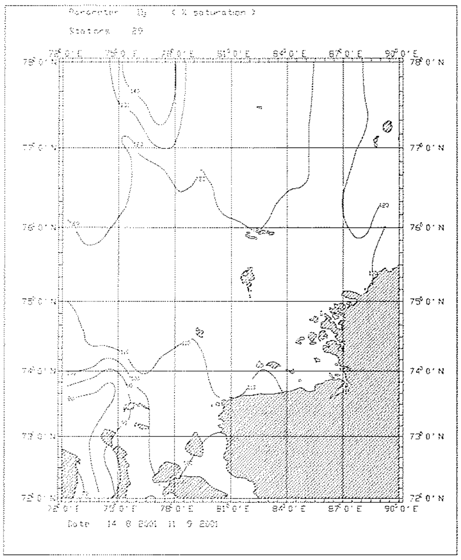
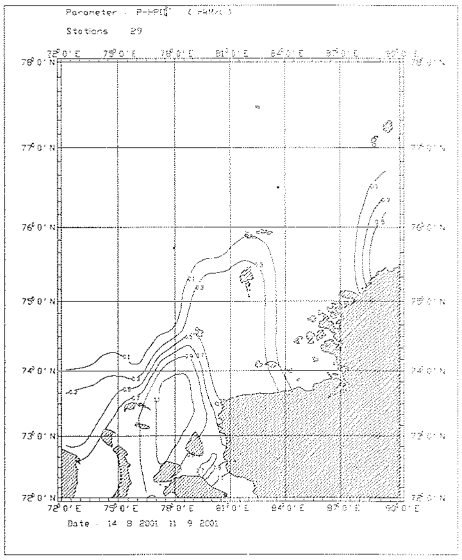


Figure 8-8: Depth variations of CH_4 concentration in water (Cruise BP-2001) along the quasimeridional section Ob-Kara Sea.



A)



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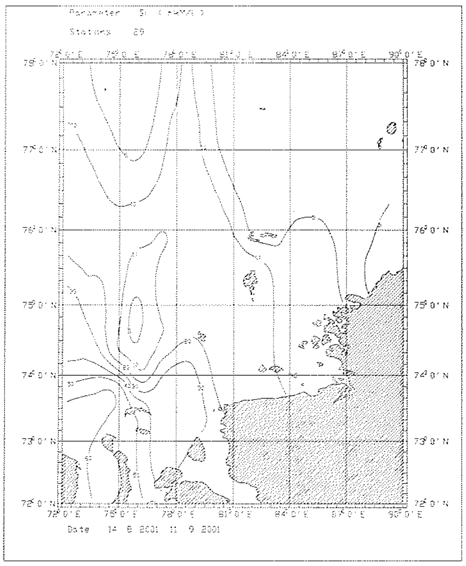
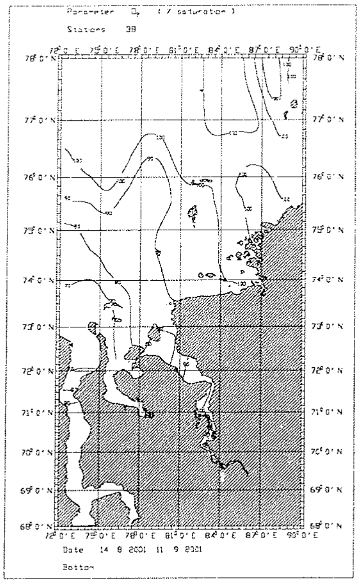
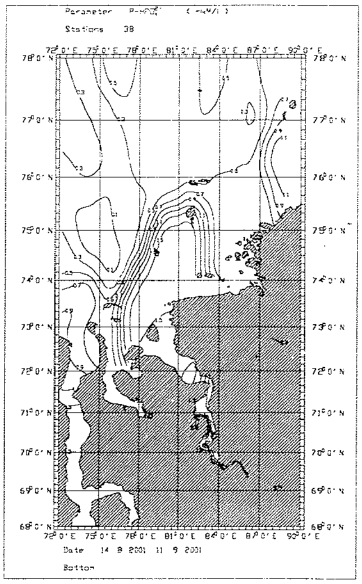


C)

Figure 8-9: Spatial variations in the hydrochemical parameters of the Kara Sea water at the pycnocline depth:
A – water saturation (%) with oxygen;
B – phosphate concentration;
C – silica concentration.



A)



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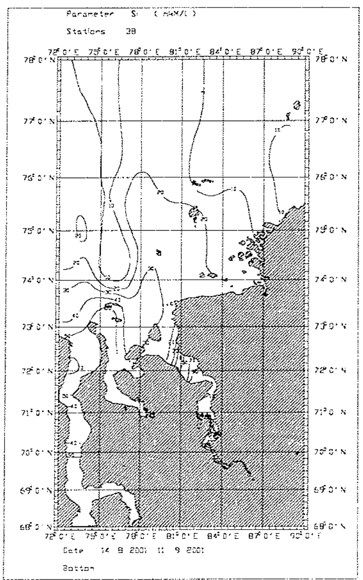

C)

Figure 8-10: Spatial variations in the hydrochemical parameters of the Kara Sea near-bottom water:

A - water saturation (%) with oxygen;

B – phosphate concentration; C – silica concentration.

Table 8-3: Hydrochemical parameters of the Kara Sea and Ob Bay water (4 - 9 October 2002, 38th Cruise of RV "Akademik Boris Petrov")

Station, water depth, [m] location	Sampling horizon [m]	T°C	S psu	pH	Oxygen		TAlk, mM	PO_4^{3-} µM
					% saturation	mg/l		
BP-02-02 32 73°59'44"N; 80°18'52"E	0-2 9 21 26	-0,06 -0,93 -1,35 -1,36	11,5 26,3 33,1 32,8	- - -	98,0 95,0 64,4 64,8	14,12 13,40 9,14 9,18	1,5 2,2 2,4 2,3	1,00 0,50 1,60 4,70
BP-02-01 90 76°13'03,29"N; 75°43'57"E	0-2 80 bottom	-1,25 -1,20 -	26,4 33,8 33,8	8,20 8,10 8,01	98,3 81,6 90,5	14,94 12,11 12,40	2;2 2,6 2,6	0,20 0,66 3,39
BP-02-12 21 72°40'22"N; 73°59'45"E	0-2 9,5 15	0,40 0,33 0,37	8,2 28,5 28,4	7,77 7,83 7,87	97,4 79,4 81,0	13,83 11,23 11,23	1,0 2,3 2,3	1,42 0,82 0,82
BP-02-11 19 71°45'09"N; 72 °48'32"E	0-2 bottom	2,35 2,43	0,13 0,13	7,60 -	93,0 -	12,75 -	0,8 -	0,46 -
BP-02-10 18 71°54'36"N; 56°05'57"E	0-2 13	1,00 1,67	0,04 0,04	7,47 7,34	93,4 94,2	13,07 13,00	0,8 0,8	1,00 0,00
BP-02-05 26 70°49'50,4"N; 73°43'57"E	0-2 bottom	3,2 -	0,0 0,0	7,71 7,35	98,2 98,3	12,91 12,65	0,8 0,8	2,46 2,48
BP-02-09 21 69°58'42"N; 73°11'18"E	0-2	2,8	0,0	7,69	96,0	13,10	0,8	2,24

BP-02-06 15 68°54'53"N; 73°39'59"E	0 2 11	0,7 1,3 1,6	0,05 0,03 0,03	7,65 7,50 7,56	96,2 96,8 97,3	13,34 13,29 13,23	0,8 0,8 0,8	2,80 2,86 3,14
BP-02-08 12 68°58'04"N; 74°21'55"E	0-2	2,5	0,0	7,60	93,2	13,29	0,8	2,46
BP-02-07 12 68°39'57"N; 73°59'37"E	0-2	2,6	0,0	7,86	96,5	13,25	1,0	2,96

Table 8-4: Hydrochemical parameters of seawater on stations of the 36nd cruise of RV "Akademik Boris Petrov"

Station,	Sampling depth, m	pH	O_2		Concentration, μM					TA1k, mM	TA1k/S $*10^4$
			mg/1	Saturation %	P* total.	P, PO_4^{3-}	N,NO_2^-	N,NO_3^-	Si SiO_4^3		
BP-01-1	0	8,36	-	-	-	0,18	0,92	1,12	4,45	2,0	755
	18	8,23	-	-	-	0,07	0,40	0,56	3,30	2,0	702
	38	8,04	-	-	-	0,07	0,52	0,60	1,00	2,4	727
BP-01-4	0	8,36	-	-	-	0,91	0,24	0,26	121,39	0,9	150000
	19	8,30	-	-	-	0,91	0,24	0,28	125,80	0,9	150000
BP-01-5	0	8,40	-	-	3,02	0,86	0,06	0,12	116,52	0,9	140625
	13	8,34	-	-	6,28	1,02	0,06	0,22	115,14	0,9	140625
BP-01-6	0	8,36	-	-	1,23	0,60	0,08	0,12	78,40	0,9	142857
	14	8,35	-	-	1,65	0,70	0,08	0,12	72,88	0,9	142857
BP-01-8	0	8,32	-	-	2,39	1,44	0,12	0,20	66,45	0,9	138461
	27	8,26	-	-	2,07	1,44	0,10	0,18	63,70	0,9	138461
BP-01-9	0	8,24	-	-	1,44	1,34	0,10	0,14	124,33	0,9	120000
	7,5	8,00	-	-	1,55	1,44	0,10	0,14	133,14	0,9	113924
BP-01-11	0	8,14	-	-	3,75	1,55	0,22	0,24	124,33	0,9	116883
	7	8,10	-	-	3,65	1,76	0,30	0,76	99,34	0,9	18000
	7,0	8,40	-	-	-	-	-	-	-	1,6	1970
	8,3	7,53	-	-	-	-	0,34	0,60	80,23	1,5	915
BP-01-14	0	8,13	10,25	97,2	1,76	1,55	0,12	0,16	76,56	0,9	113924
	18	8,27	9,96	95,4	2,28	1,65	0,12	0,16	94,20	0,9	95745
BP-01-16	0	8,24	10,14	97,6	1,23	0,65	0,06	0,12	93,09	0,9	136364
	27,3	8,24	10,02	95,1	1,44	0,49	0,06	0,08	95,30	0,9	136364
BP-01-19	0	8,20	11,25	99,8	1,55	0,70	-	-	43,49	1,0	1639
	5	8,13	11,74	90,2	1,44	0,70	-	-	20,71	2,2	783
	23	8,03	9,53	68,7	1,55	1,34	-	-	26,59	2,4	750
BP-01-23	0	8,28	11,14	101,3	2,18	1,34	0,30	0,34	77,00	0,9	1875
	5	8,18	11,56	99,8	1,97	1,12	0,30	0,34	34,67	1,2	1026
	8	8,08	11,06	83,0	2,39	1,55	0,38	0,76	25,26	2,1	727
	18	8,16	9,73	68,5	3,75	1,55	0,32	0,64	32,32	2,2	669
BP-01-26	0	8,33	17,75	110,1	0,91	0,70	-	-	25,58	1,2	976
	5,5	8,31	12,70	102,3	0,6	0,44	-	-	18,23	1,4	782
	29	8,23	11,07	80,1	1,76	1,60	-	-	27,87	2,2	663
BP-01-28	0	8,43	13,36	102,5	0,6	0,39	0,28	0,32	9,73	1,8	796
	17	8,38	12,99	89,1	0,91	0,70	0,30	0,40	7,66	2,2	724
	50	8,39	11,96	82,5	1,34	1,12	0,40	0,62	13,63	2,3	689
BP-01-30	0	8,48	14,80	104,3	0,39	0,28	0,28	0,32	5,83	2,0	733
	12	8,60	15,61	105,7	1,12	0,07	0,28	0,32	2,38	2,2	726
	46	8,40	12,33	84,0	1,55	1,23	0,32	0,62	12,26	2,4	710
BP-01-31	0	8,49	13,67	109,5	0,55	0	-	-	2,15	2,2	756
	15	8,58	14,19	105,3	0,65	0,02	-	-	2,15	2,2	728
	92	8,38	9,50	103,1	1,55	0,70	-	-	8,58	2,3	680
BP-01-34	0	8,46	14,12	101,5	0,07	0	0,04	0,10	4,91	2,1	722
	19	8,54	14,68	102,3	0,07	0,02	0,04	0,30	2,15	2,2	698
	90	8,45	13,47	90,6	0,7	0,60	0,04	0,48	4,45	2,4	706

BP-01-35	0	8,53	13,43	101,6	0,18	0,13	0,12	0,32	5,37	2,1	739
	17	8,67	14,92	103,0	0,18	0	0,12	0,32	3,07	2,2	694
	150	8,50	13,61	92,5	0,91	0,65	0,28	0,52	7,20	2,4	700
BP-01-38	0	8,52	13,36	100,2	0.07	0	0,04	0,08	2,15	2,3	796
	14	8,51	13,36	100,6	0,07	0	0,04	0,08	3,99	2,3	774
	100	8,36	13,31	89,0	0,49	0,28	0,04	0,42	6,28	2,4	704
BP-01-41	0	8,46	13,08	101,8	0,18	0,13	0,04	0,14	5,60	1,9	812
	10	8,50	13,95	100,5	0,34	0,02	0,04	0,14	4,22	2,0	760
	35	8,34	11,45	80,1	0,7	0,55	0,04	0,28	6,74	2,4	714
BP-01-43	0	8,40	12,64	100,1	0,23	0,07	0,04	0,08	7,89	1,6	780
	10	8,44	13,18	102,4	0,18	0,07	0,04	0,08	5,83	1,8	735
	40	8,34	11,84	83,0	0,7	0,60	0.04	0,34	10,65	2,4	719
BP-01-45	0	8,46	13,20	100,9	0	0	0,08	0,14	6,28	2,2	766
	18	8,47	13,93	101,3	0,13	0,07	0,12	0,16	3,53	2,3	747
	80	8,36	11,32	80,0	0,34	0,28	0,16	0,36	9,04	2,4	710
BP-01-46	0	8,49	12,92	100,2	0,13	0	0,04	0,12	19,83	1,9	748
	20	8,52	16,42	116,0	0,07	0	0,04	0,14	3,07	2.3	674
	290	8,43	12,11	86,7	0,7	0,60	0,08	0,64	9,96	2,4	692
BP-01-48	0	8,56	12,85	99,8	0,28	0,13	0,16	0,20	15,47	2,1	805
	15	8,64	13,37	98,7	0	0	0,04	0,08	2,61	2,1	656
	187	8,50	12,57	86,7	0,49	0,39	0,16	0,40	12,72	2,4	696
BP-01-56	0	8,45	12,41	99,8	0,13	0	0,04	0,16	32,01	1,8	837
	16	8,59	13,74	99,5	0,02	0	0,04	0,20	3,99	2,1	652
	170	8,53	12,88	90,1	0,23	0,13	0,04	0,28	8,58	2,4	698
BP-01-58	0	8,44	-	-	0,13	0,02	0,04	0,12	21,44	1,9	785
	20	8,54	-	-	0,18	0	0,04	0,10	10,42	2,2	766
	85	8,38	-	-	0,49	0,39	0,04	0,30	16,62	2,4	710
BP-01-59	0	8,40	12,83	100,1	0,18	0	0,04	0,08	27,87	1,8	822
	16	8,56	15,81	103,1	0,07	0	0,04	0,12	9,04	2,2	721
	165	8,43	-		0,6	0,49	0,08	0,36	12,72	2,4	702
BP-01-61	0	8,44	12,54	100,1	0,28	0,18	0,04	0,12	32,92	1,6	856
	20	8,46	13,55	99,8	0,07	0	0,04	0,12	10,42	2,3	813
	100	8,45	12,54	90,0	0,39	0,23	0,08	0,40	8,12	2,4	706
BP-01-62	0	8,36	12,89	100,5	-	-	0	0,04	23,28	1,8	779
	12	8,49	14,58	101,8	-	-	0	0,12	11,34	2,2	756
	120	8,42	12,16	83,2	-	-	0,40	0,40	9,50	2,4	706
BP-01-64	0	8,38	12,28	109,0	0,13	0,07	0,04	0,14	51,57	1,6	1039
	10	8,44	13,18	101,6	0,07	0	0,04	0,14	17,31	2,0	766
	23	8,37	13,67	99,7	0,07	0	0,04	0,12	3,99	2 2	751
	95	8,40	11,95	84,2	0,39	0,28	0,04	0,16	15,01	2,4	706
BP-01-65	0	8,36	-	-	0,07	0	0,04	0,16	35,22	1,8	937
	8	8,38	-	-	0,13	0	0,04	0,12	9,96	2,0	746
	50	8,40	-	-	0,39	0.07	0,08	0,32	9,96	2,1	631
BP-01-66	0	7,95	11,97	99,9	0,07	0,02	0,04	0,12	50,84	1,3	1000
	10	8,36	12,34	101,1	0	0	0,04	0,12	11,57	2,0	743
	45	8,25	10,26	84,2	0,49	0,28	0,08	0,32	25,12	2,4	721
BP-01-67	0	8,18	11,36	100,4	0,39	0	0,04	0,16	80,69	1,4	1261
	6	8,38	12,03	98,4	0,07	0	0,04	0,16	20,71	1,9	757
	40	8,40	9,79	76,6	0,18	0,02	0,04	0,32	20,98	2,0	633

BP-01-68	0	8,19	11,67	100,2	0,28	0,02	0,04	0,18	64,62	1,4	1414
	6	8,31	11,38	97,0	0,18	0,02	0,04	0,18	38,90	1,8	786
	20	8,40	9,16	66,6	0,6	0,39	0,04	0,32	17,31	2,3	742
BP-01-70	0	7,77	10,75	94,0	0,76	0,65	0,04	0,08	33,38	0,7	10000
	7	7,82	10,14	83,6	1,12	0,86	0,04	0,12	50,84	1,4	1061
	15	7,75	8,19	58,6	0,7	0,60	0,08	0,20	54,51	2,0	654
BP-01-72	0	7,67	10,27	94,0	2,7	1,65	0,04	0,16	18,23	0,6	153846
	20	8,04	10,12	94,0	2,91	1,34	0,04	0,16	37,06	0,7	179487
BP-01-73	0	7,93	9,88	92,8	2,07	1,34	0,08	0,22	64,62	0,8	160000
	9	8,08	9,88	93,0	2,81	1,23	0,08	0,34	61,86	0,8	170213
BP-01-73/3	0	7,87	9,92	-	-	-	-	-	-	1,0	-
BP-01-74	0	7,42	10,56	-	2,7	1,12	0,08	0,48	12,26	0,8	-
BP-01-75	0	7,33	10,61	-	1,97	1,12	0,08	0,24	10,19	0,3	-
BP-01-76	0	6,84	10,55	-	1,76	1,02	0,08	0,22	4,91	0,2	-
BP-01-77	0	7,09	10,34		2,07	0,91	0,08	0,22	7,20	0,2	-
BP-01-78	0	7,65	10,11	-	3,65	2,07	0,04	0,22	98,6	0,1	-
BP-01-79	0	7,80	9,83	-	3,86	1,97	0,32	0,40	68,29	0,1	-
BP-01-80	0	7,75	11,14	98,4	1,34	1,02	0,10	0,20	33,84	0,9	12857
	7	7,29	8,00	69,1	1,76	0,81	0,16	0,36	62,78	1,4	1085
	10	7,58	8,00	69,2	3,12	0,91	0,20	0,30	72,42	2,0	889
BP-01-82	0	7,74	11,92	104,2	0,81	0,02	0,20	0,28	66,91	1,4	1429
	7	7,59	8,73	76,7	1,44	0,39	0,24	0,32	64,16	1,9	798
	20	7,72	7,97	65,5	1,65	0,91	0,20	0,34	37,98	2,3	735

*P total was determined in the unfiltered seawater after boiling.

Table 8-5: Dissolved hydrocarbon gases in the Kara Sea, Ob and Yenisei estuaries (14 August-11 September 2001, 36 Cruise R/V "Akademik Boris Petrov").

Station,	Sampling depth,	Concentration, µg/ L		
_	m	CH_4	C_2-C_5	C_4+C_5
BP-01-01	0	0,1	0,2	0,16
	bottom	0,1	0,3	0,2
BP-01-10	0	1,5	2,1	1,9
	pycnocline	0,8	0,6	0,4
	bottom	0,9	2,0	1,9
BP-01-11	bottom	0,8	0,7	0,6
BP-01-14	0	1,7	1,4	1,1
	18	1,8	1,1	0,8
BP-01-19	0	0,5	0,8	0,7
	5	0,6	0,7	0,6
	23	0,4	0,9	0,7
BP-01-23	0	1,0	2,7	2,2
	5	1,0	2,7	2,1
	18	0,8	1,4	1,1
BP-01-26	0	0,8	3,5	2,7
	5,5	0,2	1,7	1,4
	29	0,5	3,4	1,3
	bottom	0,6	2,3	1,8
BP-01-28	0	0,4	2,6	2,0
	17	0,5	1,7	1,2
	50	0,5	2,3	1,7
	bottom	0,4	1,5	1,1
BP-01-30	12	0,2	0,6	0,5
	46	0,5	1,1	0,8
	bottom	0,6	1,5	1,2
BP-01-31	0	0,2	2,7	2,1
	15	0,2	0,5	0,4
	bottom	0,2	0,6	0,4
BP-01-34	0	0,6	2,7	2,1
	19	0,6	3,1	2,6
	90	0,4	1,5	1,1
	bottom	0,8	2,0	1,4
BP-01-35	0	0,3	1,2	0,9
	17	0,5	1,2	0,9
	bottom	0,7	3,1	2,2
BP-01-38	0	0,3	1,4	1,1
	14	0,8	5,4	4,2
	100	1,0	5,5	4,2
BP-01-43	0	0,8	4,1	3,3
	10	0,5	2,3	2,0
	40	0,7	1,6	1,3
	bottom	0,7	2,0	1,5

BP-01-46	0	0,3	1,8	1,4
	20	0,2	0,6	0,5
	290	0,1	1,2	1,0
	bottom	0,4	4,1	3,8
BP-01-48	0	0,5	1,5	1,2
	15	0,5	1,6	1,3
	187	0,4	1,6	1,3
BP-01-56	0	0,4	0,6	0,4
	16	0,1	0,8	0,6
	95	0,5	1,4	1,1
	bottom	0,3	1,3	1,0
BP-01-59	0	0,7	1,5	1,2
	16	0,6	2,0	1,6
	bottom	0,5	1,4	1,1
BP-01-61	0	0,7	1,6	1,3
	20	0,8	1,8	1,3
	100	0,8	2,2	1,8
BP-01-62	0	0,3	1,9	1,6
	12	0,5	1,3	1,0
	120	0,4	1,7	1,4
	bottom	0,2	0,9	0,7
BP-01-64	0	0,4	2,8	2,2
	10	0,3	3,4	3,0
	23	1,1	2,2	1,7
	40	0,4	2,1	1,7
	95	0,4	1,4	1,1
	bottom	0,2	0,8	0,7
BP-01-65	0	0,6	2,3	1,8
BP-01-66	0	0,3	1,1	0,8
	10	0,5	1,9	1,5
	45	0,5	1,4	1,0
	bottom	0,3	1,1	0,8
BP-01-67	6	0,5	1,5	1,1
	40	0,9	2,9	2,5
BP-01-68	0	0,4	1,9	1,5
	6	0,3	1,0	0,8
	45	0,4	0,8	0,7
BP-01-70	0	0,3	0,8	0,7
	7	1,4	2,8	2,2
	15	1,3	2,6	2,0
	bottom	1,0	1,9	1,5
BP-01-73	9	2,6	2,8	2,2
	bottom	6,6	2,2	1,6
BP-01-74	0	1,0	1,3	1,0
BP-01-75	0	3,2	2,5	2,0
BP-01-76	0	2,6	2,8	2,2
BP-01-77	0	2,7	3,1	2,2
BP-01-78	0	2,0	3,6	2,8
BP-01-79	0	1,7	1,9	1,5

BP-01-80	0	0,4	1,0	0,8
	7	1,0	0,7	0,6
	bottom	2,4	0,6	0,5
BP-01-82	0	0,5	0,8	0,5
	7	0,7	1,0	0,7
	20	0,7	0,6	0,4

Table 8-6: Comparison of hydrochemistry parameters for surface water samples from the Ob estuary taken in September 2001 (BP-01 cruise) and in October 2002 (BP-02 cruise)

Station	Location	T^{0}C	S, psu	pH	O_2 mg/L	TAlk. mM	$P\text{-}PO_4^{3-}$ µM
BP-01-78	68^{0}40'05"N; 73^{0}59'45"E	-	0,0	7,65	10,11	0,1	2,07
BP-02-07	68^{0}39'57"N; 73^{0}59'37"E	2,6	0,0	7,86	13,25	1,0	2,96
BP-01-73	68^{0}54'53"N; 73^{0}40'02"E	11,1	0,0	7,93	9,88	0,8	1,34
BP-02-06	68^{0}54'53"N; 73^{0}39'59"E	0,8	0,0	7,65	13,34	0,8	1,00
BP-01-74	68^{0}58'48"N; 74^{0}22'55"E	-	0,0	7,42	10,56	0,8	1,12
BP-02-08	68^{0}58'04"N; 74^{0}21'55"E	2,5	0,0	7,60	13,29	0,8	2,46
BP-01-72	70^{0}49'51"N; 73^{0}44'19"E	11,5	0,0	7,67	10,27	0,6	1,65
BP-02-05	70^{0}49'50"N; 73^{0}43'57"E	3,1	0,0	7,71	12,91	0,8	2,46
BP-01-70	72^{0}40'06"N; 74^{0}00'06"E	9,2	0,88	7,77	10,75	0,7	0,65
BP-02-12	72^{0}40'22"N; 73^{0}59'45"E	0,4	8,2	7,77	13,87	1,0	1,42
BP-01-61	76^{0}12'56"N; 75^{0}52'57"E	5,7	18,6	8,44	12,54	1,6	0,18
BP-02-01	76^{0}13'03"N; 75^{0}43'57"E	-1,25	26,4	8,20	14,94	2,2.	0,20

8.3. Study of anthropogenic pollution in the Kara Sea and adjacent estuaries of Yenisei and Ob in 2002

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Introduction

In the youngest past pollution of the Arctic region gained great attention in the strategy of Arctic environment protection accepted by Arctic states (Russia, USA, Canada, Norway, Denmark, Iceland, Finland, Sweden). Reasons are the opening of the Northern way for international navigation, the beginning of exploitation of petroleum deposits together with foreign companies, both, on land and in the Arctic shelves, the demilitarization and conversion of the military-industrial complex, and the increased interest of the world public to the problems of living safeness of the small native Arctic population.

The data on radioecological studies of the Russian part of the Arctic Ocean including Ob and Yenisei estuaries and rivers and the adjacent Kara Sea from 2002 are presented (Fig. 8-11). The program of investigations included the study of horizontal and vertical distribution of Cs-, Sr-, Pu-radionuclides in water and bottom sediments taking into account natural parameters of oceanography. With radiochemical analysis of water and bottom samples, taken at 14 stations, it has been shown that the consideration of natural parameters and geochemical behavior of radionuclides helps to explain fluctuations in their horizontal and vertical distribution. The vertical distribution of the radionuclides in sediment cores allows to reveal the potential radioactivity sources and to determine the time of deposition of the material in the Arctic Ocean.

Working Program

The main tasks of ecological research performed by GEOKHI in the Ob and Yenisei estuaries and the adjacent part of the Kara Sea were to study the horizontal and vertical distribution of the anthropogenic (artificial radionuclides - cesium, strontium and plutonium, heavy metals and petroleum) impurities in water and sediments. In this expedition we have continued our previous investigations to estimate the influence of natural environmental parameters, which are responsible for the distribution and migration of these pollutants in the working area.

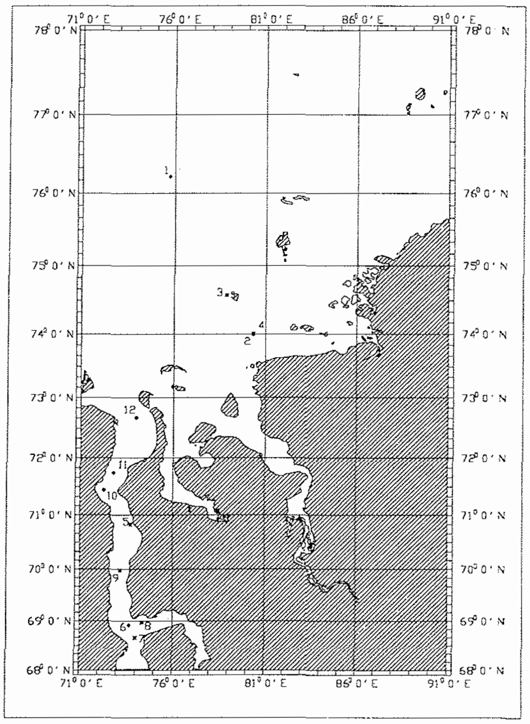


Figure 8-11: The station map of the expedition 2002 with RV "Akademik Boris Petrov".

Sampling and Analytical Methods for radionuclides

Sediments were sampled with a box corer (50x50x60 cm), with subsequent subsampling with a plastic tube having an inner diameter of 10 cm. The cores were cut in 2 cm slices, and samples were dried at a temperature of 60 - 80°C. Water was sampled with a large volume sampler (200 l Batomat) or taken by a pump through a plastic tube system, and filled in storage tanks. Before analysis the samples were filtered through a cartridge filter to remove suspended matter >0.45 μm.

For the analysis of ^{137}Cs in sediments we used direct γ-measurements without decomposition of the sample. ^{137}Cs was determined in water samples of 200 l volume using the sorption method under dynamic conditions with subsequent γ-spectrometer measurements on concentrates.

The determination of ^{90}Sr in the water samples included precipitation of strontium carbonate, which then was finally precipitated as strontium oxalatum.

For the analysis of plutonium in water samples Pu was precipitated with iron hydroxide with subsequent radiochemical cleaning and adsorption of Pu on LaF_3. To analyze Pu concentrations in sediment cores Pu was extracted by boiling of the sediment sample in 7M HNO_3 with $KBrO_3$. Afterwards the sample was treated like the water samples for Pu analysis.

Preliminary Results of radionuclides

The ^{137}Cs-data from the top layer (0-2cm) of the sediments from all stations of the Expedition BP02 are presented in Table 8-7. The distribution pattern of ^{137}Cs in the upper (0-2 cm) sediment layer is irregular (Table 8-7).

Table 8-7: Results of determination of radionuclides in samples of surface sediments from the 38th cruise of RV "Akademik Boris Petrov" [Bq/kg].

Station	Activity of ^{137}Cs Bq/_g (_=0.95)	Latitude ^{0}N	Longitude ^{0}E
BP02-01	6,2±1,3	76^{0}13.08	75^{0}43.97
BP02-02	13,0±2,0	74^{0}00.07	80^{0}19.87
BP02-05	4,4±0,6	70^{0}49.4	73^{0}43.7
BP02-06	13,0±3,0	68^{0}54.89	73^{0}39.99
BP02-07	9,1±2,0	68^{0}40.7	73^{0}59.74
BP02-08	9,3±2,0	68^{0}58.08	74^{0}22.03
BP02-09	8,4±2,0	69^{0}58.7	73^{0}11.3
BP02-13	7,6±1,0	72^{0}31.42	55^{0}30.4
BP02-14	15,0±3,0	72^{0}33.07	55^{0}28.95

We analyzed same samples of surface sediments for ^{239,240}Pu (Tab. 8-8).

Table 8-8: Content of ^{239,240}Pu [Bq/kg] in the surface sediments (0-2cm).

Station	^{239,240}Pu [Bq/kg]
BP02-01	0,35
BP02-02	0,29
BP02-04	0,37

The results of 2002 confirm our previous conclusion about the significance of the surface sediments lithology for the radioactivity level of ^{137}Cs. Granulometric analysis of sediments has allowed to receive direct relation between a specific activity of ^{137}Cs of sediments and the percentage of clay fraction in studied samples (Tab. 8-9, Fig.8-12).

Table 8-9: Results of fraction composition (mm) and activity of ^{137}Cs in surface sediments (0-2cm).

Station	Fraction composition (mm), %				Activity Cs-137 Bq/kg
	0.05-0.01	0.01-0.005	**0.005-0.001**	<0.001	
BP00-04	9.5	9.3	**10.9**	14,1	**5,4±0,8**
BP00-07	3.0	5.5	**18.9**	16,3	**16,0±2,4**
BP00-15	29.9	13.9	**21.3**	28,0	**28,0±4,2**
BP00-17	3.0	36.1	**9.6**	14,3	**12,0±1,8**
BP00-22	2.7	14.1	**39.4**	27,2	**40,0±6,0**
BP00-23	5.2	21.4	**21.2**	36,4	**21,7±3,3**
BP00-29	0.9	10.7	**11.7**	19,4	**6,0±0,9**
BP00-35	0.5	15.7	**28.0**	53,0	**13,8±2,1**

In this report we present the results of our previous investigations of sediments, which we have sampled in the expedition of 2000 with RV "Akademik Boris Petrov".

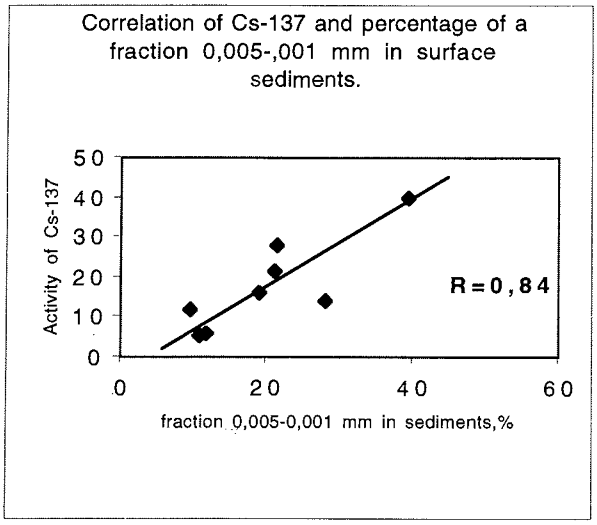


Figure 8-12: The distribution of ^{137}Cs and clay fraction [%] in surface sediments of the Kara Sea and Ob and Yenisei estuaries.

Considering the results of activity of radiocesium in surface sediments obtained in 1995 and 2001-2002 (Fig. 8-13), it is confirmed that a considerable decrease of general radioactivity took place due variations of sedimentation processes and supply of suspended matter with clean fluvial waters of the Ob and Yenisei rivers.

By comparison of the data from the expedition in 2002 with results of former expeditions, it is possible to conclude that significant changes of specific activities of man-made and natural radionuclides were absent during the last several years. It testifies that the conducted drillings in the Ob Bay didn't influence the ecological conditions in the working area until 2002.

In the Ob and Yenisei estuaries and the adjacent Kara Sea the sedimentation processes are controlled by conditions of predominant sedimentation, high hydrodynamic activity, partial fluid wash of ancient deposits, transportation and accumulation of matter. It means, that there is a number of hampering factors, such as bioturbation, influencing of underwater currents, transformation of a fluvial current in different seasons etc. In order to reconstruct sedimentation processes the origin of trends on distribution curves vs. sediment depths may disappear, and the real picture of sedimentation processes may be distorted during separate local time periods.

The study of vertical distribution of artificial radionuclides (first of all of cesium-137) has shown, that several samples have significant variations of specific concentrations of this radionuclide along core depth. The comparison of the received data with geological description of the vertical structure of sediments show that the significant variations are not related to the structural heterogeneity in the vertical section, but more likely are connected with various rates of radioactivity entering into the marine environment. It allows to estimate of sedimentation rate of the modern sediments and to identify the periods of massive inflow of radioactivity into the Kara Sea and to determine sources of such inflow.

In Figure 8-14, 8-15, and 8-16 the profiles of distribution of cesium-137 vs. core depth of selected sites in the Ob Bay of the expedition in 2002 and in Figure 8-17 the cesium-137 vertical distribution of a selected site of the expedition in 2001 are presented. These data show that the sedimentation rate amounts to 0.3-0.35 cm/year in the Ob Bay and fit well to earlier data (Stepanets et al. 2001).

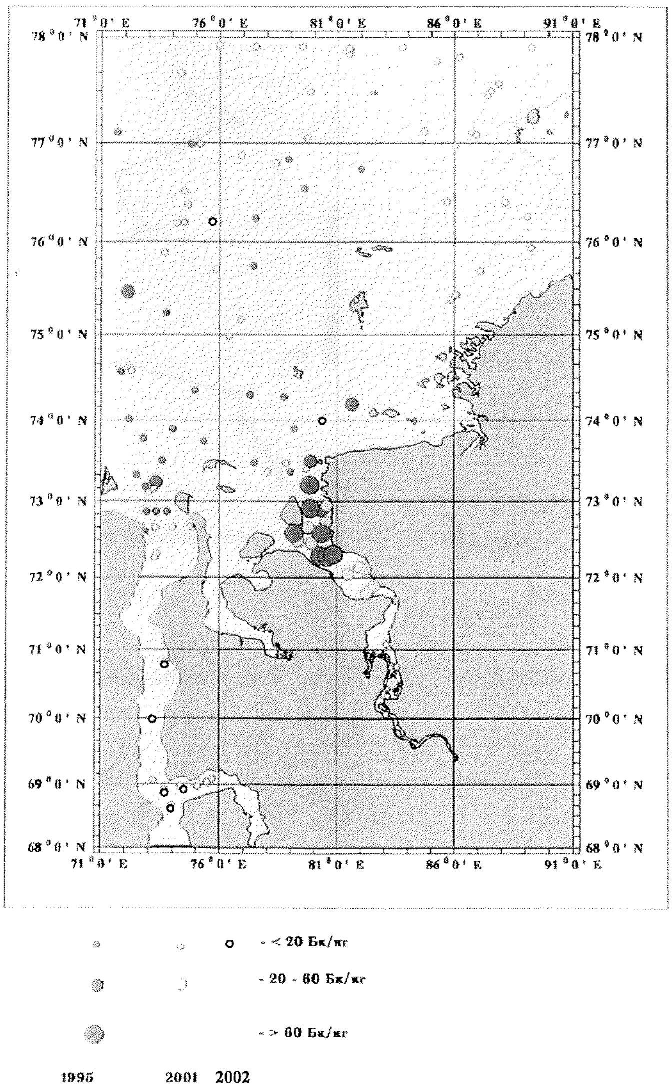


Figure 8-13: Comparison of ^{137}Cs-radioactivity in the upper layer (0-2 cm) of sediments (obtained from expeditions 1995 and 2001-2002).

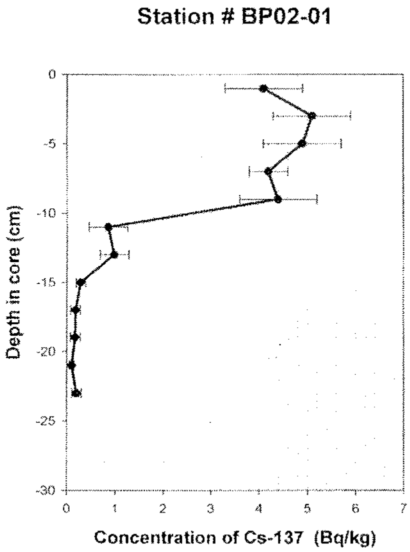


Fig. 8-14

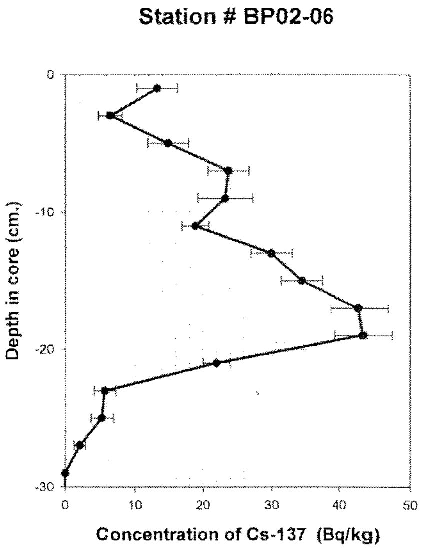


Fig. 8-15

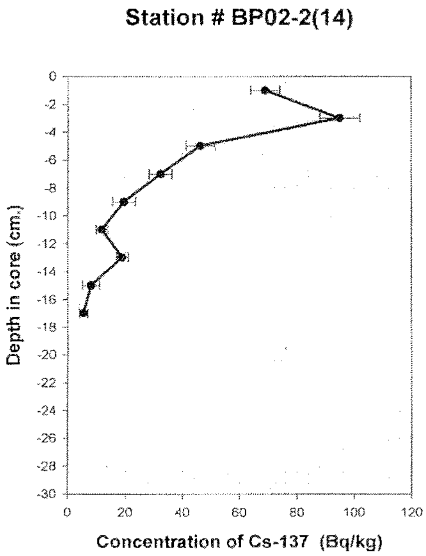


Fig. 8-16

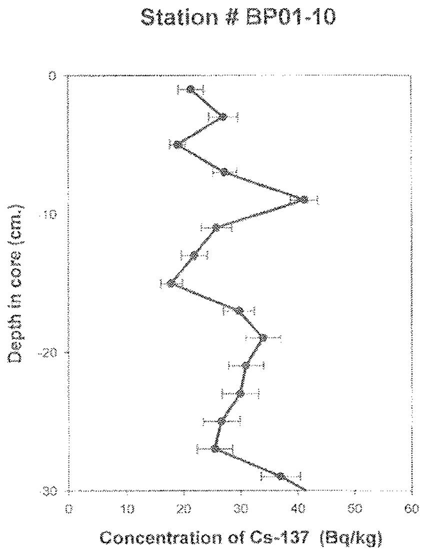


Fig. 8-17

Figure 8-14 - 8-17: Concentrations of Cs-137 vs. depths of four short sediment cores, obtained during the expeditions 2001 and 2002 into the Kara Sea and the estuaries of Ob and Yenisei.

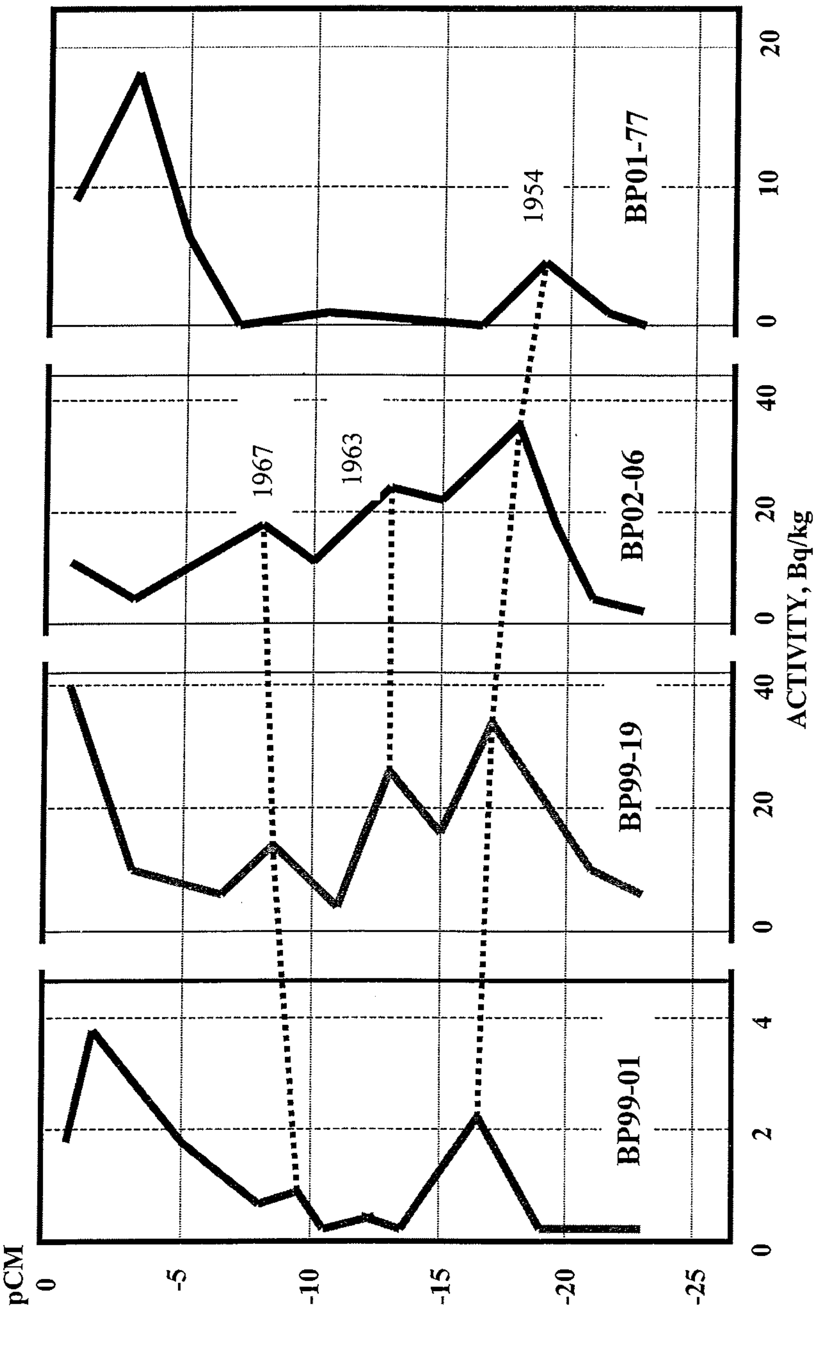


Figure 8-18: Cesium-137 activity in sediment cores of a transect from the Ob River to the Kara Sea.

Profiles of distribution of cesium-137 in sediment cores record its deposition in time. It is possible to estimate temporary dates. The first appearances of cesium-137 in sediments were fixed basically in 1954, when the concentration of cesium-137 has achieved a level, sufficient for its registration. Thus, the deepest significant concentration maximum of cesium-137 in a core can be attributed to 1954. In some cases, if two maxima of cesium-137 are visible without decreased values at the end of the core, the second maximum concentration can be interpreted by the term "approximately 1963". With the depth of the maxima and the assumption that the radionuclides were deposited right after entering the sea it is possible to evaluate the sedimentation rate of modern sediments within approximately 50 years, i.e. from time of a start of nuclear testing and to attribute the registered intermediate pikes to definite time intervals.

In this case it is possible to date the maximum at the horizon of 8–9 cm of sediment cores from the Ob Bay (Fig. 8-18). It is corresponding to the year 1967, when there was one of the largest accidents on the plant "Mayak".

Investigations on hydrocarbons

In the last years the Kara Sea was often esteemed as region of potential minings of oil and gas and, simultaneously, as possible routes concerning cheap pipeline and tanker haul of hydrocarbon.

Dissolved organic matter is one of the main components in group of high-toxic matters, which can lead to large influence on an ecological condition of marine ecosystems. Organic matter enters water mainly with wastes of industrial firms on effecting synthetic surface-active agents. The danger of petroleum for a water ecosystem consists first of all of their adsorption on a surface of cages of microorganisms of the lowest trophic level, that has an effect on the characteristics of an ecosystem and parameters of a self-cleaning of a water environment.

Determination of petroleum in samples of bottom sediments

The sample is dried at room temperature and minced in a porcelain casserole. After sieving through the screen of 1 mm, the sample (0.2 g) is placed in a conical flask on 100 mm^3. 10 ml of chloroform are added and shaken for 15 min. The mixture is filtered and rinsed twice with 5 cm^3 of chloroform. The filtrate is placed in a sleeve on 100 cm^3 and dried in an air flow. The dried filtrate is solved in 5 cm^3 of hexane. The obtained solution runs through a chromatographic column of 2 g Al_2O_3, and a flush of 10 cm^3 of hexane. The eluate is collect in a measuring graduate, its volume is recorded and concentration of petroleum on an analyzer of a liquid "Fluorat-02-3A" measured. The error of determination amounts to 60 %. (at P= 0.95).

Preliminary results on hydrocarbons

The analysis of the obtained samples after ending of drillings in the Tas Bay has shown absence of significant variations in distribution of petroleum, testifying the absence of influencing from the drillings on ecological conditions in the investigated area (Tab. 8-10 and 8-11).

Table 8-10: Results of petroleum concentrations in surface sediments sampled in Tas Bay (BP-01).

No samples	mg/g
1	0,008
2	0,012
3	0,011
4	0,009
5	0,010
6	0,006
7	0,009
8	0,005
9	0,013
10	0,007
11	0,008
12	0,012
13	0,009

Table 8-11: Results of petroleum concentrations in surface sediments sampled in Tas Bay (BP-02).

Number of samples	mg/g
1	0,013
2	0,010
3	0,008
4	0,008
5	0,010
6	0,005
7	0,009
8	0,004
9	0,014
10	0,006

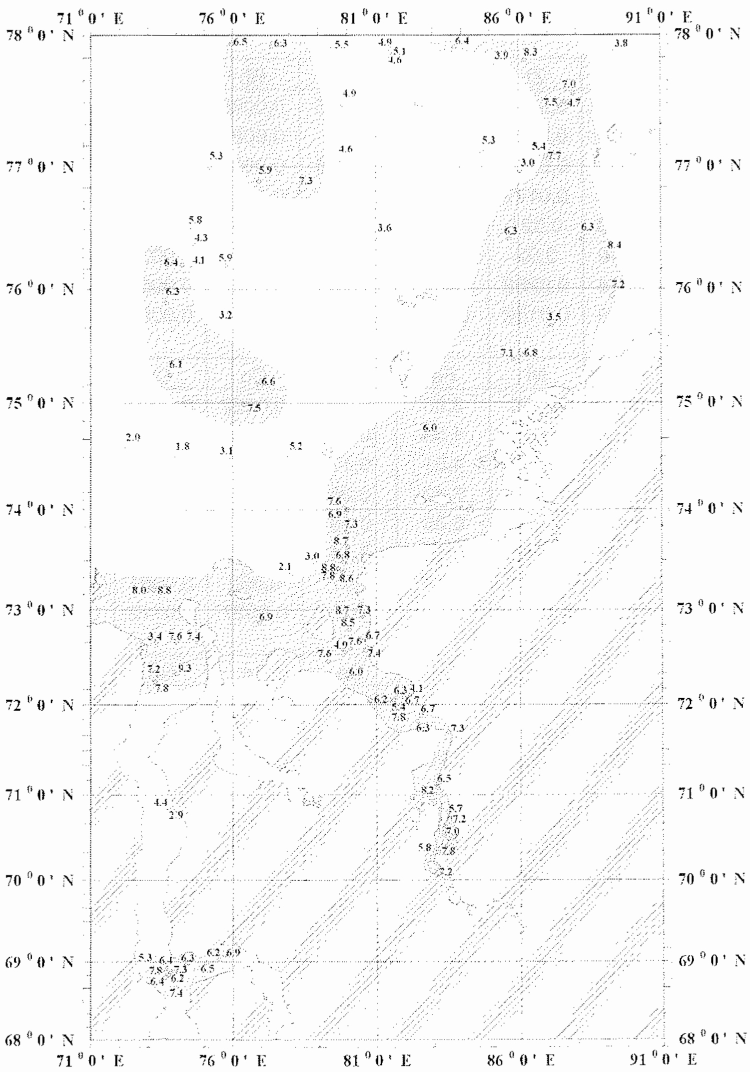
Investigations on heavy elements

The contents of heavy elements were determined by a X-Ray-fluorescence method using a X-ray spectrometer, which allows to determine chemical elements from Ti up to Sr on a L-line and from Ba up to U on a L-line on fluorescence radiation. The power sanction in a central part of a spectrum (~ 30 eV) allows to ensure high sensitivity of the analysis with minimum errors of measurements. The determination of elemental contents is carried out by using external standards.

The results of content of the standard element (iron) in the bottom sediments are shown in Figure 8-19 and Table 8-12. Two geochemical types of sediments with different contents of iron can be distinguished.

The regional distribution of the two sediment groups in the investigated area of the Ob and Yenisei estuaries on data of the expeditions 1999 - 2002 is shown in Figure 8-19. A well-defined zonation is observed: The inner zone presented mainly by sediments with high contents of iron (> 6,1%) is replaced northwestward by sediments with low contents of iron (< 6,1%). The observed zonation corresponds to the distribution of river waters and shows peculiarities of spreading river water into the Kara Sea.

Thus, the preliminary results show a significant difference of the iron content in the sediment of estuaries of Ob and Yenisei, that can be explained by various geochemical types of bottom sediments. The X-ray-fluorescence analysis of samples using ratios of various elements to a "reference" element will allow to evaluate the influence of the geological nature of the rivers in more detail. The extension of the mixing zone can be recognized as well as the possible contribution of each river to the distribution of heavy elements in the marine area.



- <6 % - >6 %

Figure 8-19: The spreading zones of rivers run-off to the Kara Sea on the data selection of the several types of sediments (Fe).

Table 8-12: Results of determination of heavy metals in samples of bottom sediments.

Station BP02-	Nb	Zr	Y	Sr	Rb	Th	Pb	As	Zn
1	0,0016	0,0126	0,0027	0,0225	0,0088	0,0064	0,0007	0,0009	0,0118
2	0,0017	0,0123	0,0035	0,021	0,0085	0,0021	0,0017	0,0008	0,0087
5	0,0014	0,0206	0,003	0,0188	0,0068	0,0093	0,0005	0,0022	0,0071
6	0,0014	0,0172	0,0028	0,0153	0,0078	0,0014	0,001	0,0022	0,009
7	0,0013	0,021	0,0031	0,0159	0,0092	0,002	0,0025	0,0013	0,0051
8	0,0012	0,02	0,0035	0,0184	0,0079	0,0036	0,0026	0,0018	0,0066
9	0,0014	0,0262	0,0027	0,0241	0,0086	0,0051	0,0011	0,0027	0,0076
12	0,0019	0,0152	0,003	0,0207	0,0091	0,0027	0,0011	0,0014	0,0069

Station BP02-	Cu	Ni	Fe	Mn	Co	Cr	V	Ce	La
1	0,0014	0,005	3,85	0,76	0,0022	0,0097	0,0143	0,0052	0,0051
2	0,0015	0,006	4,53	0,11	0,0026	0,011	0,0167	0,0037	0,0022
5	0,0011	0,0047	4,51	0,17	0,0024	0,0071	0,0093	0,0052	0,0038
6	0,0049	0,0064	7,42	0,36	0,0013	0,0116	0,0153	0,006	0,0044
7	0,0067	0,0068	6,39	0,19	0,0027	0,0131	0,0126	0,0043	0,003
8	0,0032	0,0046	5,58	0,14	0,0022	0,0104	0,0116	0,0055	0,0032
9	0,0039	0,0045	4,84	0,17	0,002	0,0081	0,011	0,0054	0,0035
12	0,0043	0,0074	5,76	0,1	0,0027	0,0112	0,0148	0,0056	0,0039

Station BP02-	Ti	Ba	Ca	Ga	Se	Nd	Bi	U	
1	0,44	0,059	0,65	0,0013	0,003	0,0055	0,0011	0,0002	
2	0,47	0,044	1,1	0,0013	0,0035	0,0062	0,0007	0,0002	
5	0,36	0,061	0,76	0,0014	0,0027	0,0045	n.d.	0,0004	
6	0,53	0,075	1,14	0,0013	0,0028	0,0041	0,0004	0,0006	
7	0,53	0,06	0,77	0,0014	0,0047	0,0036	n.d.	0,0001	
8	0,51	0,062	0,63	0,0017	0,0051	0,0048	n.d.	0,0001	
9	0,51	0,073	1,05	0,0016	0,0058	0,0025	n.d.	0,0007	
12	0,51	0,061	0,69	0,001	0,0064	0,0032	0,0019	0,0005	

Conclusions

The accomplished researches may allow receiving a rather objective picture on the ecological condition of the Arctic seas, first of all of Kara Sea and the estuaries of Ob and Yenisei. Taking into account the existent potential sources of pollution, despite of rather low concentrations of radionuclides in this basin, the realization of researches of radioecological conditions in places of the radioactive wastes, in estuaries of the Siberian rivers and in the adjacent Kara sea is obviously important.

The X-ray-fluorescence analysis of samples using ratios of various elements to a "reference" element will allow to evaluate the influence of the geological nature of the rivers in more detail. The extension of the mixing zone can be recognized as well as the possible contribution of each river to the distribution of heavy elements in the marine area.

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10.1 Station list

Abbreviations of activities:

BD - Benthos Dredge
CTD - Conductivity-Temperature-Depth probe for oceanography
Grab - Van-Veen-Grab
LBC - Large Box Corer (GKG)
MUC - Multiple Corer
PHN - Plankton Hand Net (10µm) (AWI, Geo)
PN - Plankton Net (150µm) (AWI, Bio)
Bucket - for surface water samples
Pump - Water pump
RS - Rosette sampler
ST - Sediment Trap

Station	Date	Time [UTC]	Latitude °N	Longitude °E	Water depth [m] uncorr.	Water depth [m]	Gear No.	Activity
BP02-01A	04.10.02	6:00	76°13,08	75°43,97	85,5	90,3		ST-Recovery
BP02-01B	04.10.02	10:00	76°13,08	75°43,97	85,5	90,3		CTD/RS
								BUC/Pump/PN
			76°16,37	75°43,02	85	89,8	/01	LBC
			76°16,37	75°43,02	85	89,8	/02	MUC
			76°16,37	75°43,02	85	89,8	/03	MUC
			76°16,37	75°43,02	85	89,8		BD
BP02-02A	06.10.02	4:30	74°00,07	80°19,87	32,2	37		ST-Recovery
BP02-02B	06.10.02	5:25	73°59,58	80°19,53	32,2	37		CTD/RS/BUC
								Pump/PN
			73°59,28	80°02,80	32,1	36,9	/01	LBC
							/02	MUC
								BD
BP02-03	06.10.02	15:30	74°34,69	78°52,53	32,7	37,5	/01	MUC
								BD
BP02-04	07.10.02	2:00	74°00,06	80°19,90	34,2	39		ST-Deployment
BP02-05	08.10.02	4:23	70°49,84	73°43,70	21,3	26,1		Bucket
							/01	MUC
BP02-06	08.10.02	4:00	68°54,91	73°39,94	10,4	15,2		CTD/RS/BUC
								Pump/PN
							/01	MUC
							/02	MUC
BP02-07	08.10.02	17:00	68°40,07	73°59,74	7,8	12,6		Bucket
							/01	Grab
BP02-08	08.10.02	19:16	68°58,08	74°22,03	7,8	12,6	/01	Grab
BP02-09	09.10.02	2:13	69°58,70	73°11,35	15,4	20,2	/01	Grab
BP02-10	09.10.02	10:15	71°26,81	72°17,13	13,9	18,7		CTD
BP02-11	09.10.02	12:45	71°45,05	72°48,63	15,4	20,2		CTD
BP02-12	09.10.02	18:05	72°40,40	73°59,80	16,6	21,4		CTD/RS/BUC
								Pump/PN
							/01	MUC
							/02	MUC
							/03	Grab
							/04	Grab
							/05	Grab
								BD

10.2

Geological Core Descriptions

R/V "AKADEMIK BORIS PETROV" - 2002

GEOLOGICAL CORE DESCRIPTIONS

Legend

Lithology

- clay
- silty clay
- sandy silty clay
- sandy clay
- silt
- clayey silt
- sandy silt
- sandy silt with gravel
- clayey sand
- sand
- sand with gravel
- clay clasts
- spots and lenses

- sharp boundary
- gradational boundary
- transition zone

Structure

- lamination
- bioturbation
- drop stones
- bivalves and shell debris
- tubes of polychaets
- h hydrotroilite
- plant remains

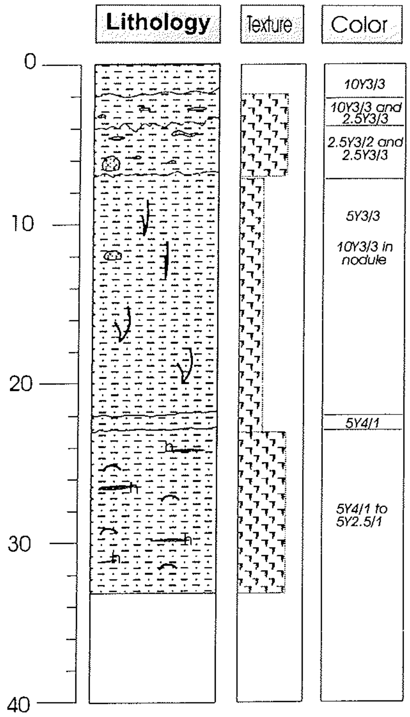
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-01-BC

Southern Kara Sea

76° 13.055' N
75° 43.96' E

Water depth: 90 m
Recovery: 33 cm



Description

0-2 cm: dark brown (10Y3/3) liquid silty clay with some sand and gravel

2-4 cm: dark brown (10Y3/3) and dark olive brown (2.5Y3/3) sandy silty clay with small clayey clasts; very soft; burrows filled by aggregated clay; wavy boundary

4-7 cm: olive brown (2.5Y3/2) and dark olive brown (2.5Y3/3) silty clay with clay clasts; burrows (up to 20 mm in diameter) filled by dark brown (10Y3/3) aggregated clay

7-22 cm: dark olive gray (5Y3/2) silty clay with rare black spots of hydrotroilite; slightly bioturbated; burrows (up to 20 mm in diameter) filled by dark brown (10Y3/3) aggregated clay; thin (<1 mm) tubes of polychaets from 11 to 16 cm and thick (about 2 mm) ones - below 16 cm

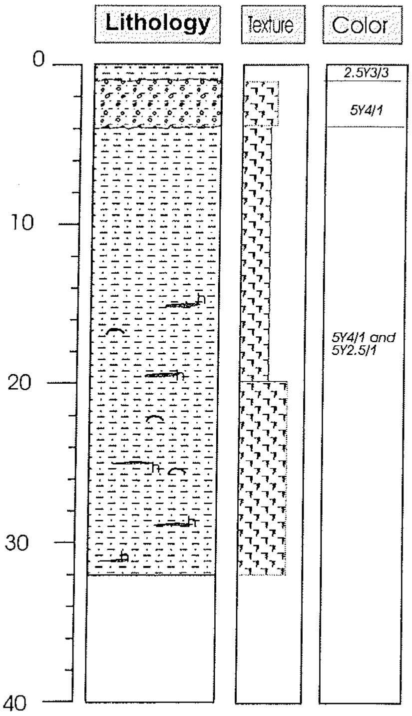
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-02-BC

Southern Kara Sea

73° 59.742' N
80° 18.871' E

Water depth: 39 m
Recovery: 32 cm



Description

0-1 cm: dark olive brown (2.5Y3/3) liquid clay with some silt

1-4 cm: dark gray (5Y4/1) clay with some silt and small clay clasts; very soft; bioturbated

4-32 cm: dark gray (5Y4/1) to black (5Y2.5/1) stiff silty clay with black spots and lenses of hydrotroilite, its content increase below 20 cm; some shell debris; bioturbated

R/V "AKADEMIK BORIS PETROV" - 2002

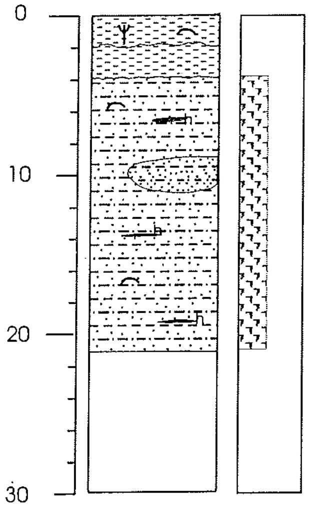
BP02-03-MUC

Southern Kara Sea

74° 34.6' N
78° 52.6' E

Water depth: 33 m
Recovery: 21 cm

Lithology	Texture	Color	Description



Color	Description
2.5Y3/3	0-2 cm: dark olive brown (2.5Y3/3) liquid clay with some amount of bivalves and plant remains
2.5Y3/3	2-4 cm: dark olive brown (2.5Y3/3) clay; very soft
5Y4/1	4-21cm: olive gray (5Y4/2) to dark olive gray (5Y3/2) and black (5Y2.5/1) silty clay to clayey silt with fine sand; black spots; bioturbated; some amount of bivalves; fining downcore
5Y4/1 and 5Y2.5/1	lense of olive gray (5Y4/2) sand with clay clasts and

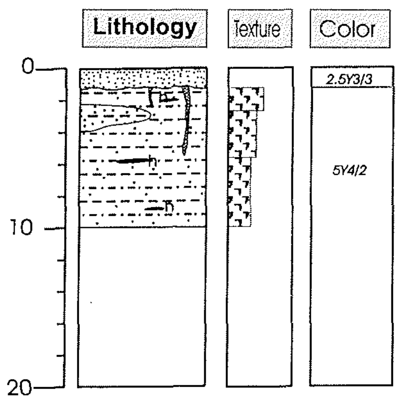
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-05-MUC

Ob Estuary

70° 49.844' N
73° 39.996' E

Water depth: 26 m
Recovery: 10 cm



Description

0-1 cm: dark olive brown (2.5Y3/3) liquid sand with gravel; some amount of silt and clay; polychaets including lithified tubes

1-10 cm: dark olive gray (5Y4/2) silty clay and clayey silt with some fine sand; black spots; the burrows are filled by dark (10Y3/3) clay

lense of dark olive gray (5Y4/2) sandy clay with clay

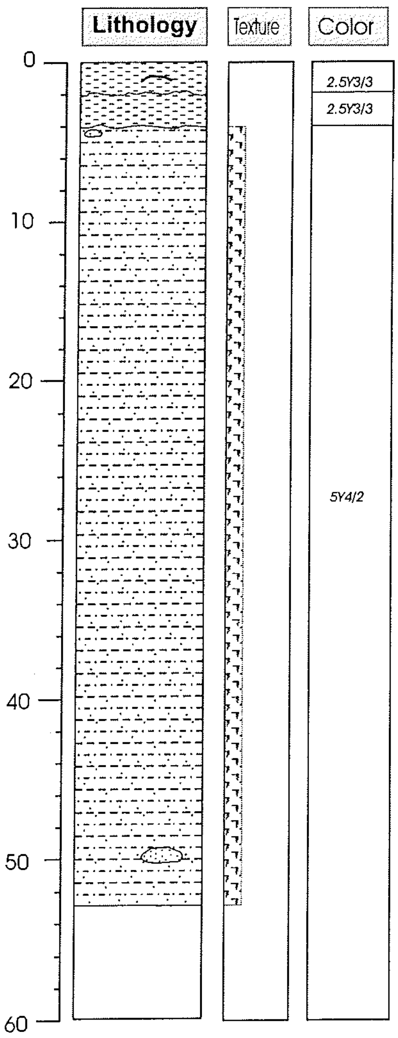
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-06-MUC

Ob Estuary

68° 54.899' N
73° 39.996' E

Water depth: 15 m
Recovery: 53 cm



Description

0-2 cm: dark olive brown (2.5Y3/3) very soft diatomaceous clay; some bivalves

2-4 cm: dark olive brown (2.5Y3/3) soft diatomaceous clay

4-53 cm: dark olive gray (5Y4/2) diatomaceous silty clay and clayey silt with some sand; content of sand and silt are variable; some intervals are enriched in clay clasts and coarse fractions; bioturbated; small

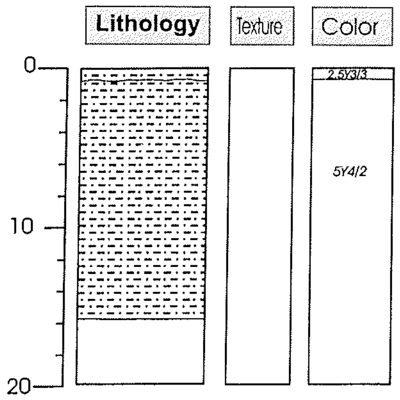
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-07Grab

Ob Estuary

68° 39.96' N
73° 59.622' E

Water depth: 12 m
Recovery: 15 cm



Description

0-0.5 cm: dark olive brown (2.5Y3/3) diatomaceous silty clay

0.5-15 cm: dark olive gray (5Y4/2) diatomaceous silty clay

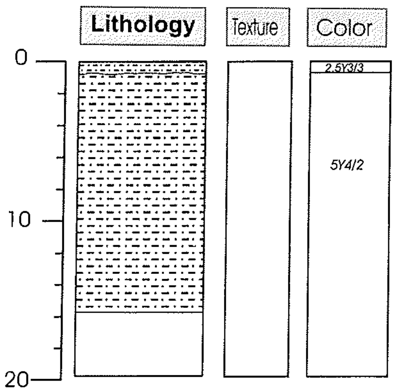
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-08Grab

Ob Estuary

68° 39.96' N
73° 59.622' E

Water depth: 12 m
Recovery: 15 cm



Description

0-0.5 cm: dark olive brown (2.5Y3/3) diatomaceous silty clay

0.5-15 cm: dark olive gray (5Y4/2) diatomaceous silty clay

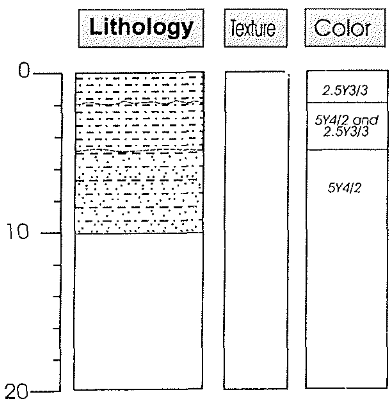
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-09Grab

Ob Estuary

69° 58.7' N
73° 11.3' E

Water depth: 21 m
Recovery: 15 cm



Description

0-02 cm: dark olive brown (2.5Y3/3) clayey silt

2-5 cm: dark olive brown (2.5Y3/3) and dark olive gray (5Y4/2) soft clayey silt

5-15 cm: dark olive gray (5Y4/2) silty middle sand with clay

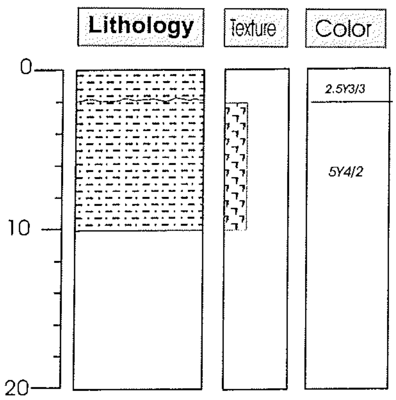
R/V "AKADEMIK BORIS PETROV" - 2002

BP02-12Grab

Ob Estuary

72°40.36' N
73°59.75' E

Water depth: 21 m
Recovery: 10 cm



Description

0-02 cm: dark olive brown (2.5Y3/3) silty clay

2-10 cm: dark olive gray (5Y4/2) silty clay; lithified tubes of polychaets; bioturbated

10.3

Methods

10-3: 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 2002.

	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

	Institute	Methods	Parameter
2. Sediments			
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
Sedimentology/Mineralogy	IORAS	Microscopy	Heavy minerals; grain size
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; pollen stratigraphy
Micropaleontology	IORAS	Microscopy	Benthic foraminifera
Geochemistry	GEOMAR	MS	Stable inorganic carbon and oxygen isotopes
Inorganic geochemistry	AWI	RFA	Major and minor elements
Inorganic geochemistry	GEOKHI	XRS	Heavy elements
Core logging	AWI	Multi-sensor core logging	Magnetic susceptibility, density, velocity
Dating of sediment cores	AWI	AMS 14C	Chronology; flux rates
Sediment profiling	AWI	Sediment echograph, 3.5 khz profiling	sediment thickness, sediment structures

10.4

Participants

10.4: Research Participants

Name	Discipline	Institution
Levitan, Michael	Chief of Expedition	GEOKHI
Schoster, Frank	Co - chief Scientist	AWI
Bogacheva, Margarita	Geochemistry	GEOKHI
Borisov, Alexander	Radio- Geochemistry	GEOKHI
Heider, Rafaela	Biology	AWI
Kodina, Ludmilla	Organic Geochemistry	GEOKHI
Krupskaja, Viktoria	Sedimentology	GEOKHI
Lahajnar, Niko	Organic Geochemistry	IFBM
Larionov, Viktor	Biology	MMBI
Ligaev, Alexander	Radio - Geochemistry	GEOKHI
Nagel, Birgit	Biogeochemistry	IFBM
Nitzsche, Catrin	Biogeochemistry	IFBM
Osadchiy, Nikolay	Engineer	GEOKHI
Rehm, Peter	Biology	AWI
Salzer, Ulrike	Geochemistry	AWI
Schmelkov, Boris	Engineer	GEOKHI
Sizov, Yevgeniy	Radio - Geochemistry	GEOKHI
Solovjeva, Galina	Radio - Geochemistry	GEOKHI
Tokarev, Viktor	Organic Geochemistry	GEOKHI
Vlasova, Ludmilla	Organic Geochemistry	GEOKHI

Ships Crew

Kondratev, Viktor	Capitain
Dmitrenko, Peter	Chief mate
Moiseev, Alexey	2nd Mate
Vaulin, Alexander	2nd Mate
Opekunov, Viner	3nd Mate
Krytin, Alexey	Chief Radio
Horshev, Viktor	Scientific - Engineer
Latko, Alexander	Scientific - Engineer
Kysmin, Oleg	Doctor
Yakybovskiy, Pavel	Chief Mechanic
Penkauskas, Antanas	2nd Mechaniker
Alhasov, Georgiy	3nd Mechaniker
Konik, Alexander	4nd Mechaniker
Ganoshenko, Anatoliy	Elektro - Engineer
Drosdov, Ruslan	2nd Elektro - Engineer
Golikov, Yuriy	Motorman
Markovskiy, Vladimir	Boatswain
Petrov, Oleg	Seaman
Domrachev, Alexey	Seaman
Pavlov, Vladimir	Seaman
Vasilchenko, Alexander	Seaman
Moriz, Igor	Seaman
Shelomenzev, Alexander	Seaman
Smirnov, Vladimir	Seaman
Slepchenko, Vladimir	Motorman
Lyatovizkiy, Oleg	Motorman
Phil, Vladimir	Motorman
Saizev, Anatoliy	Motorman
Sityashenko, Yevgeniy	Cook
Kramskaya, Ludmila	Cook
Gavrilyuk, Irina	Stewardess
Dolmatova, Irina	Stewardess
Grizeshina, Irina	Stewardess
Korschenevskaya, Marina	Stewardess
Titova, Irina	Stewardess
Vorobyeva, Rimma	Stewardess