RUSSIAN-GERMAN COOPERATION

Laptev Sea System

Frontal Zones & Polynya Systems in the Laptev Sea: The TRANSDRIFT XVII Expedition

31.08.2010 – 09.10.2010

T. Klagge (IFM-GEOMAR) and A. Novikhin (AARI),

with contributions by the shipboard scientific party

Cruise report

TABLE OF CONTENTS

Abbreviations and acronyms

AARI	State Research Center – Arctic and Antarctic Research Institute
ADCP	Acoustic Doppler Current Profiler
AFM	Carousel Water Sampler Automatic Fire Module
AW	Atlantic water
AWI	Alfred Wegener Institute for Polar and Marine Research
BOD	Biochemical Oxygen Demand
CDOM	Chromophoric Dissolved Organic Matter
CTD	Conductivity Temperature Depth Meter
CTTu	Conductivity Temperature Turbidity Meter
DO	Dissolved Oxygen
IPY	International Polar Year
OSL	Otto Schmidt Laboratory for Polar and Marine Research
SPM	Suspended Particulate Matter
ZMAW	Centre for Marine and Atmospheric Sciences

1. INTRODUCTION

1.1. SCIENTIFIC BACKGROUND

Over the past decade it has become evident that the Arctic is undergoing significant and sweeping changes such as increased air temperatures and enhanced wind mixing over most of the arctic shelf seas, and reduced sea-ice cover and marked changes in amplitude and seasonality of river discharge. Most of these changes are already manifested on shelf environments. The Laptev Sea shelf (Siberian Arctic) and the Laptev Sea polynya were internationally defined as key regions for monitoring and investigating the variability and changes in system parameters in terms of changing boundary conditions as a result of climate change.

The project "Laptev Sea System: the Eurasian Shelf Seas in the Arctic's Changing Environment – Frontal Zones and Polynya Systems in the Laptev Sea" is a multi-disciplinary approach including remote sensing, multi-year sea-floor observatories, ice camps and ship expeditions, and coupled sea-ice/ocean modeling. Russian-German research teams from Bremerhaven, Kiel, Moscow, St. Petersburg, and Tiksi are studying the flaw polynya in response to oceanic, sea-ice and atmospheric forcings as well as feedbacks of the Laptev Sea flaw polynya to the Arctic system.

1.2. GOALS AND TASKS

The main aim of the expedition TRANSDRIFT XVII was to obtain data on the present state of the marine environment in the Siberian Arctic shelf seas using up-to-date measuring and sampling techniques. The major goals of the expedition were the following:

- investigation of oceanographic, hydrochemical, biological, and sedimentological conditions in the inner parts of the seas where frontal zones between riverine and marine waters occur in summer, and polynyas are formed in winter;
- investigation of frontal zones and lateral and vertical flows of heat, salt and particulate matter under different conditions of density stratification and bottom topography;
- investigation of the annual oceanographic records (current velocity, bottom-water temperature, salinity) from multiyear seafloor observatory stations deployed in the Lena polynya area;
- the biological investigations are aimed at 1.) monitoring the Laptev Sea shelf ecosystems to gain additional information on the structure and functioning of Arctic ecosystems during the ice-free period in relation to various environmental parameters and 2.) analyzing food webs and carbon flux in shelf ecosystems and assessing the role of autotrophic and heterotrophic elements of food webs in the carbon cycle;
- application of the data on the seasonal variability of different parameters characterizing marine ecosystems for climate forecast modeling.

The research tasks correspond to the main research initiatives of the IPY (International Polar Year 2007/08) and the “Laptev Sea System” program. These are:

- oceanographic survey in the Barents, Kara, Laptev, and East Siberian seas during summer and fall;
- hydrophysical investigations within polygons in the Kara and Laptev seas positioned in the local seasonal frontal zones;
- oceanographic measurements at selected stations along transects and hydrophysical polygons;
- water sampling at oceanographic stations for measuring nutrient content, concentration of dissolved oxygen, pH, composition of ions, chlorophyll *a* concentration, suspended matter and organic carbon content;
- biological sampling (phyto/zooplankton, benthic organisms) at the oceanographic stations;
- marine geological investigations (analysis of downcore records and surface sediment characteristics);
- onboard meteorological survey;
- analysis of the data on thermohaline characteristics of the arctic shelf seas in a specific season;
- analysis of the spatial-temporal distribution of oceanographic parameters over the Arctic seas;
- analysis of the spatial-temporal distribution and seasonal variability of freshwater plumes;
- revealing the seasonal local frontal zones and observation of their variability in space and time;
- characterization of the Atlantic waters entering the St. Anna and Voronin troughs in the Kara Sea and tracing their further subsurface inflow to the Laptev Sea shelf;
- revealing the zone with stagnant waters on the Arctic shelves;
- thermohaline measurements in flaw leads and polynyas;
- estimation of the lateral heat and salt exchange at the freshwater/saltwater interface;
- investigations of the transformation of structural zones and water masses in the shallow regions;
- enlargement of the oceanographic databases of the State Informational World Ocean Service (ESIMO), Russian Hydrometeorological Survey (Rosgidromet), and Arctic and Antarctic Research Institute (AARI);
- investigation of the taxonomic composition, total abundance and biomass of phytoplankton and its distribution in the Laptev and Kara seas in relation to diverse abiotic factors and specific conditions of certain years;
- obtaining the data on vertical and lateral distribution of chlorophyll *a* as the main indicator of primary productivity in the Laptev Sea, its daily and seasonal dynamics;
- investigation of the taxonomic composition, spatial and temporal distribution of zooplankton, seasonal dynamics of its total abundance and biomass, as well as

variability of the species composition and relative abundance of certain species depending on hydrological and hydrochemical characteristics;

- obtaining new data on the distribution of benthic species and total abundance, biomass, and structure of benthic assemblages in the shelf zone, especially in the region where the polynya is located in the winter;
- collecting the data on the composition and abundance of ichthyofauna, birds and mammals as the end consumers of food webs.

1.3. MODERN SETTING

1.3.1 KARA SEA

The sea is bounded by the West Siberian Lowland, the islands of Vaigach, Novaya Zemlya, Franz Josef Land, Severnaya Zemlya and Taimyr Peninsula. The boundary with the Arctic Ocean runs from Cape Kolzat (Franz Josef Land) to Cape Arkticheskii (Severnaya Zemlya). The area of the Kara Sea is 883x103 km², and the average water depth is 127 m. The maximum water depth in St. Anna Trough reaches 620 m. There are many islands in the Kara Sea, which occupy a total area of 10x102 km² mainly in its northeastern part (Minin's Skerries, Nordenskiold Archipelago, and others) (Atlas of the Arctic, 1985). The typical features of the Kara Sea climate are strong cooling in winter and weak warming in summer, unstable weather conditions during winter and stable atmospheric conditions in summer (Chernigovsky and Marshunova, 1965). The sea ice cover, which is present during the greater part of the year, evens surface water temperature contrasts. The vertical seawater temperature distribution shows strong seasonal contrasts in different parts of the sea. Salinity ranges from 3-5‰ in the southern regions, affected by freshwater runoff (Ivanov, 1976) and sea-ice meltwater, to 33-34‰ in the northern areas, influenced by the Arctic Ocean water masses. Tides in the Kara Sea are low and do not exceed several dozens of centimeters.

1.3.2. LAPTEV SEA

The sea is located between the Siberian coast, Taimyr Peninsula, and the New Siberian and Severnaya Zemlya islands. The boundary with the Arctic Ocean runs from Cape Arkticheskii (Severnaya Zemlya) to the point with coordinates 79°N and 139°E located on the continental slope north of Kotel'nyi Island. There are several dozens of islands in the Laptev Sea with a total area of 3,784 km² (Atlas of the Arctic, 1985). These are mainly located in its southwestern part. Stolbovoi and Bel'kovskii islands are located in the northeast. The climatic conditions of the Laptev Sea may be defined as marine polar. The hydrological regime of the sea is considerably influenced by the runoff of big Siberian rivers. Freshened warm surface water masses spread over large territories forming a vast frontal zone (Buynevich et al., 1980). Severe climate conditions, perennial sea ice (from October till May the whole sea is ice-covered) and flaw polynyas considerably influence the hydrological and hydrochemical regimes of the Laptev Sea (Zakharov, 1966, 1996). The sea has a cyclonic surface water circulation. The tides are well expressed with an irregular semidiurnal character.

1.3.3. East Siberian Sea

The sea is located at the northeastern coast of Asia between the New Siberian and Wrangel islands. The northern boundary with the Arctic Ocean runs from the point with coordinates 79°N and 139°E to the point with coordinates 76°N and 180°E. The East Siberian Sea is connected with the Chukchi Sea by Long Strait and by the territory to the north of Wrangel Island. The total area of the sea is 913x103 km², and the average depth is 45 m. The shallow shelf with depths less than 50 m occupies about 72% of its territory (Atlas of the Arctic, 1985). The sea is located in the area of interaction between the atmospheric influence of the Atlantic and Pacific oceans. Freshwater runoff to the sea is relatively low. Surface water temperature decreases in northward direction during all seasons. In winter it is close to freezing point. In summer, temperature distribution depends upon sea-ice conditions. Temperature only slightly varies with depth. Salinity increases from southwest to northeast. From October to June the sea is completely ice-covered. Bottom sediments are characterized by submarine permafrost and relic ice. In fall and winter the waters of the East Siberian Sea are well oxygenated. The minimum concentrations of dissolved oxygen are characteristic of the bottom water layer.

1.4. Expedition background

The TRANSDRIFT XVII expedition is an integral part of the joined Russian-German project “Laptev Sea System”. It is funded by the German Federal Ministry for Education and Research, the Russian Ministry of Education and Science, the German Academic Exchange Service (DAAD) and the Alfred Wegener Institute for Polar and Marine Research.

The vessel used for the expedition was RV "Nikolay Evgenov" (Fig. 1.1). Her sister ship, RV "Yakov Smirnitsky", was already successfully used for the TRANSDRIFT VII, VIII, X and XVI expeditions. The vessel belongs to the Hydrobase Arkhangelsk.

Fig. 1.1: RV “Nikolay Evgenov”, Hydrobase Arkhangelsk.

The working program of the TRANSDRIFT XVII expedition focused on different aspects: in addition to investigating the exchange processes and interaction between atmosphere, hydrosphere and seafloor, three oceanographic seafloor observatories ("moorings") were recovered during the expedition. These seafloor observatories were deployed during the TRANSDRIFT XVI expedition in September 2009 for a period of one year (September 2009 to September 2010) to monitor seasonal variability in oceanographic parameters within the water column. In addition to that five of these seafloor observatories were re-deployed throughout the cruise.

1.5. Expedition summary

The TRANSDRIFT XVII expedition took place from August 31 to October 9, 2010.

Because a tugboat sank close to the Lena Delta while assisting a research cutter in distress during a severe storm, all ships in the Laptev Sea including the "Nikolay Evgenov" had to answer the distress calls and help searching for missing crew members. The scientific party, therefore, had a delay of several days in Tiksi. The party boarded RV "Nikolay Evgenov" on September 9 and left harbor on September 10, early morning, after preparing the onboard laboratory and working equipment.

Ten days were spent for research in the Laptev Sea, carrying out 45 hydrological stations, as well as for recovery of two and deployment of five seafloor observatories. All in all eleven of the 56 planned stations were skipped due to a strong storm that forced the ship to get some shelter west of Bel'kovskii Island for two days.

After finishing the work in the Laptev Sea and passing through Vilkitsky Strait, the ship went north to recover the St. ANNA seafloor observatory, which was deployed by the Arctica-Kara-2009 cruise in the previous year. The scientific work ended at that position, and the ship went to the Yenissey river, where the scientific crew and equipment changed to RV "Dmitriy Ovtsin". This ship then went on to Dikson, and from there directly to the final destination, Arkhangelsk, where we arrived on October 9, 2010.

A list of all stations, hydrographic stations as well as seafloor observatory operations, can be found in Figure 1.2.

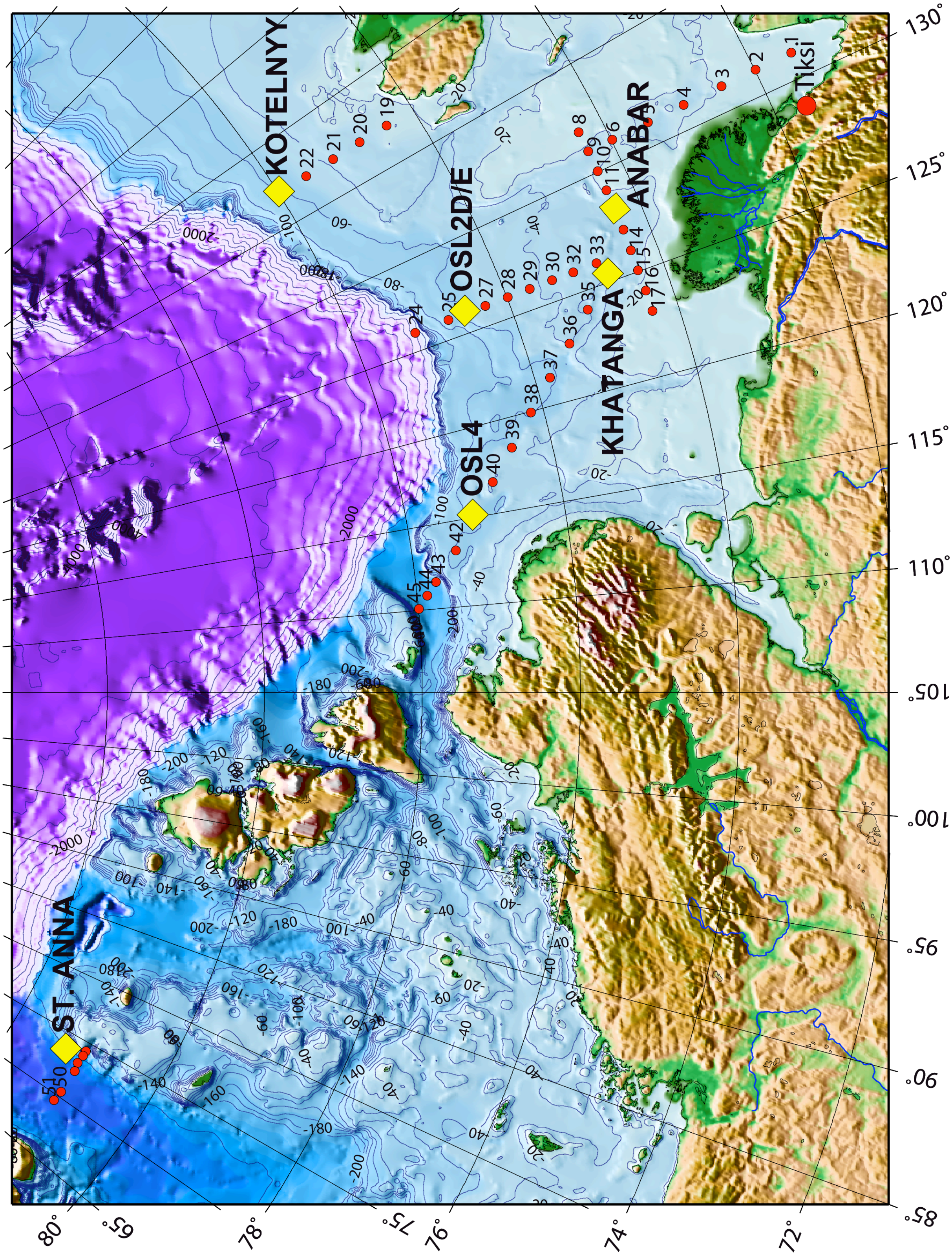


Fig. 1.2: Station map of the TRANSDRIFT XVII cruise. All hydrographical stations are marked red, all stations where seafloor observatory recovery and/or deployment took place are marked yellow.

1.6. METHODS AND EQUIPMENT – GENERAL

Throughout the cruise the main instrument was a carousel water sampler of the type SBE 32C with 5 liter water bottles, which was used to collect water samples from different water depths (this device is described in more detail in the oceanographic section of this report). It is equipped with a CTD SBE19+, which measures conductivity, temperature and pressure, as well as with additional sensors for dissolved oxygen, turbidity and fluorescence. If possible this instrument was used at every station, but on some stations it was only possible to use a plain CTD SBE19+ without any additional sensors. For details on which sensors were used at which station, see the station list in the appendix.

On many stations, especially in the southern and central Laptev Sea, we used a second CTD SBE19+ with an additional CDOM sensor (chromophoric dissolved organic matter).

In addition to that, the abilities of the ship were limited in terms of deploying the carousel water sampler in water depth greater than 50 m: the crane which needs to be used for the water sampling casts wasn't able to reach greater depths. Due to that, stations that were deeper usually had two CTD casts: one CTD cast with additional sensors for dissolved oxygen, turbidity and fluorescence on the carousel water sampler up to a depth of 50 m, and a second CTD cast with another CTD, either with or without additional CDOM sensor, to take a profile of the whole water column.

Due to the fact that there are quite often two CTD-profiles from two different instruments (both SBE19+) for the same station number, Figure 1.3 shows the similarity between both sensor data. It can be seen that both instruments measure very exactly and with a very small difference only, which is most likely introduced by the temporal and spatial difference between both CTD casts: on some stations they were used one after the other, and the ship also drifted to a slightly different position, so it is also likely that slightly different properties were measured in the water, which causes the differences indicated in Figure 1.3.

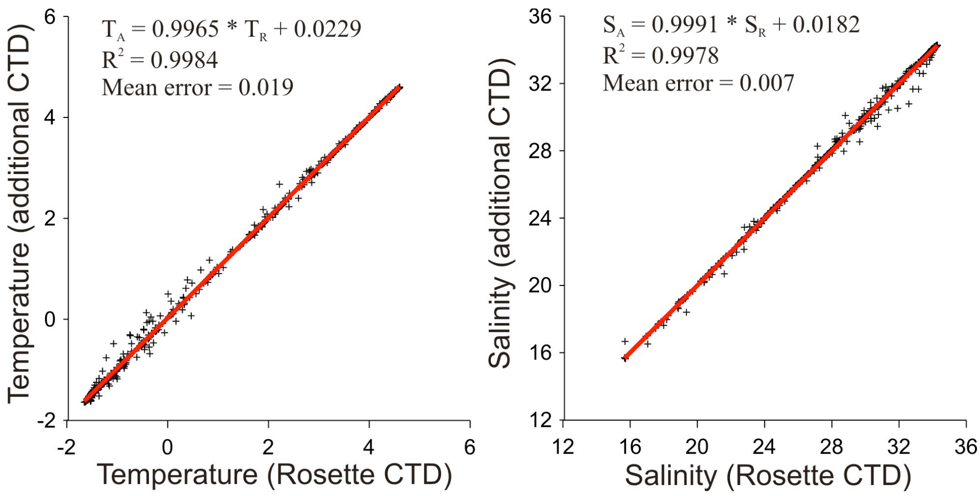


Fig. 1.3: The scatter-plot of all available Rosette CTD records vs. additional CTD data carried out at the same depths at every station. The data from 1-m running mean vertical profiles are presented.

Which CTD and which sensors were used at which station can be seen from the station map in Figure 1.4. This information can be found in more detail in the station list in the appendix.

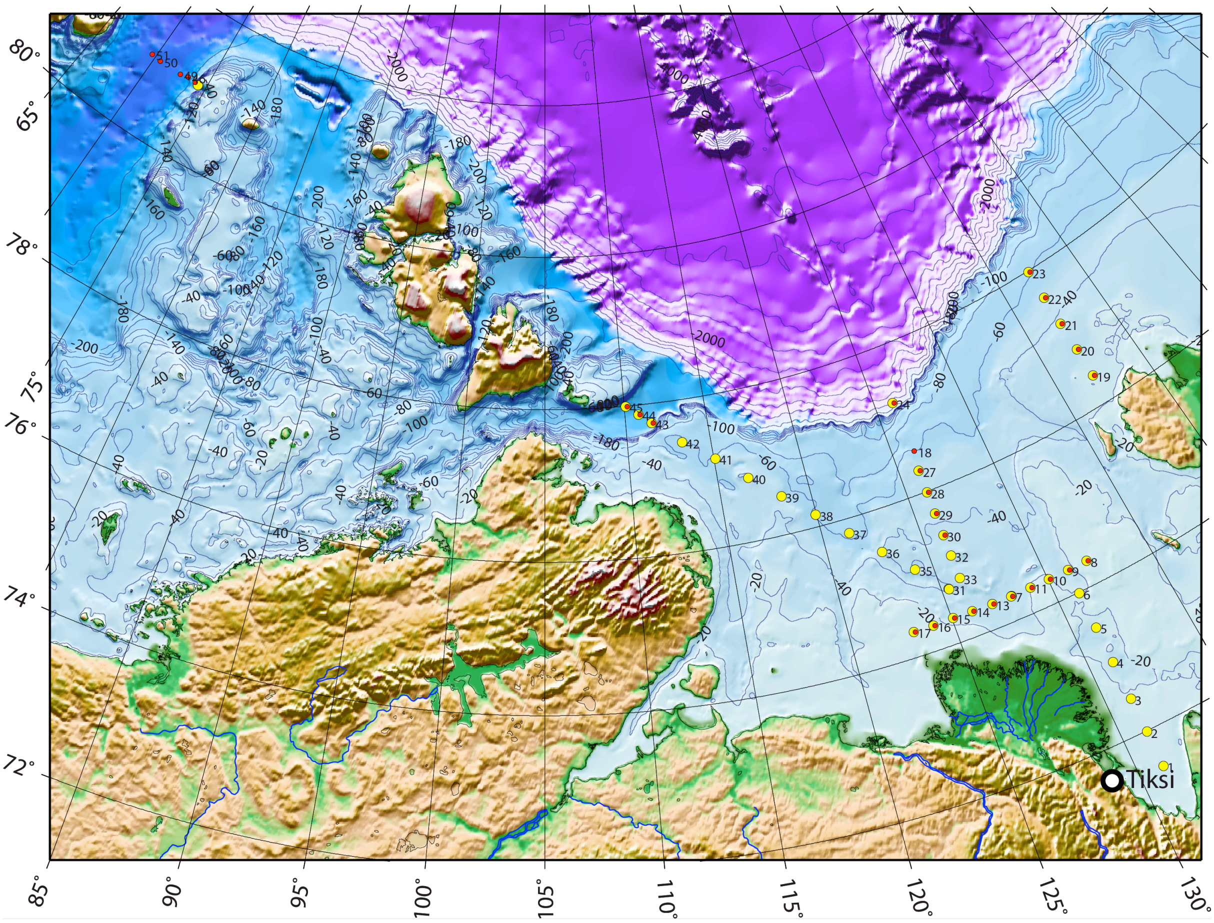


Fig. 1.4: Stations where the CTD SBE19+ on the carousel water sampler was used (with dissolved oxygen, turbidity and fluorescence sensor) are marked yellow, and an additional red dot indicates a second CTD cast with the second SBE19+ (partly with CDOM sensor, but especially for deeper stations to get a complete water profile).

2. WEATHER AND ICE DATA

Figures 2.1, 2.2 and 2.3 show the meteorological observations that were measured by the ship's meteorological equipment. The data was collected every four hours (00:00, 04:00, 08:00, 12:00, 16:00, and 20:00, all in UTC). For the weather data for each station see the meteorological part of the station protocol in Appendix C, where the wind speed, direction, atmospheric pressure and temperature are described for the exact time of station work.

2.1. AIR TEMPERATURE

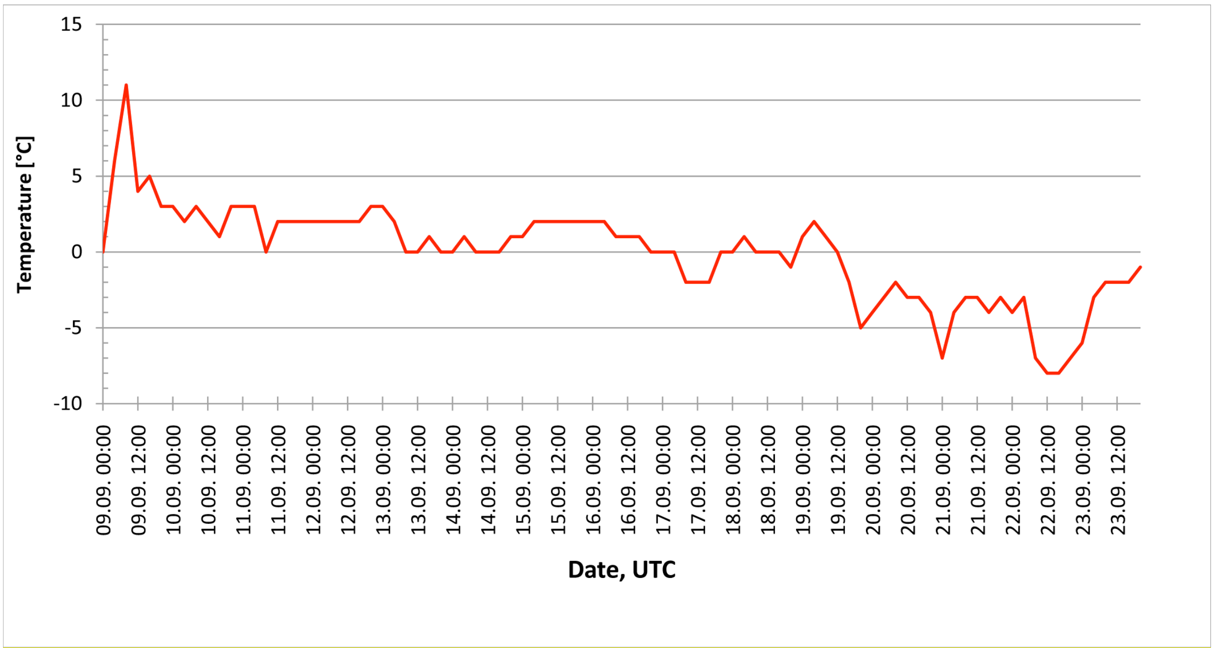


Fig. 2.1: Plot of air temperature, measured ~9 m above sea level, for the duration of cruise. Time is in UTC.

2.2. Wind speed and direction

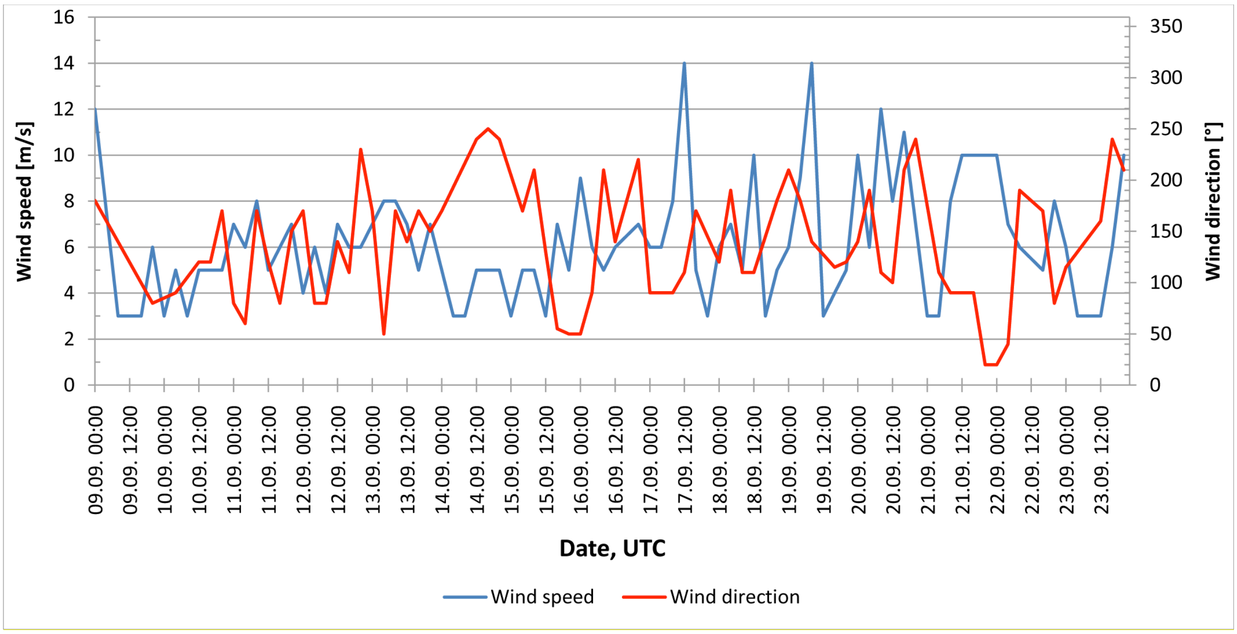


Fig. 2.2: Plot of wind speed (blue) and wind direction (red) for the duration of cruise. Time is in UTC.

2.3. Atmospheric pressure

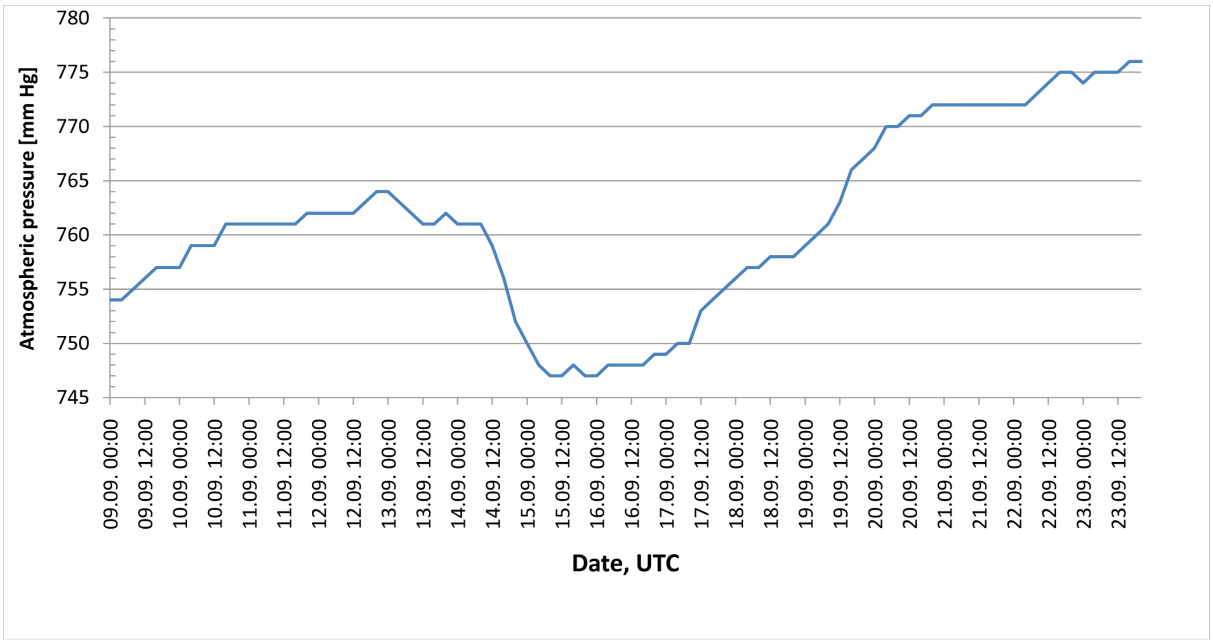


Fig. 2.3: Plot of atmospheric pressure for the duration of cruise. Time is in UTC.

2.4. Ice conditions in the Laptev and Kara seas during the cruise

Due to the fact that some of our stations, especially the seafloor observatories KOTELNYY, ST. ANNA and the stations 42-45, were located in regions where we could expect ice, it was necessary to watch for the current sea ice concentrations. The maps (figs. 2.4, 2.5 and 2.6) were provided by the sea-ice group of the ZMAW (Centre for Marine and Atmospheric Sciences), while the latest AMSR-satellite images (for most detailed local ice information) where pre-processed and provided by Thomas Krumpen, Alfred Wegener Institute for Polar and Marine Research (AWI).

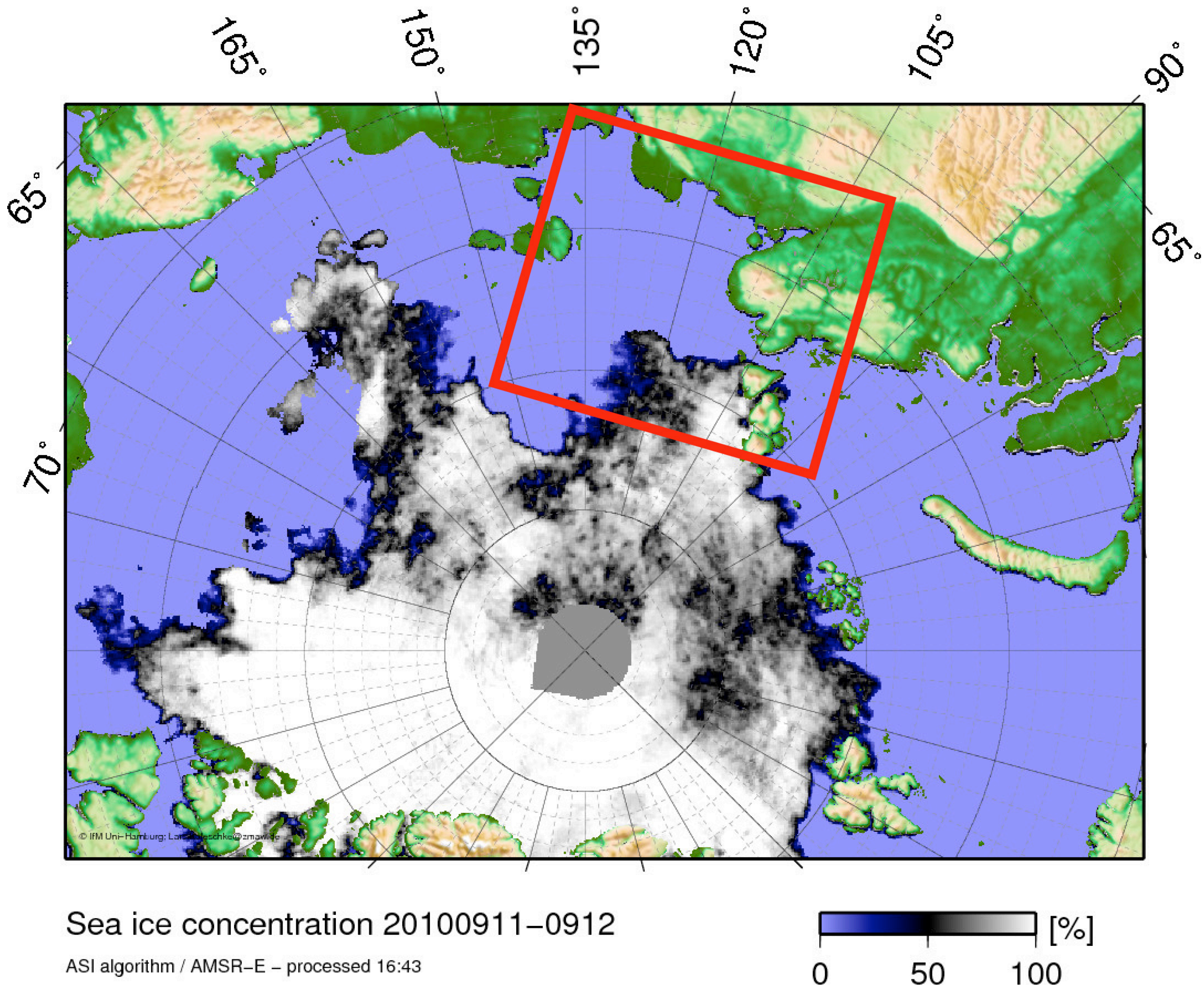


Fig. 2.4: Sea ice concentration shortly after the beginning of our working program in the Laptev Sea. All relevant regions of our working area (which is marked by the red frame) were free of ice. Source: www.zmaw.de.

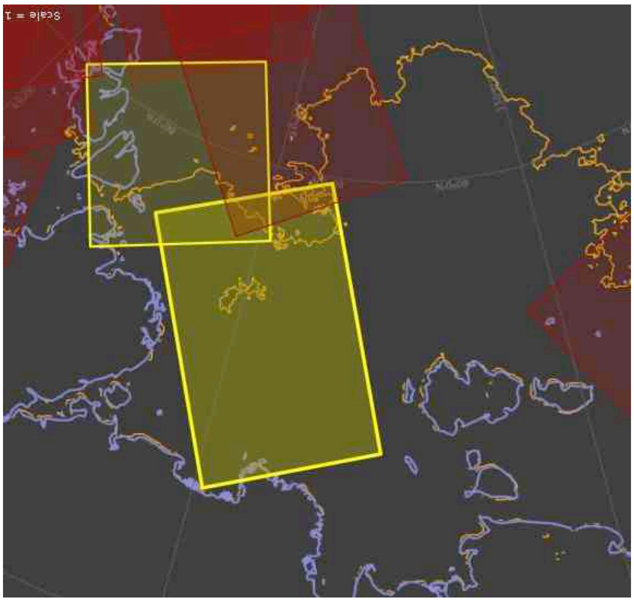


Fig. 2.5: Sea ice extend in the Laptev Sea on September 20, 2010. The thin yellow line shows the ice edge, derived by AMSR satellite data. The red and yellow rectangles indicate the area for which more detailed satellite images are available. Source: T. Krumpen, AWI.

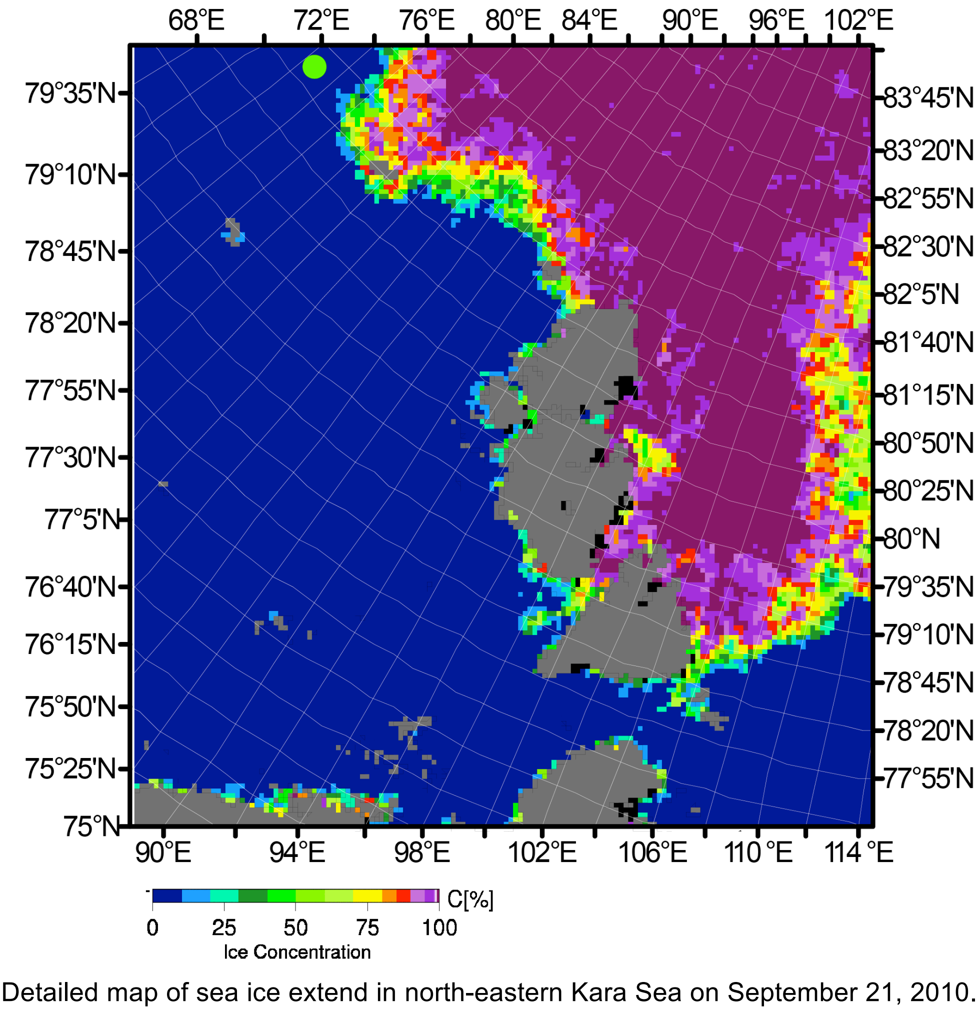


Fig. 2.6: Detailed map of sea ice extend in north-eastern Kara Sea on September 21, 2010. The round green dot in the upper left corner indicates the position of seafloor observatory ST. ANNA. Map derived by AMSR-satellite data. Source: T. Krumpen, AWI.

3. BIOLOGICAL INVESTIGATIONS

Climatic changes are one of the most urgent among modern ecological problems. Climate warming strongly affects the high latitudes of the Northern Hemisphere causing shrinking of the ice cover in the Arctic Ocean (Barber & Massom, 2007), enhancing the influence of Atlantic waters on the Arctic regions (Polyakov et al., 2005), and increasing freshwater discharge (Berezovskaya et al., 2005). About 50% of the Arctic Ocean area are occupied by the shallow continental shelf, which plays an important role in the transformation of water masses (Aagaard et al., 1981), biogeochemical processes and carbon cycling in the Arctic (Stein & Macdonald, 2004). The predicted climate-induced changes in atmospheric processes, temperature-salinity characteristics of water masses, water stratification, sedimentation processes, and ice-free period duration will cause changes in light regime and phytoplankton bloom period, as well as the amount and distribution of nutrients. This will directly affect biochemical processes and their rate, planktic and benthic assemblages and the higher components of food webs, as well as the productivity of the Arctic marine ecosytems.

The main goals of the biological investigations during this summer expedition were as follows:

- monitoring the Laptev Sea shelf ecosystems to gain additional information on the structure and functioning of Arctic ecosystems during the ice-free period in relation to various environmental parameters;
- analysis of food webs and carbon flux in shelf ecosystems and assessment of the role of autotrophic and heterotrophic elements of food webs in the carbon cycle.

The main research tasks were:

- investigation of the taxonomic composition, total abundance and biomass of phytoplankton and its distribution in the Laptev Sea in relation to diverse abiotic factors and specific conditions of certain years;
- obtaining the data on vertical and lateral distribution of chlorophyll *a*, which is the main indicator of primary productivity in the Laptev Sea, and its daily and seasonal dynamics;
- investigation of the taxonomic composition, spatial and temporal distribution of zooplankton, seasonal dynamics of its total abundance and biomass, as well as variability of the species composition and relative abundance of certain species depending on hydrological and hydrochemical characteristics;
- obtaining new data on the distribution of benthic species, total abundance, biomass, and structure of benthic assemblages in the shelf zone, especially in the region where the polynya is located in winter;
- collecting the data on the composition and abundance of ichthyofauna, birds and mammals as the highest components of food webs.

The samples that were taken during the TRANSDRIFT XVII cruise will allow us to continue multiyear the monitoring of the ecosystem of the Laptev Sea shelf. An analysis of the long-term data series allows indicating some trends/oscillations in the species composition and dynamics of the pelagic system and providing the background for the further assessment of ecosystem changes connected with climate variability in the Arctic region.

The samples were taken and processed by F. Martynov, A. Novikhin, A. Gukov, O. Zhaden, S. Antonova, I. Kryukova, I. Semeryuk, A. Loginova, I. Ivanoshchuk and Y. Tropina.

3.1. Methods and equipment

3.1.1. Chlorophyll *a* sampling

Water samples of 0.5 litres were taken from the carousel water sampler at standard water depths and were poured into plastic bottles. The water samples were processed on board and were filtered in the laboratory as follows:

- the water samples were filtered through Whatman GF/F filters (0.7 microns) with pressure of not more than 0.2 bar;
- after the water was filtered, the filters were put with tweezers in Eppendorf tubes and/or aluminum foil, signed with station and depth, and immediately put in the freezer on board (with temperatures not higher than -20ºC).

Further processing of the samples, especially measuring the amount of chlorophyll in the filters, will take place at the Otto Schmidt Laboratory for Polar and Marine Research (OSL) with a fluorimeter TD 700 and SPECORD 200, after transport to St. Petersburg in a freezer. The stations where chlorophyll *a* samples were taken during the TRANSDRIFT XVII cruise are shown in Figure 3.1.

3.1.2. Phytoplankton sampling

Phytoplankton samples were taken with an Apstein net with a 40-cm diameter and mesh size of 20 microns. Depth levels of taken samples were in the water column below the pycnocline, as indicated for the prior CTD cast. After that samples were poured into plastic bottles and fixed with 4% neutral formalin. The samples will be further processed at the OSL and Moscow State University.

The stations where phytoplankton samples were taken during the TRANSDRIFT XVII cruise are shown in Figure 3.1.

3.1.3. Zooplankton sampling

Zooplankton samples were taken with an Apstein net with 40-cm diameter and mesh size of 100 microns. Depth levels of taken samples are in the water column below the pycnocline, as indicated for the prior CTD cast, and the total water column from bottom to top. After that samples were poured into plastic bottles and fixed with 4% neutral formalin. Also samples of zooplankton for DNA analysis were taken with the same method, except that the fixing fluid was changed to pure ethanol (96%). The samples will be further processed at the OSL.

The stations where zooplankton samples were taken during the TRANSDRIFT XVII cruise are also shown in figure 3.1.

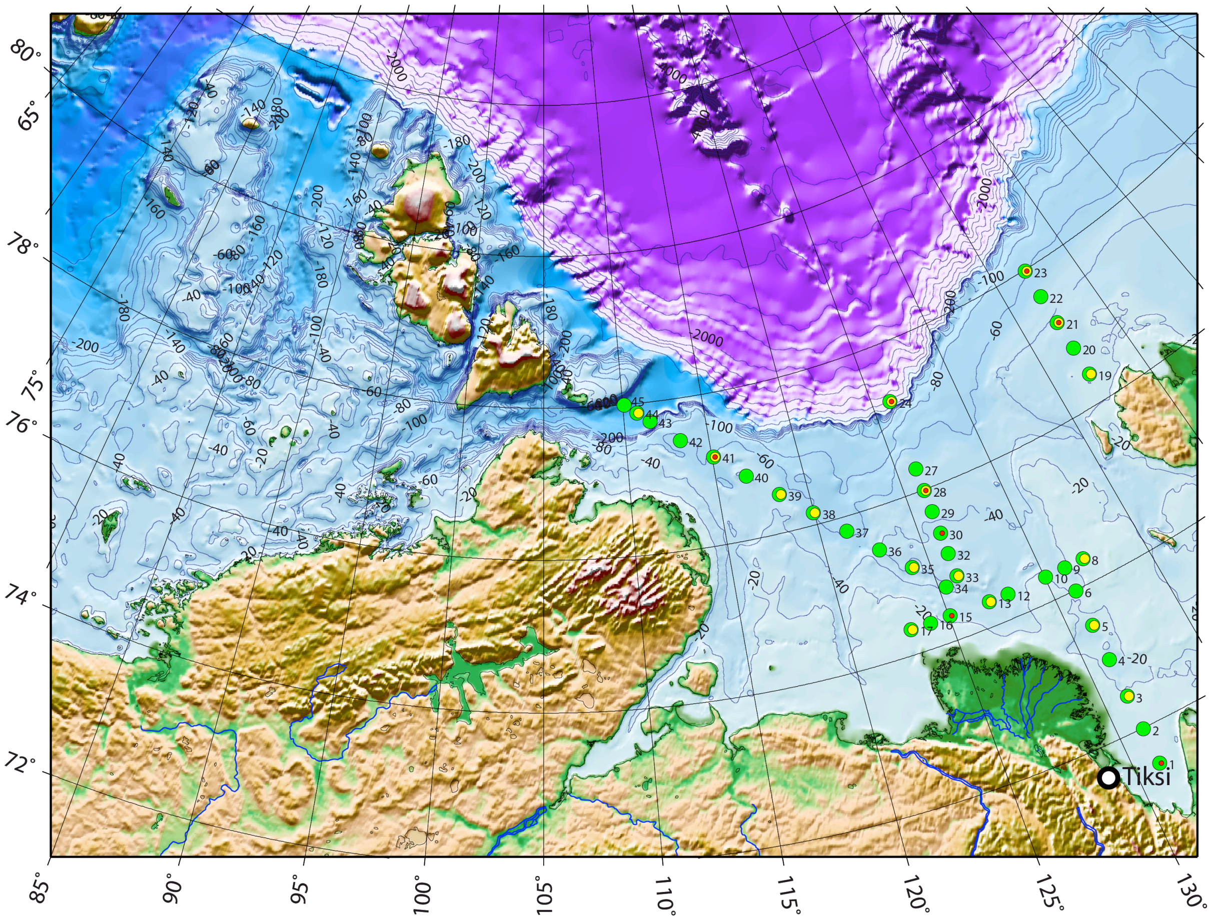


Fig. 3.1: Biological stations that were performed during TRANSDRIFT XVII. Stations where chlorophyll *a* samples were taken are marked green, while stations with phytoplankton sampling are marked yellow and stations with zooplankton sampling are marked red.

3.1.4. INVESTIGATIONS ON MACROBENTHOS AND BOTTOM BIOCOENOSIS

During the TRANSDRIFT XVII expedition to the Laptev Sea in September 2010 we sampled 35 stations. 35 quantitative and six qualitative samples of macrozoobenthos were taken. The locations of the stations can be seen in Fig. 3.2. Samples were taken by using a Van Veen bottom-grab with a capture area of 0.025 m². The captured seafloor was flushed through a series of sieves with a minimum mesh diameter of 1 mm. Organisms were sorted by groups and fixated by 70% ethanol.

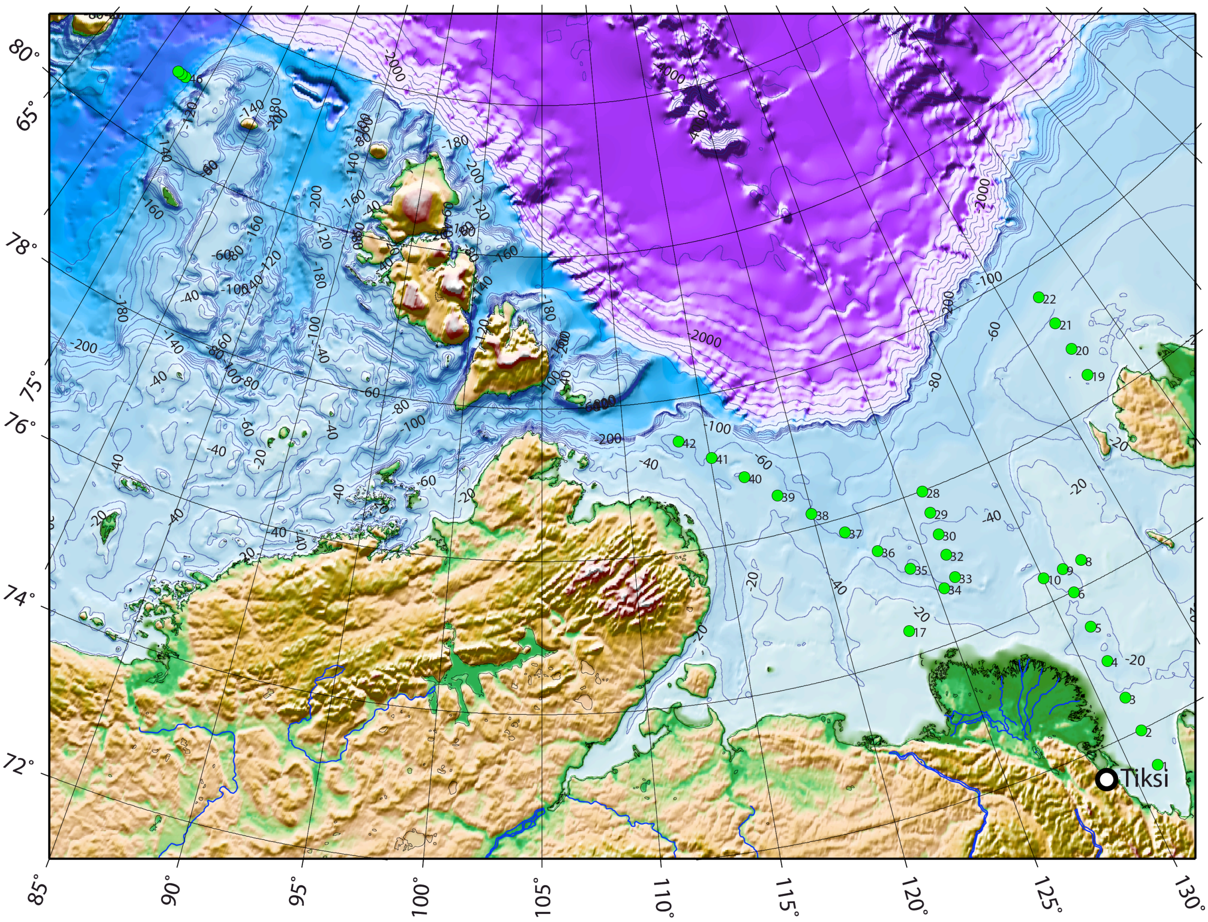


Fig. 3.2: Stations that were performed during TRANSDRIFT XVII for macrobenthos and bottom bio-coenosis investigations.

3.2. First results

During the cruise 250 samples for chlorophyll *a*, 33 samples for zooplankton (8 of them for DNA analysis) and 16 samples for phytoplankton were collected.

3.2.1. Preliminarily results for chlorophyll *a* distribution

During the TRANSDRIFT XVII expedition we obtained data on chlorophyll *a* distribution by a WETlabs WETstar Chlorophyll sensor (WETlabs, USA) to measure fluorescence (mg/m^3) along the oceanographic profiles. According to previous work with this sensor it shows higher values than can be measured in-situ by direct sampling. But after recalculating (dividing) the values with coefficient 3.5 we can use this corrected data for a preliminarily conclusion on chlorophyll *a* distribution/ concentration in the investigated area.

This year there were three main patterns of distribution of chlorophyll *a* values in the Laptev Sea, which are detailed below.

The first pattern is strongly connected with the river water plume, and seems to be remains of the River Lena phytoplankton bloom. Highest values of this pattern occur in the upper layer at the station NE10-02 with a value of 2.64 mg/m^3 on the 4-m level (at 72°N in Fig. 3.3). The thickness of this layer was about 12 m (from 1 m to 13 m depth) with a temperature of +7.8°C and a salinity of 6-9 PSU. Interestingly that same pattern occured at the station NE10-19, located on the 137°E transect close to the north shore of Kotelny Island. The highest value on this site was 1.51 mg/m^3 at 5 m depth with a layer thickness of 5 m (from 3 m to 8 m) and a temperature of +4.35°C as well as a salinity of 15 PSU. This can be evidence for river water plume distribution so far north, but it should further be proved by phytoplankton samples.

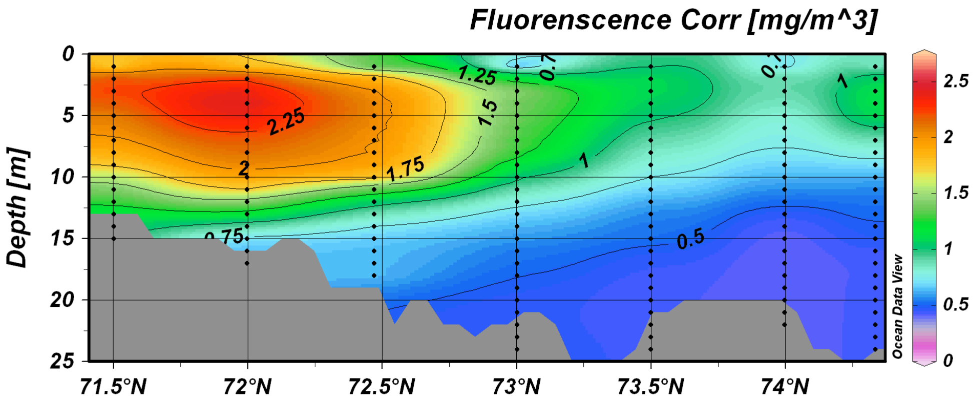


Fig. 3.3: Chlorophyll *a* concentration along the 131°E transect.

The second pattern is characterized by transitional hydrological values. This can be considered as the river front area with a temperature around +3.2°C and a salinity of 22.6 PSU. The highest values of this pattern are found at station NE10-12 (at 128°E in figs. 3.4) at 74.20°N in front of the northern region of the Lena Delta. The thickness of this layer is 5 m (from 2 m to 7 m) with its maximum value at 2 m: 8.7 mg/m^3. This is the highest value which was observed during this cruise.

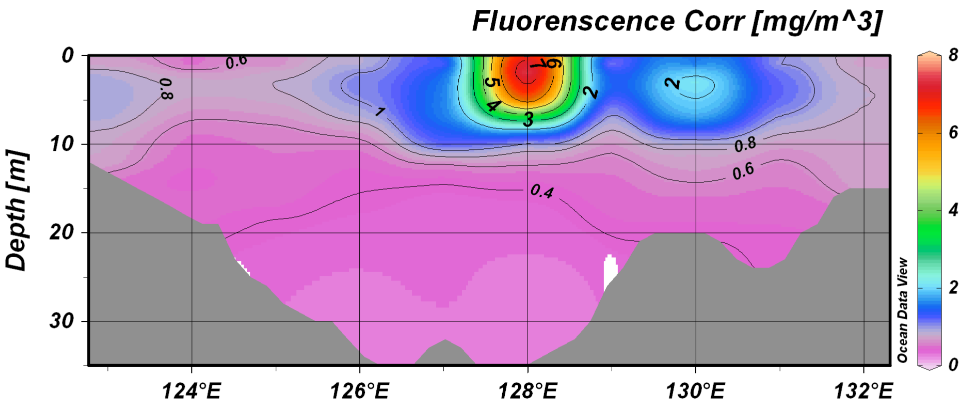


Fig. 3.4: Chlorophyll *a* concentration along the 74.20°N transect.

The third pattern is situated in the area of the continental slope at station NE10-24 at the northernmost point of the 126°E transect (Fig. 3.5). The thickness of this layer is 7 m (from 15 m to 22 m) with its maximum value at 19 m: 6.58 mg/m^3. This layer has a low temperature value (-1.55°C) and a high salinity value (32.5 PSU). The same pattern could be observed at the northern stations NE10-39 and NE10-40. The layers at those stations have the same hydrological characteristics. The value of fluorescence was in the range of 4.62-5.21 mg/m^3. Also these stations are characterized by the highest dissolved oxygen (DO) concentration, which could be connected with high phytoplankton activity. An interesting fact is that this pattern was observed previously in 2007. A peak of chlorophyll concentration occurs at the same position (NE10-24) and with exactly the same hydrological characteristics. But in 2008 and 2009 this peak was not present in the Laptev Sea. This can be a seasonal pattern and we need more data to find out the reason of its appearance.

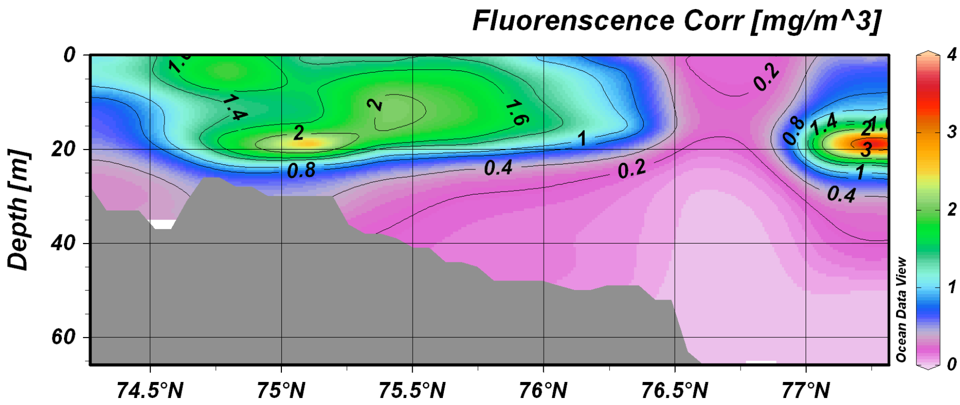


Fig. 3.5: Chlorophyll *a* concentration along the 126°E transect.

3.2.2. Preliminarily results for macrobenthos and bottom biocoenosis

As a result of our sampling ten bottom biocoenosis were preliminarily defined. It confirms the data of the last expedition to the Laptev Sea.

Station 42 had a maximum depth of ~64 m. Silt was the predominating ground type. This can be caused by prevailing fine grained sedimentation in the central part of the sea. Zoobenthos biomass distribution depends on depth and bottom ground type.

Boreal-Arctic species prevail in the biocoenosis content. In the area of the Lena Delta shore, brackish water species prevail. In the mouth area of Lena River, *Saduria eutomon*, *S. sibirica* and *Portlandia aestuariorum* prevail. At depths of more than 10 m *Portlandia arctica* dominated, while *Tridonta borealis* (on the sandy-silt ground type) also occurs. At depths of about 30 m the domination of the biocoenoses changes to Echinodermata (*Ophyocanta bidentata*, *Ophyocten sericeum*) and polychaeta (*Maldane sarsi*).

The type of the ground in areas with the same depth plays a major role in the species distribution. Salinity of the bottom water at the stations was in the range of 10-33 PSU. Molluscs were the prevailing species in the depth range of 35-60 m. In the area of the Siberian polynya, biocoenoses of *Leonucula belotti* with biomass up to 150 g/m^2 were found. In the area of the river paleovalleys, polychaeta and amphipoda species are of major occurrence.

The main factors determining the distribution of the bottom biocoenoses are the hydrological regime and the ground type.

4. Hydrochemical investigations

Hydrochemical investigations are important for environmental monitoring. Dissolved oxygen is essential for the respiration of organisms. It accumulates in seawater due to photosynthesis and seawater-atmosphere exchange. It is then utilized for respiration and decomposition of organic matter. Nutrients (silicates, phosphates, nitrites, nitrates) form the mineral basis for primary production. Together with temperature and salinity, hydrochemical parameters provide evidence for the distribution of water masses and their temporal and spatial variability.

During the expedition, water sampling for hydrochemical analysis was carried out at 39 stations in the Laptev Sea (Fig. 4.1). Water sampling was carried out with the SBE 32c rosette equipped with twelve 5-l Niskin bottles, SBE 19plus CTD sensor and AFM module. These instruments are described in detail in the oceanographic section of this cruise report. Sampling was carried out on standard levels which are for the Laptev Sea Shelf as follows: 0 (surface, so 0-2 m), 5, 10, 15, 20, 25, 30, 40, 50 m and the level which is as close as possible to the bottom). All rosette casts were operated with the back crane of the ship. Water sampling deeper than 50 m was not possible due to the cable length of the crane. 261 DO samples were analyzed onboard. 262 samples were taken to analyze nutrients. Eleven samples were taken for biochemical oxygen demand (BOD).

The samples were taken and processed by A. Novikhin, A. Nikulina, I. Kryukova, I. Semeryuk and A. Loginova.

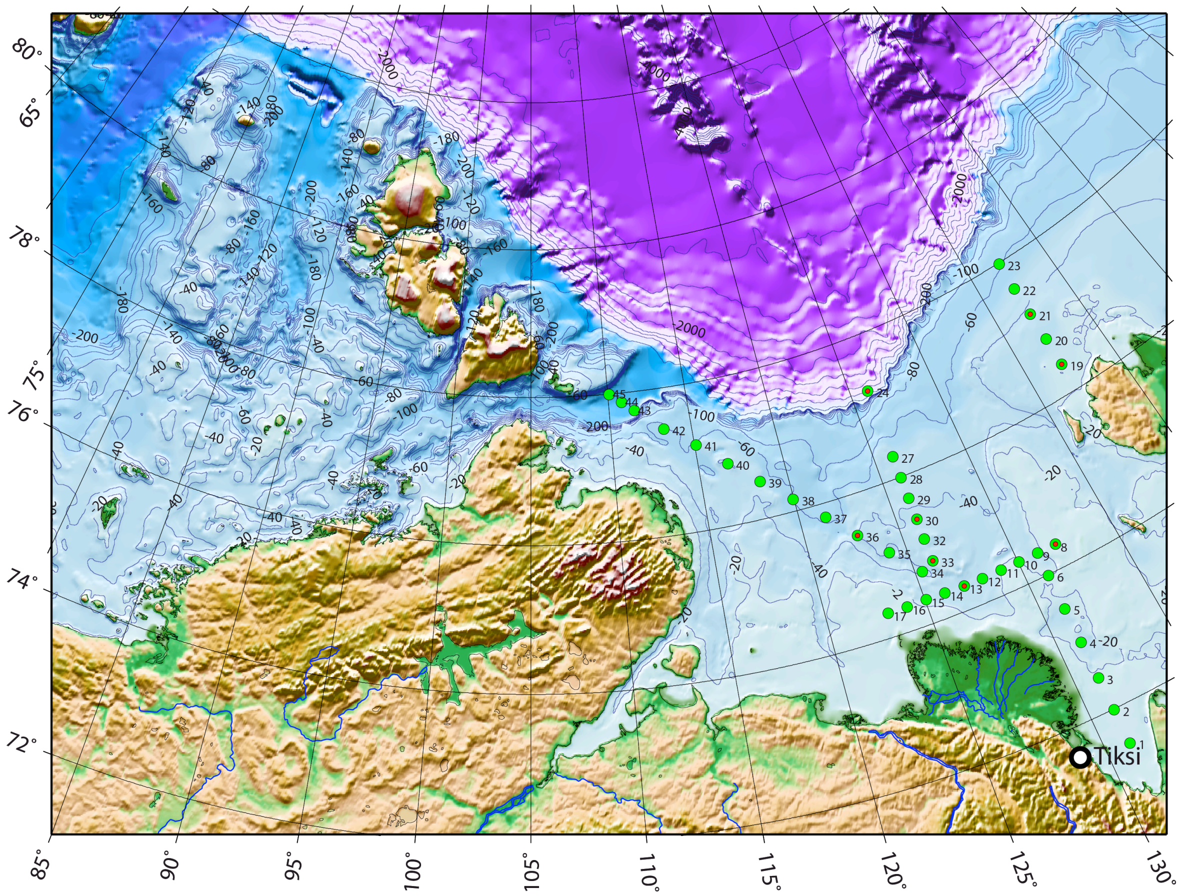


Fig. 4.1: Hydrochemical stations that were performed during TRANSDRIFT XVII. Stations where samples for nutrients and oxygen were taken are marked green, while stations where BOD samples were taken are marked red.

4.1. Methods and equipment

The samples for determining DO (dissolved oxygen) were taken first. Water was sampled into ~100-ml precalibrated glass bottles. After sampling, oxygen was fixed by sequential adding of 1 ml of manganese chloride solution and 1 ml of potassium iodide/sodium hydroxide solution. The sample was mixed actively until an evenly distributed precipitate was formed. After precipitating it was dissolved by addition of 2 ml of sulfuric acid. The dissolved oxygen content was determined by titration with sodium thiosulphate using an automatic burette ABU-80 following the modified Winkler method (Oradovsky, 1993).

Biochemical oxygen demand (BOD) samples were also taken during the cruise:

- station 8: 2 and 5 m BOD1;
- station 13: 30 m (bottom) BOD1 and BOD5;
- station 19: 21 m (bottom) BOD1;
- station 21: 32 m (bottom) BOD1;
- station 24: 15 m BOD1;
- station 30: 15 m BOD1;
- station 33: 15 m BOD1;
- station 36: 15 m BOD1.

The BOD samples were taken directly after DO sampling from the same rosette bottle in the same kind of glass bottles closed without fixing. Then the sample was stored in a dark cool place for one day for BOD1 and for five days for BOD5. After that the sample was treated with standard DO measurement procedure. The BOD was determined as the difference between usual DO concentration and the DO concentration in the sample.

The water samples for nutrient measurements were collected in 50-ml plastic bottles. Immediately after sampling the bottles were frozen in a freezer with temperatures below -17ºC. They were transported to the OSL for further analysis.

The dissolved oxygen was additionally measured by an SBE43 sensor mounted on the oceanographic SBE19plus CTD sensor. During the 2007-2009 cruises this yielded relatively good results in comparison with other DO sensors. Figure 4.2 demonstrates a comparison between sensor data and DO measurements with the Winkler method in September 2010. The sensor yields good results in the of range 7.5-8.3 ml/l of DO. At higher concentrations the data is not reliable. It does make sense to develop a data filtering procedure to reconstruct the values. At the moment only parts of the SBE43 sensor data of this cruise can be used for DO distribution analysis.

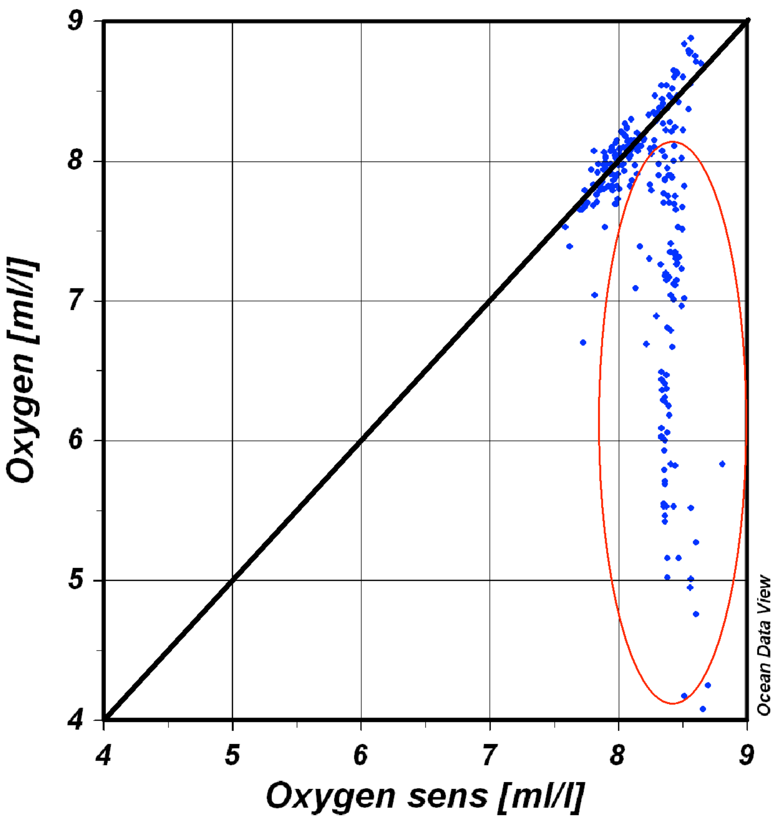


Fig. 4.2: Dissolved oxygen concentrations obtained with the SBE43 sensor and Winkler method in September 2010.

4.2. First results

Two transects illustrate the main pattern of water mass distribution in the shelf regions of the Laptev Sea: along 74°20’N and 126°E. Since these transects were also carried out during the summer cruises of 2007-2009, it is possible to compare the data of these four years. In summer 2009 the transect north-westward from the Lena Delta was also carried out and can be compared with 2010 cruise data. The parameters used for analysis are DO concentrations and DO saturation distribution. They were analyzed together with temperature, salinity and chlorophyll. More information can be obtained after processing the nutrient and CDOM samples.

The DO concentrations during the cruise had a range between 4.08 ml/l (station 4, bottom layer) and 8.88 ml/l (station 39, 15 m). The mean value is 7.54 ml/l.

The surface structural zone at the 131°00’E transect (Fig. 4.3) is represented by a mixed 12-m layer of river plume water. In agreement with temperature distribution, DO concentrations are higher in the northern part of the transect. In this part of the transect (station 9) there is a zone with increased DO concentrations (up to 8.13 ml/l) in the 5-10-m layer, where the water is saturated with oxygen over 101%. This coincides with the measured Chlorophyll maxima. In the bottom layer the lowest DO concentrations (4.08 ml/l) during this cruise are observed at station 4 in 22 m depth. They are 0.8 ml/l lower than the climatic mean but nearly equal to DO values for this region in September 2009. Such minima correspond to the bottom depressions where water masses remain from winter months and DO is strongly utilized for organic matter decomposition.

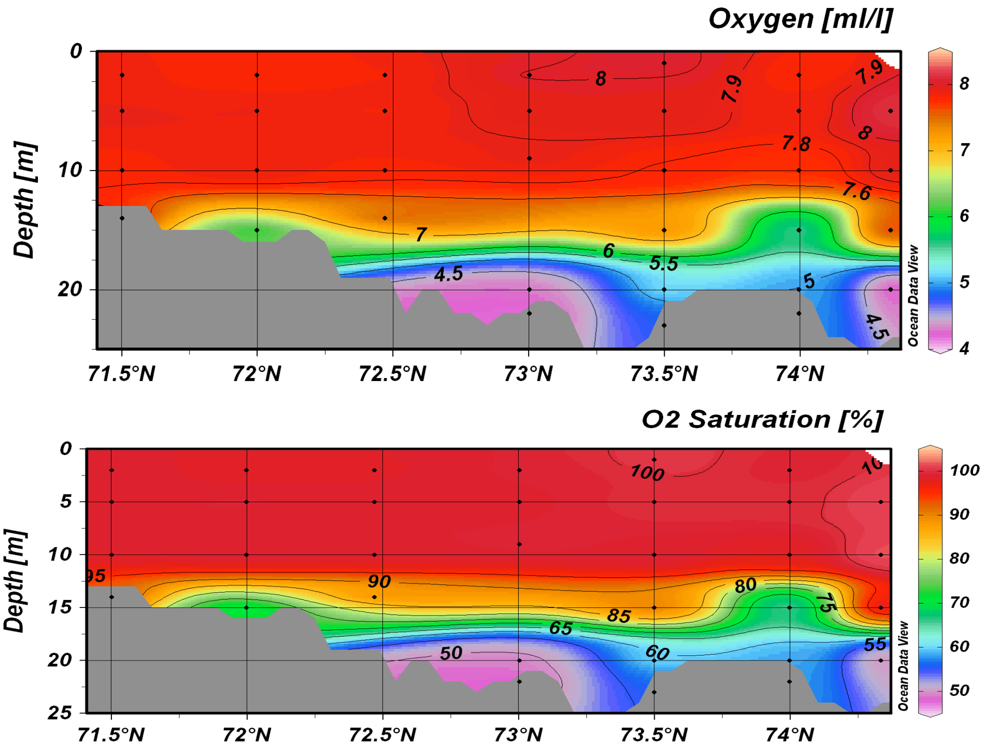


Fig. 4.3: Dissolved oxygen and DO saturation distribution on the 131°00’E transect in September 2010.

The eastern part of the transect 74°20’N (Fig. 4.4) is occupied by the river water eastward from 130°E. The water column here is mixed to 20 m. In the bottom depression (station 9) DO minima could be observed (4.17 ml/l). At the longitude 126-131°E there is the river plume, and a frontal zone could be distinguished. The water here has a high DO concentration (8.7 ml/l), is highly saturated with DO (102.6%) and is characterized by high Chlorophyll concentrations. In the bottom layer of this transect (lower than ~20 m) there is the winter bottom water mass. It is low-saturated with DO (70%, 5.16 ml/l), and has a temperature of about -1.0°C as well as a salinity of 31.8 PSU.

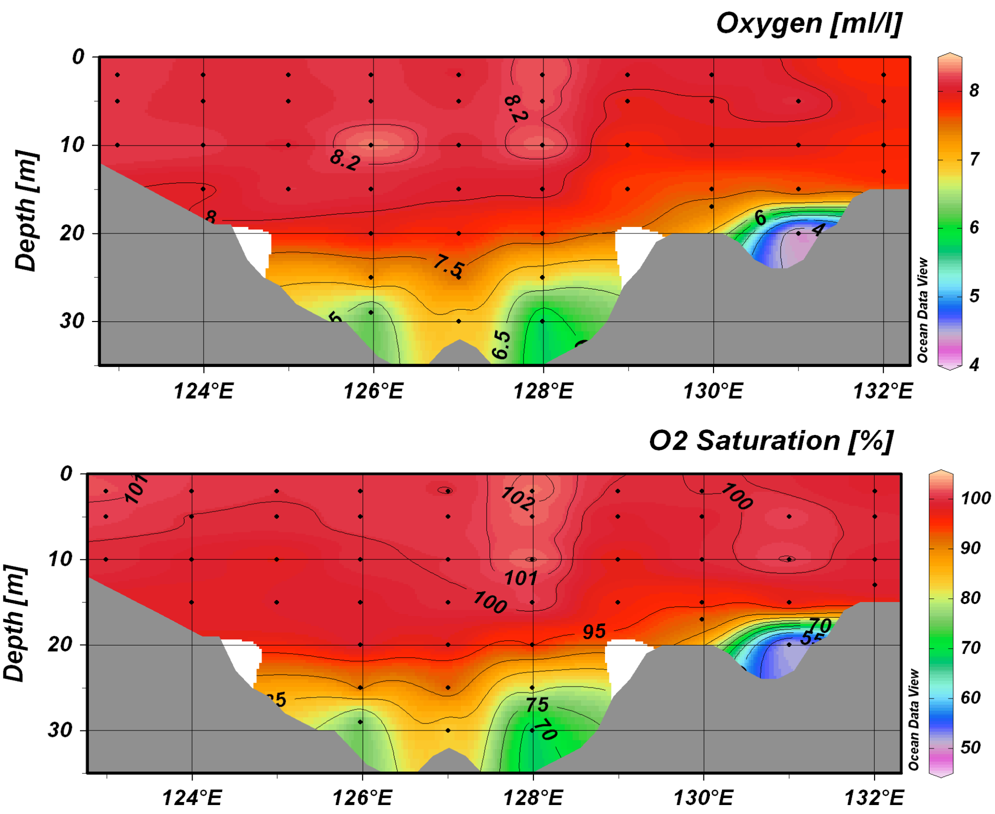


Fig. 4.4: Dissolved oxygen and DO saturation distribution on the 74°20’N transect in September 2010.

The river water on the transect 126°E (Fig. 4.5) extended to 74°N in the upper 10 m and has DO concentrations of 8.15-8.35 ml/l. Up to 77°N there is a vast river plume frontal zone. Here the mixed layer has a thickness of about 20 m. DO concentrations are 8.0-8.2 ml/l and the water mass is saturated with oxygen up to 101%. It is characterized by high chlorophyll *a* concentrations. Northward from 77°N in the 15-25 m layer the intermediate oxygen maximum is observed. DO saturation is up to 103.8%. This layer also has extremely high local chlorophyll *a* concentrations. The bottom layer is occupied by saline cold waters with relatively low DO concentrations (5.46 ml/l).

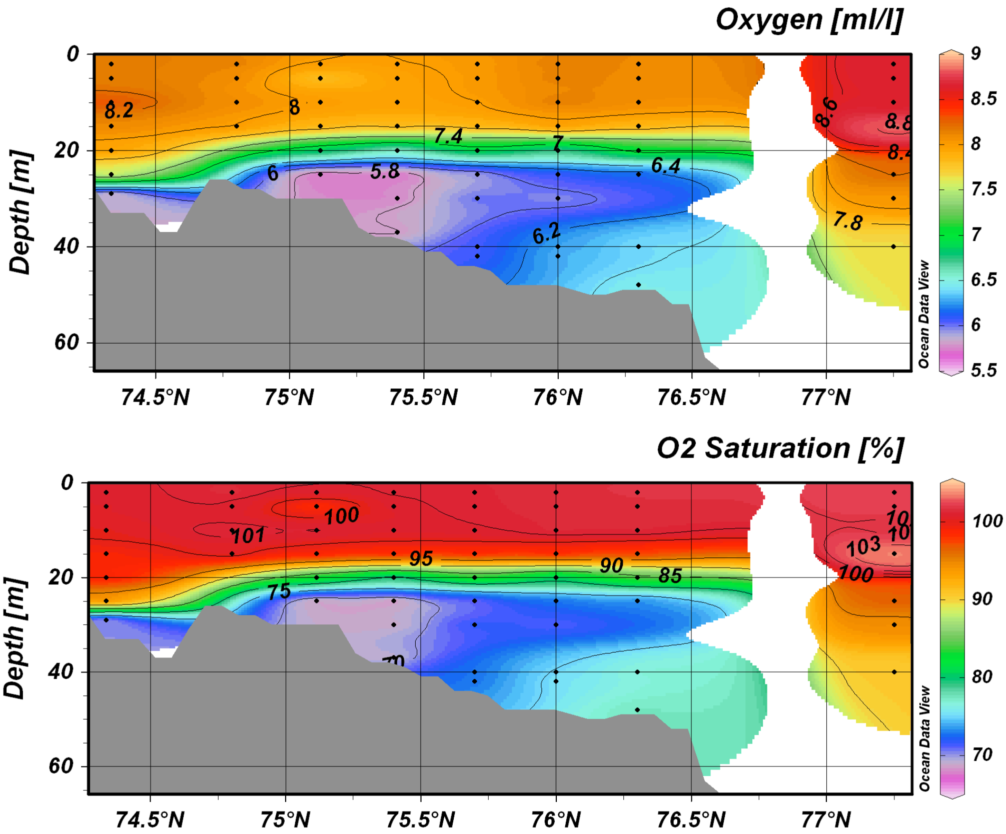


Fig. 4.5: Dissolved oxygen and DO saturation distribution on the 126°00'E transect in September 2010.

The river water plume could be recognized to 77°N at the transect 137°E (Fig. 4.6) within the upper 7 m, which corresponds to the extension of the river plume at the 126°E transect. DO concentration is about 7.8-8.15 ml/l in the surface layer. Oxygen concentrations are lower (6.70 ml/l) in the bottom layer of the southern part of the transect, which is related to DO consumption in oxidizing processes. Between 77°N and 77°30'N evidence of East Siberian bottom water mass could be observed in the bottom layer. It is characterized by relatively low DO (6.18 ml/l) and usually high nutrients, but this thesis can be proven only after the nutrient samples have been analyzed. Northward from 78°N weakly pronounced intermediate DO maxima could be recognized in the 8-13 m layer. Water is saturated with DO up to 100.4%.

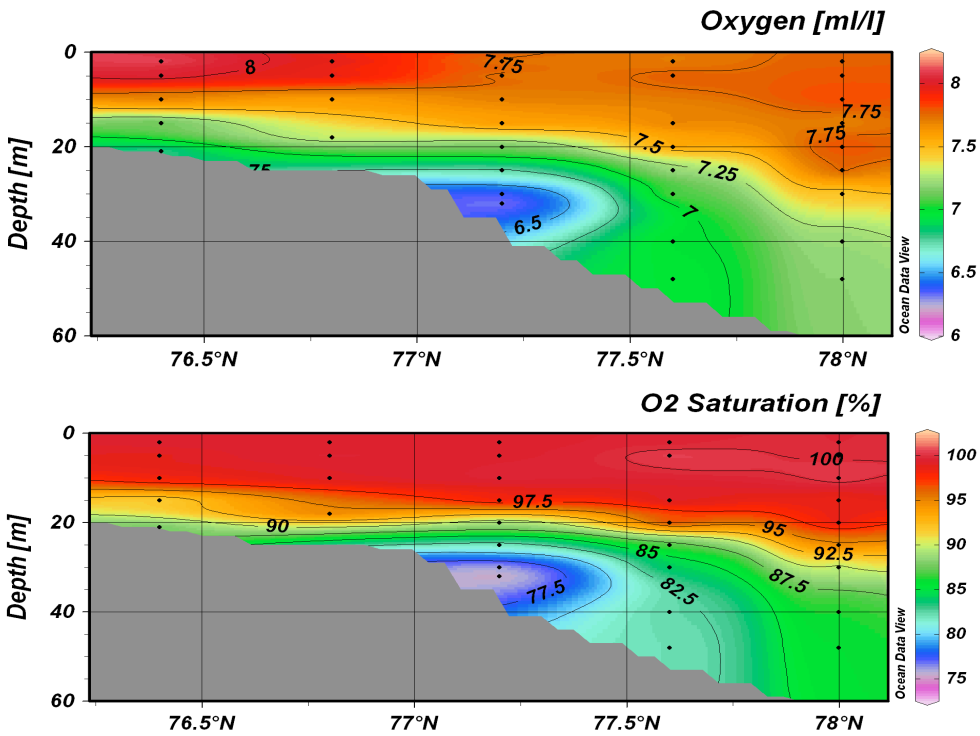


Fig. 4.6: Dissolved oxygen and DO saturation distribution on the 137°00'E transect in September 2010.

On the transect north-westward from Lena delta the surface layer is high saturated with DO (more than 100%) to 20 m depth (Fig. 4.7). At 15 m (Station 39) the DO maximum is fixed (8.88 ml/l). This maximum relates to a high oxygen intermediate layer, which was described for 126°N and can be partly recognized at the 137°N transects. In the bottom layer the remnants of a poorly DO-saturated (5.16 ml/l) winter water mass could be recognized.

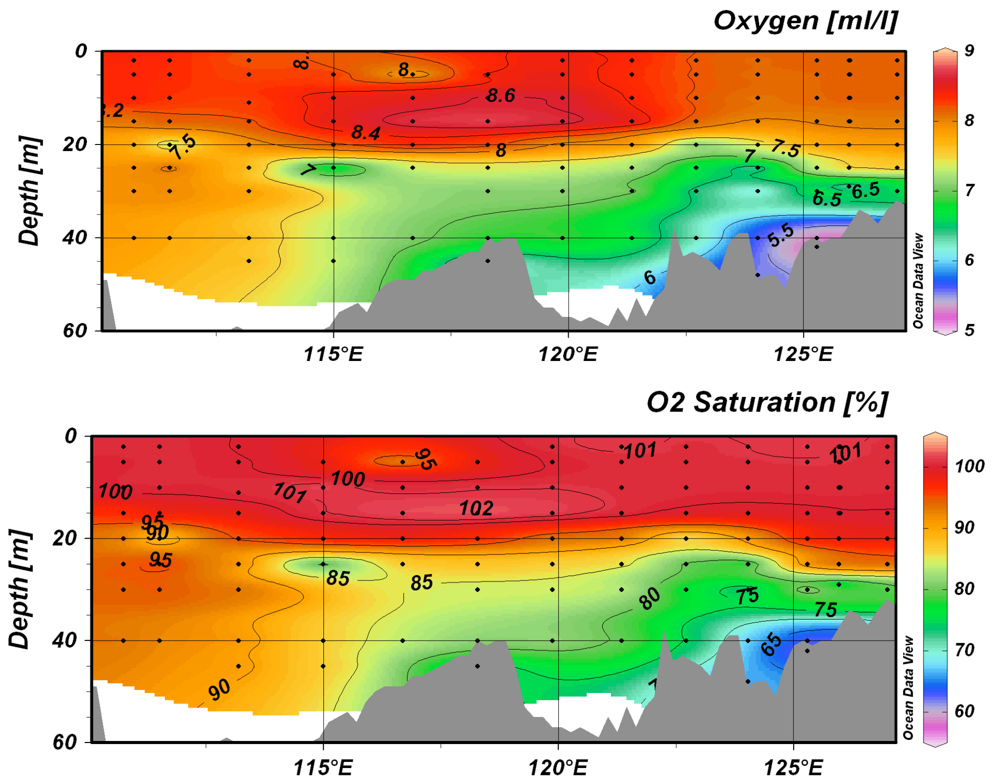


Fig. 4.7: Dissolved oxygen and DO saturation distribution on the transect north-westward from Lena delta in September 2010.

Most of the BOD samples were collected from the 15-m layer, which corresponds to the DO maxima depth in the Laptev Sea (Fig. 4.1). They display the average oxygen usage at the bottom layer of 0.14 ml/l*day-1, so BOD during five days in the bottom layer is about 0.7 ml/l. The average DO consumption in the intermediate oxygen maxima layer (at 15 m depth) is 0.16 ml/l*day-1.

To summarize: in the bottom depressions of the southern Laptev Sea shelf we observed very low DO concentrations (0.7-0.8 ml/l lower than the climatic mean). At the same time in the surface layer DO concentrations were nearly equal to the mean values. The intermediate DO maxima were expanded at the north-western part of the Laptev Sea, which corresponds to the river plume pattern.

5. Oceanographic investigations

Drastic climatic changes have recently been observed in the Arctic environment being evident in the sea-ice cover, thermohaline properties of surface and intermediate waters, air temperatures and atmospheric circulation. The Siberian shelves are the regions where the most pronounced consequences of these changes have been observed since the beginning of the 21st century. The warmer atmosphere and longer ice-free period result in more heat being accumulated in the surface, intermediate and bottom layers during summer. This heat is a plausible source for the a reduced ice thickness in the subsequent winter. The Laptev Sea is also affected by warmer Atlantic waters (AW) penetrating the outer and inner shelves through the deep submarine canyons. Although the AW are insulated from the atmosphere by the halocline layer, these waters demonstrate an extreme increase in temperatures and are suggested to present another potential source affecting sea-ice formation. On the other hand, the sea-ice shrinking and river runoff increase likely shift the Laptev Sea freshwater balance toward a fresher state. This means that vertical stratification is getting less penetrable for vertical mixing and heat/salt exchange.

However the particular problems of the Laptev Sea interior respond to the rapid Arctic changes have been insufficiently studied. Thus, the continuation of field activities within the framework of the joint Russian-German project “The Eurasian Shelf Seas in the Arctic's Changing Environment: Frontal Zones and Polynya Systems in the Laptev Sea” provides a good opportunity to conduct scientific researches aimed to consider the following objectives:

- to determine the general spatial distribution of temperature and salinity over the Laptev Sea shelf and figure out the position of frontal zones formed between the fresh river water plume and more saline waters of the deep Arctic Basin;
- to examine the influence of atmospheric forcing on river discharge distribution;
- to trace heat content anomalies over the Laptev Sea shelf and their vertical and horizontal extensions;
- to identify (through both thermohaline and hydrochemical analysis) the shallowest area on the inner shelf with evidence of Atlantic Waters;
- to determine the key mechanisms specifying the seasonal and climatic variations of water mass properties based on mooring records;
- reflecting the thermohaline preconditions prior to the new seasonal cycle of ice formation.

In order to answer these questions the oceanographic activities during the TRANSDRIFT XVII expedition were aimed to collect the data at several snap-shot sections and recover/deploy several mooring stations over the Laptev Sea shelf.

5.1. Seafloor observatories

During the TRANDRIFT XVI expedition in 2009 three seafloor observatories (ANABAR, KHATANGA and OSL2D, all shown in Fig. 1.2) were deployed for the period of one year in our working area to study the seasonal variability in temperature and salinity distribution within the water column, interacting processes in the transition water column/sediment and in the current system, and the transport processes as well as to monitor the ice conditions.

Two of the seafloor observatories were deployed in the nearshore area north of the Lena Delta to characterize processes in an onshore/offshore environment, to study changes in the hydrodynamic system and its interaction with the seafloor, and to catch polynya events during winter time. All of these seafloor observatories should have been recovered during the TRANSDRIFT XVII expedition. Recovery of the seafloor observatory OSL2D was not successful due to an unknown damage on the mooring: it was at the correct location but lying horizontally on the seafloor and did not come up.

Three seafloor observatories, namely ANABAR, KHATANGA and OSL2E, were re-deployed at the very same positions, while OSL4 and KOTELNYY are new seafloor observatories. Complementary high resolution (temporal and spatial) measurements of the water column were carried out near the bottom stations and along linking profiles including temperature, salinity, chlorophyll, oxygen, nutrients, turbidity and total suspended matter concentration measurements in the water column. These measurements were carried out by using a programmable carousel water sampler SBE 32C, as described below in more detail.

In addition the seafloor observatory in the St. Anna Trough (ST. ANNA, Fig. 5.1), deployed by AARI in 2009, was successfully recovered. This observatory was not re-deployed.

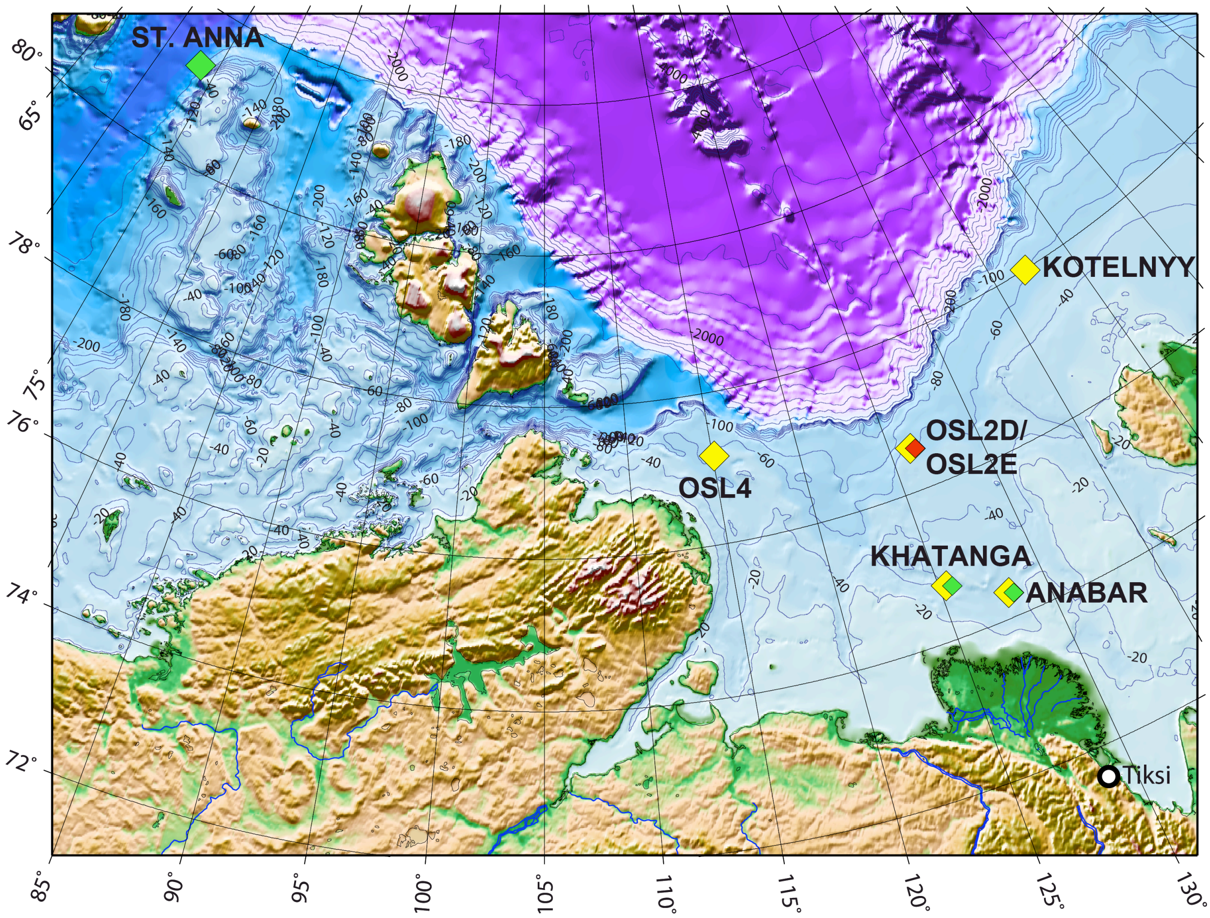


Fig. 5.1: All seafloor observatory deployments are marked yellow, while all successful recoveries are marked green. Red indicates the seafloor observatory that was scheduled to be recovered but could not be recovered.

All in all three seafloor observatories were recovered successfully (ANABAR09, KHATANGA09, ST. ANNA), one could not be recovered (OSL2D), and five were deployed (ANABAR10, KHATANGA10, OSL2E, KOTELNYY, OSL4).

All seafloor observatory operations where performed by T. Klagge, F. Martynov, A. Novikhin, S. Kirillov, I. Dmitrenko, V. Selyuzhenok, B. Juhls, T. Vollmer and F. Greil.

5.1.1. Methods and equipment

In general each seafloor observatory is equipped with at least one ADCP (Acoustic Doppler Current Profiler), which is able to measure current velocity and direction of the whole water column. We used ADCPs produced by RDI (USA), with a working frequency of either 300 kHz (for bigger range) or 1200 kHz (for higher resolution, and to cover gaps that could not be measured by the 300 kHz ADCP). In addition each observatory is equipped with at least one CTD SBE37, measuring conductivity, temperature and pressure at its deployment depth. Some seafloor observatories are equipped additionally with a conductivity-temperature-depth meter (CTTu; XR-420, produced by RBR, Canada), measuring conductivity, temperature and turbidity.

Due to the fact that each seafloor observatory design is at least slightly different, each of the recovered and deployed observatories is described in detail in the appendix, showing the sampling details (programming) of each instrument, as well as each observatory layout.

The general technical details of the instruments that are used on the seafloor observatories are shown in the following list.

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz (Acoustic Doppler Current Profiler)
  Memory: 64 Mbyte Flash-memory
  Nominal range: 135 m
  Vertical resolution (BIN cell size): 1 m
  Standard deviation: <25 mm/s
- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz (Acoustic Doppler Current Profiler)
  Memory: 64 Mbyte Flash-memory
  Nominal range: 15 m
  Vertical resolution (BIN cell size): 0.25 m
  Standard deviation: <25 mm/s
- RBR XR-420 CTTu (Conductivity-Temperature recorder with additional turbidity sensor)
  Memory: 8 Mbyte Flash-memory
  Conductivity range: 0 to 70 mS/cm
  Conductivity accuracy: 0.003 mS/cm
  Temperature range: -5 to +35°C
  Temperature accuracy: 0.0002°C
  Turbidity range: 0 to 750 FTU
  Turbidity accuracy: <2% deviation for 0-750 FTU
- Seabird SBE37 CTD (Conductivity-Temperature-Depth recorder)
  Memory: 2 Mbyte Flash-memory
  Conductivity range: 0 to 70 mS/cm

Conductivity accuracy: 0.003 mS/cm
Temperature range: -5 to +35°C
Temperature accuracy: 0.0002°C
Depth range: 0 to 100 m, 0 to 350 m and 0 to 600 m (depends on observatory)
Depth accuracy: 0.1% of full scale range

- Release-system IXSEA OCEANO 2500
  These releases are necessary for location and recovery of the seafloor observatories, and are equipped with a hydro-acoustic sender and receiver to communicate with the research vessel, and to initiate the release of the seafloor observatory from the anchor during recovery.

Verifying the ADCP data of the recovered seafloor observatories ANABAR09 and KHATANGA09 reveals that there is an error in measuring the current direction between the uplooking 300 kHz ADCP and the downlooking 1200 kHz ADCP.

This error can be assumed because there is nearly an overlap of the water masses measured by both ADCPs, and a difference of direction between these water masses of more than a few degree is very unlikely. Figure 5.2 shows the differences between the directions of the measured currents, which actually should be close to zero, but is ~50° for ANABAR09 and ~70° for KHATANGA09. The reason for these errors is still unknown and has to be discussed with the producer of the ADCPs (RDI, USA). In addition to that we will try to verify the ADCP data of the uplooking 300 kHz ADCP by comparing the drift direction of the surface ice, as measured by the ADCPs bottom track, against AMSR satellite images, which show the ice drift very well. By doing so we hope to be able to correct the ADCP current direction data to get a valid data set for the 2009-2010 deployment duration.

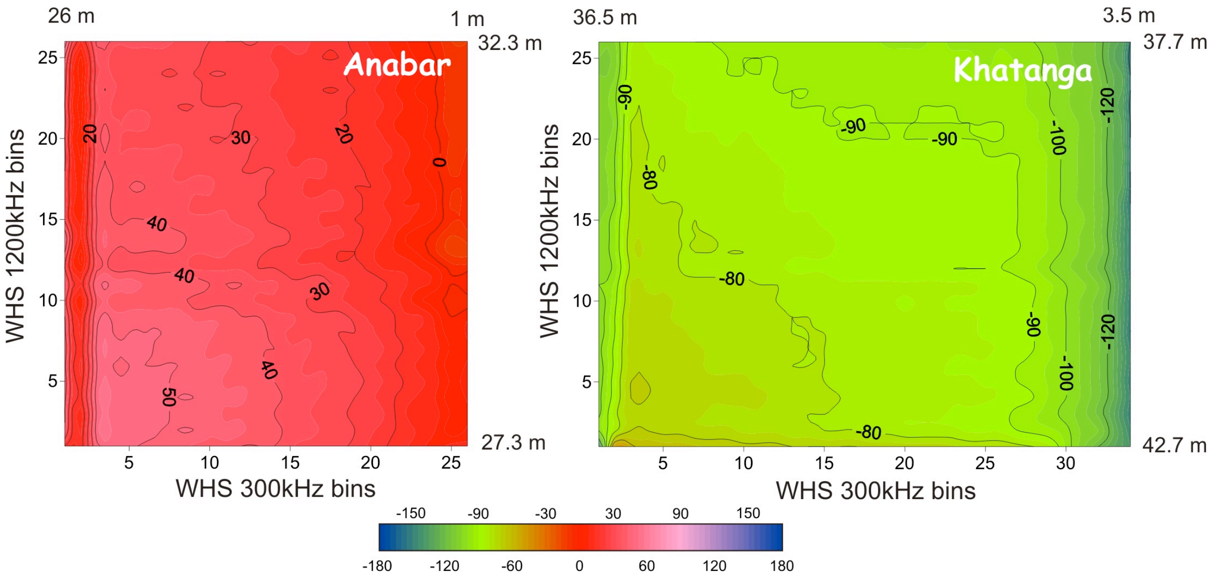


Fig. 5.2: The relative angles at which the highest correlation between two time-series current vectors (the uplooking WHS 300 kHz ADCP and the downlooking WHS 1200 kHz ADCP) are observed at ANABAR09 and KHATANGA09.

5.2. CTD MEASUREMENTS

Complementary high resolution measurements of the water column were carried out near the seafloor observatories and along linking profiles including temperature, salinity, chlorophyll, oxygen, CDOM and turbidity. These measurements were carried out by using two CTDs Seabird 19+, which were equipped with additional sensors and were either mounted on the carousel water sampler or used as single device on the hydrographic winch.

A map of all stations where a CTD cast was taken during the cruise is shown in Figure 5.3.

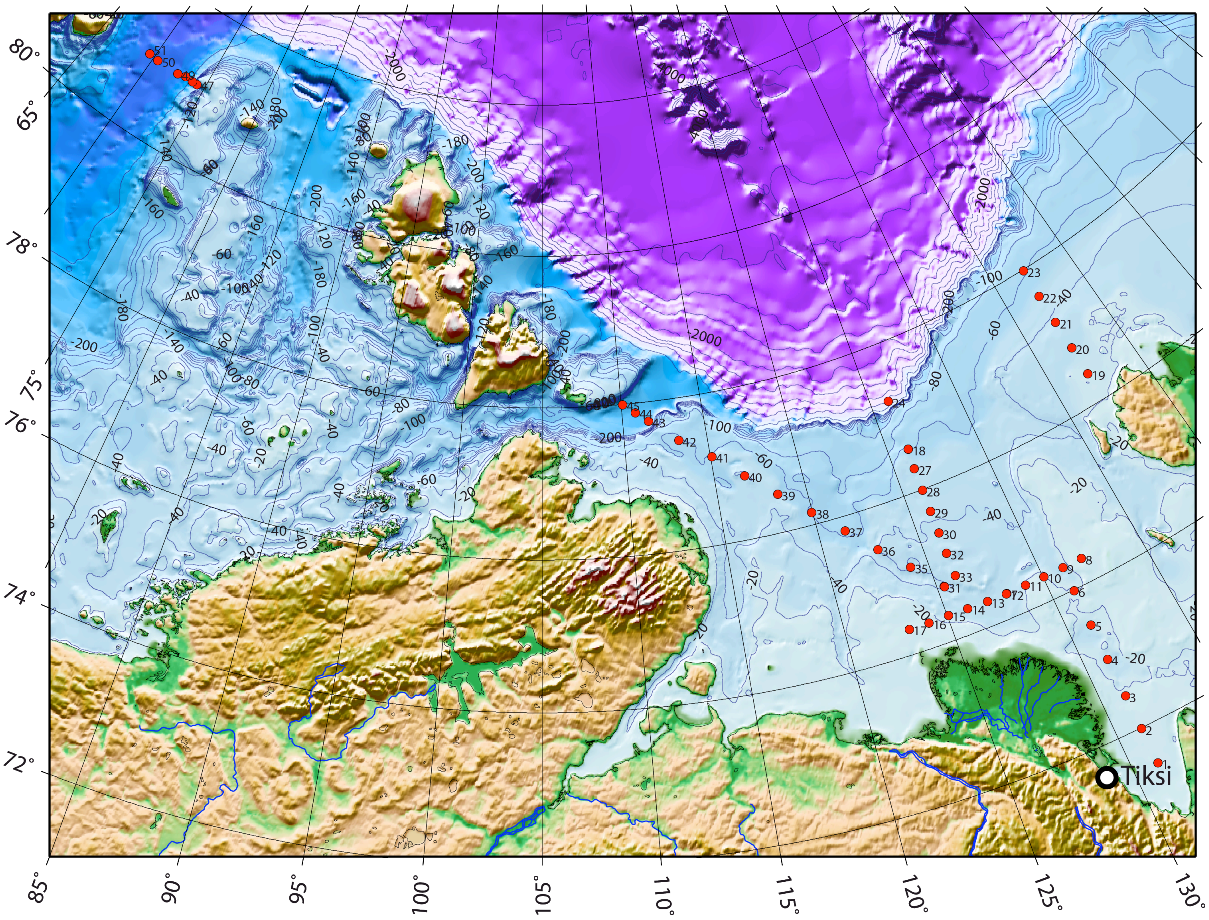


Fig. 5.3: All stations where CTD casts were taken during the TRANSDRIFT XVII cruise.

The carousel water sampler (rosette) and the CTDs were operatred by T. Klagge, A. Novikhin, F. Martynov, S. Kirillov, I. Dmitrenko, V. Selyuzhenok, B. Juhls, T. Vollmer and F. Greil.

5.2.1. Methods and equipment

Investigations at oceanographic stations included water probing and sampling with the use of the following equipment: CTD (Conductivity, temperature, depth) probe SBE 19 plus, a programmable carousel water sampler SBE 32C (“rosette”) with 5-liter plastic water-sampling bottles, and a release for closing the water-sampling bottles at certain depth levels (AFM, Automatic Fire Module). These instruments were operated by the ship’s crane as well as by the oceanographic winch (Fig. 5.4).

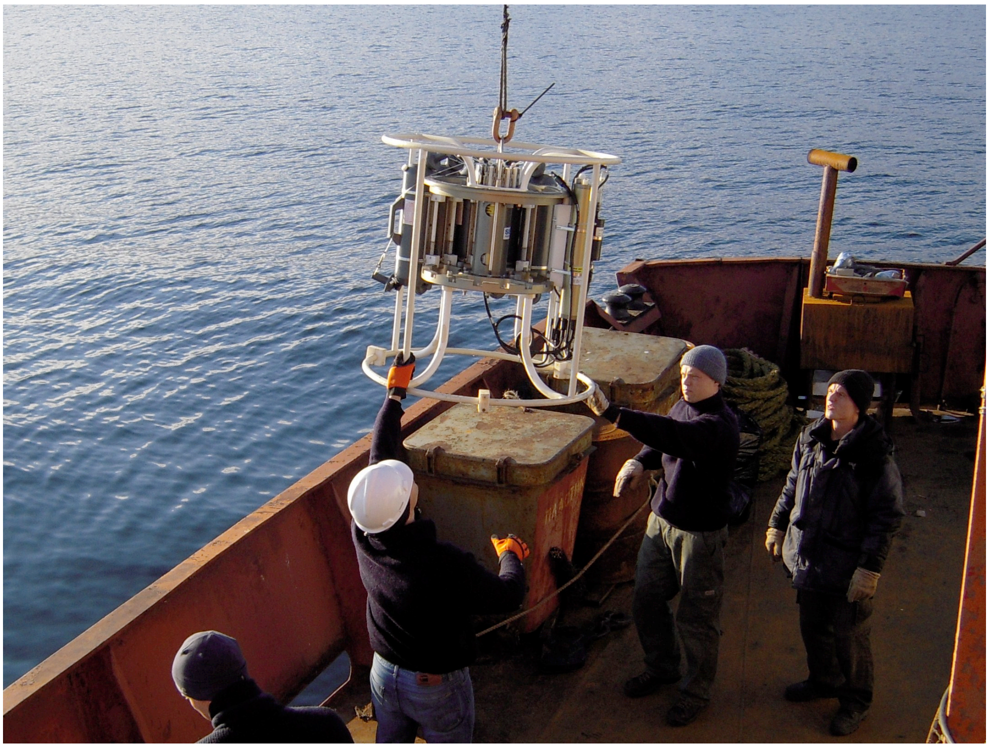


Fig. 5.4: The carousel water sampler SBE 32C ("rosette") which was used during our cruise.

The CTD SBE19+ system (Fig. 5.5), produced by Seabird Electronics Inc. (USA), continuously measures conductivity, temperature, dissolved oxygen, turbidity and chlorophyll at ~0.10 m depth intervals (assuming the 4Hz sample rate and the rate of deceasing ~30-40 cm/s).

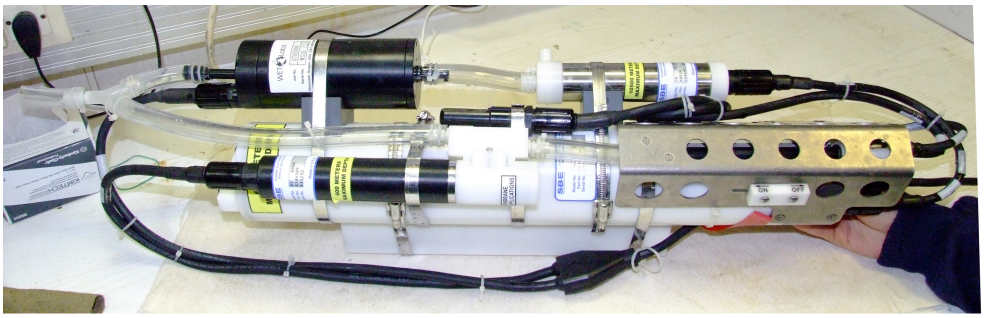


Fig. 5.5: CTD SBE19plus with additional sensors for dissolved oxygen, turbidity and fluorescence.

The measurement ranges are -5 to 35°C for temperature, 0 to 9 S/m for conductivity, and 0 to 600 m for hydrostatic pressure (maximum operational depth). The accuracy is 0.005°C for temperature, 0.0005 cm/m for conductivity, and 0.1% of the total measurement range for the hydrostatic pressure. Stability (monthly) of the temperature sensor is 0.0002°C, that of the conductivity sensor is 0.0003 cm/m, and of the hydrostatic pressure sensor 0.004% of the total measurement range. Resolution for temperature measurements is 0.0001°C, for conductivity measurements 0.00001 cm/m for freshwater, 0.00005 cm/m for seawater, and 0.00007 cm/m for highly saline water, and for hydrostatic pressure measurements 0.002% of the total measurement range. The default frequency of profile measurements is four scans per second (4 Hz).

The probe is equipped with a fixed memory of 8 MB recording the measurement results. The interface is RS-232. Power supply is maintained by nine batteries Duracell MN1300 (LR20, D-Cell) allowing for ~60 hours of profiling. The measured cast-data is downloaded from the fixed memory after the end of each measurement (CTD cast) by using the default Seabird cable and software. Remote data downloading or live data visualization is not possible due to the limited ship capabilities.

The instrument is equipped with additional sensors for measuring water turbidity (Seapoint OBS), dissolved oxygen concentration (SBE43) and fluorescence (WETlabs WETstar).

In addition to that a second CTD SBE19plus was used at several stations, having the very same initial characteristics as the SBE19plus above. On this second CTD only one additional sensor was attached, namely a WETlabs WETstar CDOM sensor (WETlabs, USA) to measure the amount of chromophoric dissolved organic matter along the CTD profile. Please note that at stations 26-30 the pumped tube which delivers freshwater to the sensor was cracked, so it can be assumed that the CDOM as well as the conductivity values at these stations do not fit to the depth and should be treated as not reliable. Due to the fact that the temperature sensor does not rely on pumped water, this sensor should have worked correctly.

The detailed technical and calibration characteristics of each mentioned instrument are shown in Table 5.1.

Table 5.1: Details for all sensors used for CTD profiling

Instrument	Producer	Sampling rate	Accuracy	Last calibration
Conductivity sensor of CTD SBE19+, serial # 5152	Seabird Electronics, USA	4 Hz	0.0005 S/m	August 2009
Temperature sensor of CTD SBE19+, serial # 5152	Seabird Electronics, USA	4 Hz	0.005°C	August 2009
Pressure sensor of CTD SBE19+, serial # 5152	Seabird Electronics, USA	4 Hz	0.1% of full scale range	August 2009
Conductivity sensor of CTD SBE19+, serial # 5245	Seabird Electronics, USA	4 Hz	0.0005 S/m	February 2009
Temperature sensor of CTD SBE19+, serial # 5245	Seabird Electronics, USA	4 Hz	0.005°C	January 2008, verified February 2009 (no calibration needed, coefficients stay the same)
Pressure sensor of CTD SBE19+, serial # 5245	Seabird Electronics, USA	4 Hz	0.1% of full scale range	October 2007, verified February 2009 (no calibration needed, coefficients stay the same)
Turbidity sensor	Seapoint	4 Hz	< 2% deviation for 0-750 FTU	June 2008
Oxygen sensor SBE43	Seabird Electronics, USA	4 Hz	2% of saturation	August 2009
Chlorophyll sensor	WETlabs WETstar	4 Hz	0.4 mV	July 2007
CDOM sensor	WETlabs WETstar	4 Hz	0.4 mV	May 2010

5.2. FIRST RESULTS

The salinities and temperatures measured at 2 m depth during the snap-shot oceanographic survey in September 2010 allow mapping the riverine water distribution over the Laptev Sea shelf (figs. 5.6, 5.7). These data show that the freshest waters are observed east of the Lena Delta in close vicinity of the Bykovskaya girt. The typical surface salinities over this region are within the range of 6-8 PSU with temperatures up to 7-8°C. The waters north of the Lena Delta are considerably transformed by mixing processes and heat loss to the atmosphere. This leads to more saline and colder surface waters with temperatures and salinities being in the range of +3 to +5°C and 17-20 PSU, respectively. The lack of observational data strongly restricts the examination of a likely path of riverine water in the eastern/ south-eastern Laptev Sea. However, the CTD measurements north of Kotelnyi traced the low salinity (~15-16 PSU) in the surface layer accompanied with relatively high temperatures (+4.0 to +4.5°C) providing evidence for the river origin of the waters being present in this region. Considering the higher salinities north of the Lena Delta we can suggest that the Lena River discharge spreads to the east and north-east presumably due to the anticyclonic atmospheric circulation over the Siberian shelves during summer.

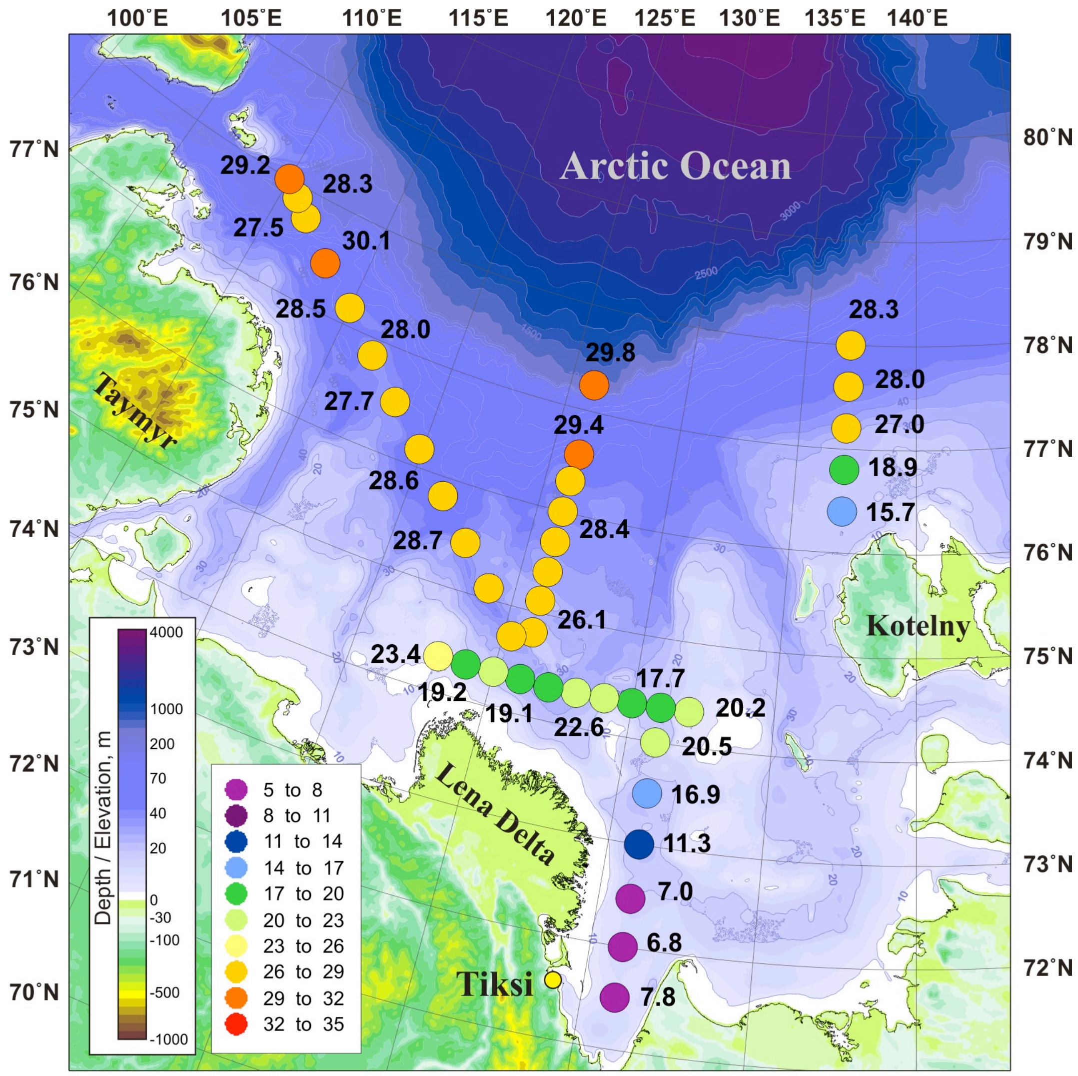


Fig. 5.6: Map of surface water salinity distribution in the Laptev Sea in September 2010.

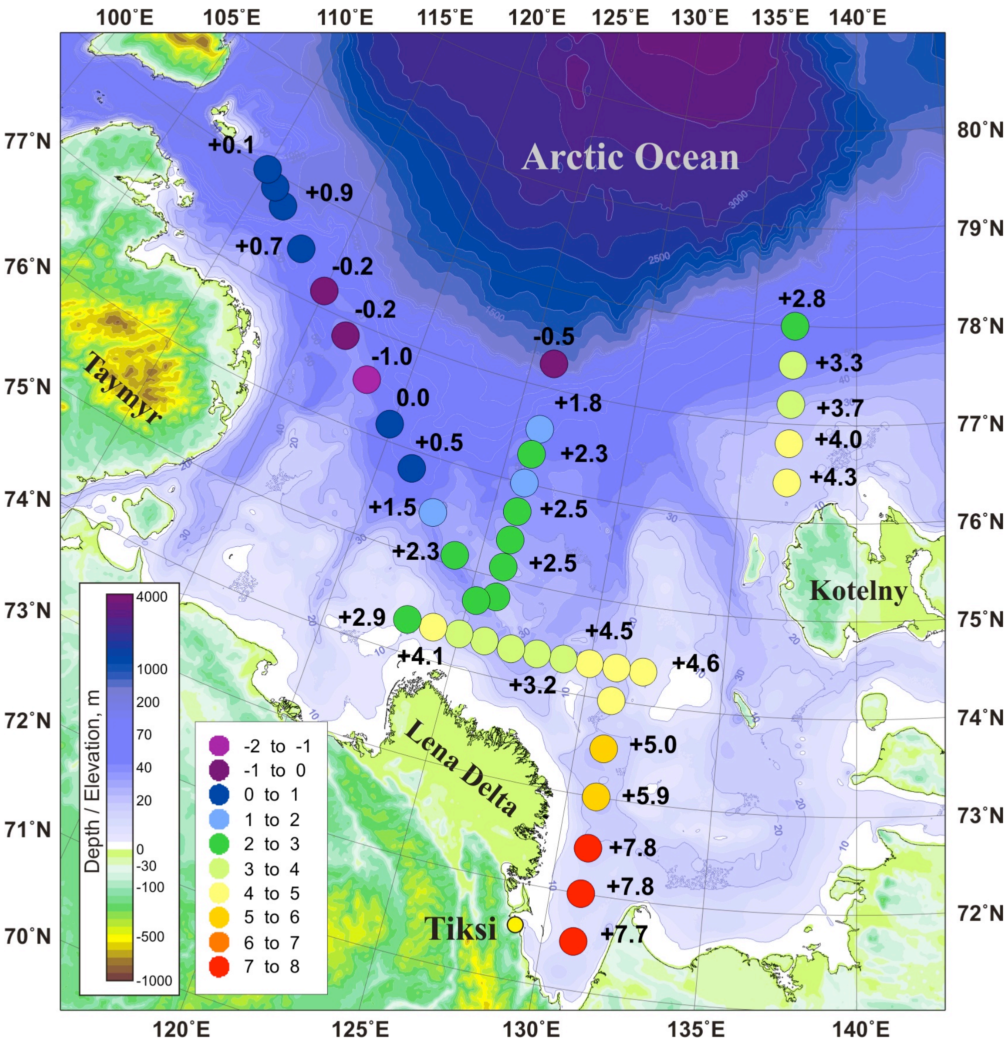


Fig. 5.7: Map of surface water temperature [°C] distribution in the Laptev Sea in September 2010.

A review of vertical temperature (T) and salinity (S) distribution at several oceanographic sections was carried out to distinguish the key vertical thermohaline structure over the Laptev Sea shelf. Figure 5.8 shows the changes in T and S properties at the snap-shot oceanographic sections east and north of Lena Delta. A pronounced two-layer structure is evident through these transects: a weakly stratified warm and fresh surface layer which occupies the upper 10-15 m; and a highly stratified pycnocline layer insulating salty and cold bottom waters having negative temperatures and salinities higher than 25-27 PSU.

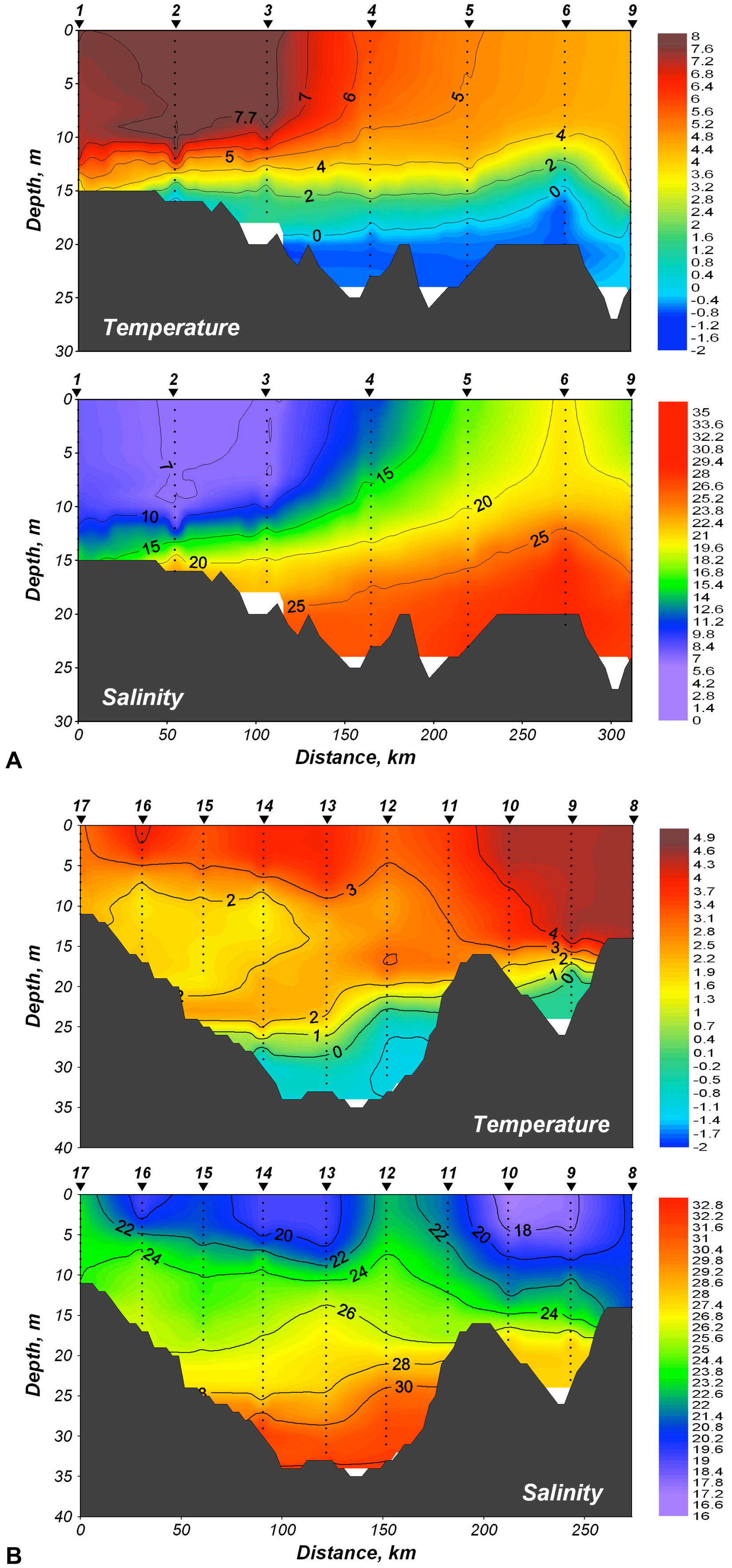


Fig. 5.8: Vertical distribution of temperature and salinity in the sections east of the Lena Delta along 131°E (A) and north of Lena Delta along 74.33°N (B)

The mixing between the fresh river and more salty surrounding waters leads to a gradual increase in both surface water salinities and pycnocline depth toward the north. The signature of high surface water temperatures north of Kotelnyi Island suggests that the heat exchange with the atmosphere exceeds the thermal energy loss due to the lateral and vertical mixing processes. It accordingly results in a deeper thermocline in comparison with the depth of the pycnocline associated with river discharge (Fig. 5.9).

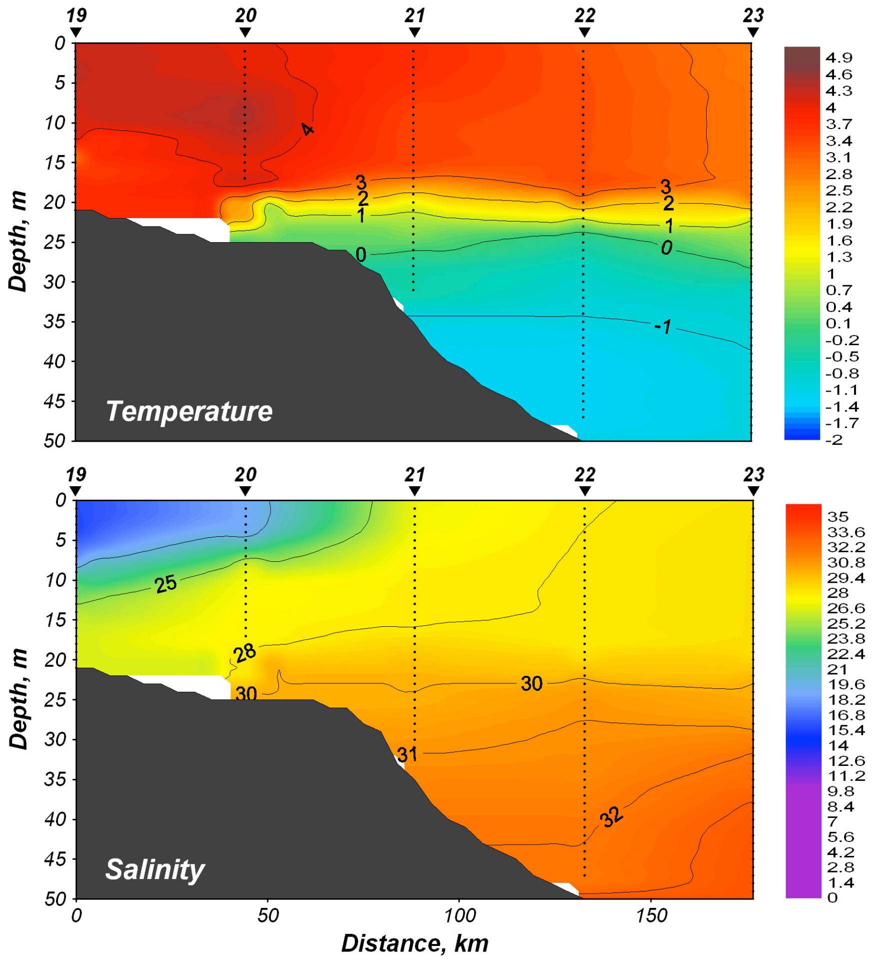


Fig. 5.9: Vertical distribution of temperature and salinity in the section north of Kotelnyi (along 137°E).

Both the Rosette CTD (down to 50 m depth or seafloor) and the additional CTD (for the deeper transect portions) were used to plot the temperature and salinity transects from Lena Delta to Vilkitsky Strait (Fig. 5.10). A comparison of the similarity of both series of CTD measurements can be found in section 1.6, the general description of methods and equipment. The deepest part of these transects with depths up to 300 m is located in the west and captures the submarine valley connecting deep basin and Vilkitsky Strait. This valley is a feasible channel providing the path for Atlantic Waters (AW) inflow from the Laptev Sea continental slope to the shallow shelves. The existence of AW signature in this depression is evident since it is the only possible source of warmer waters in the intermediate depths and near the bottom in this region. Thus, the lower part of the water column deeper than 100 m demonstrates a steady increase of water temperatures up to 0.5-0.7°C accompanied with numerous thermohaline intrusions at different levels (Fig. 5.11). These intrusive structures are the intrinsic attribute which indicates the cross-frontal AW layer dynamics in the deep Arctic Basin.

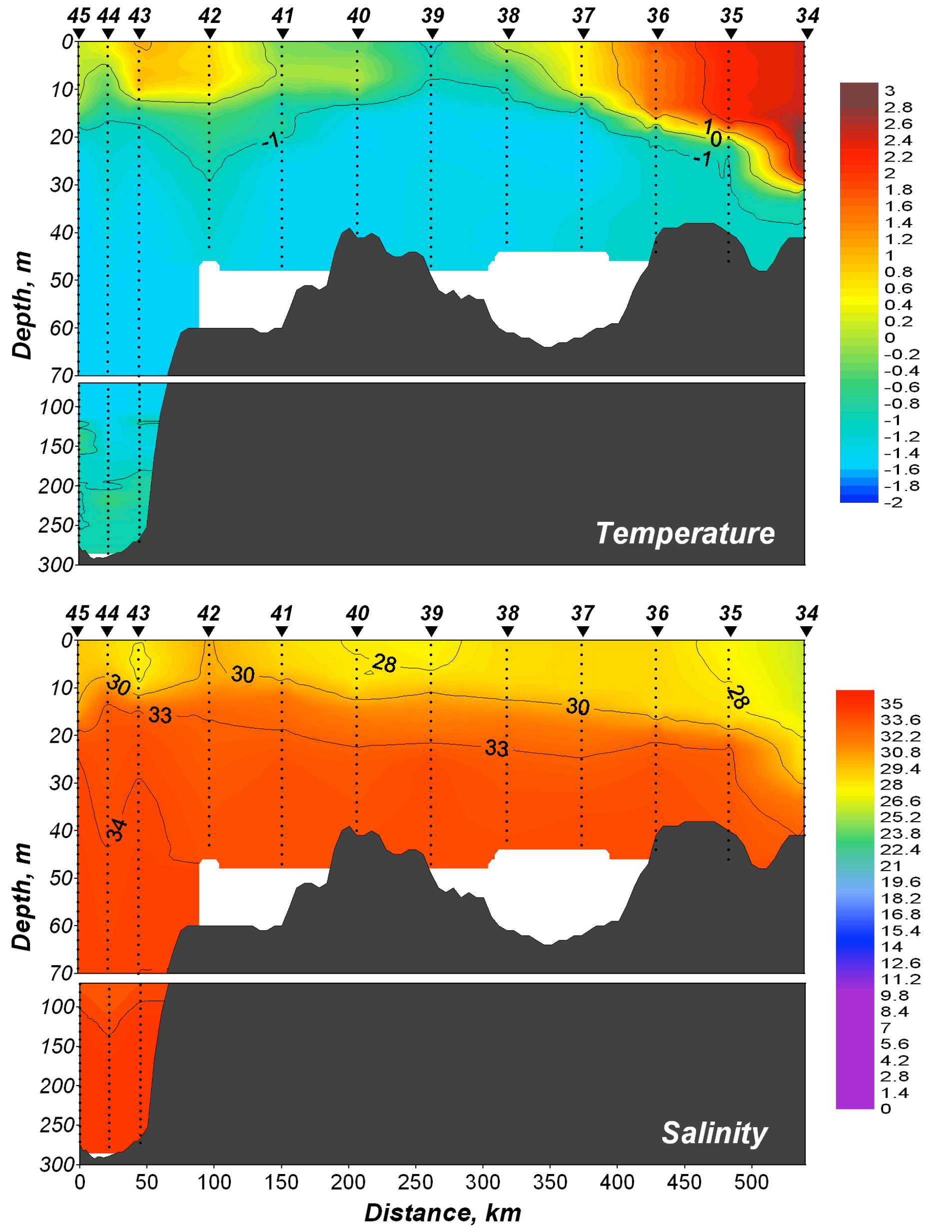


Fig. 5.10: Vertical distribution of temperature and salinity in the western section.

Another remarkable feature of this transect is the presence of relatively warm (+1°C) and fresh (~28 PSU) surface waters in the west (Fig. 5.10). One may suppose that these waters originate from the Kara Sea and flow to the north-western Laptev Sea through Vilkitsky Strait.

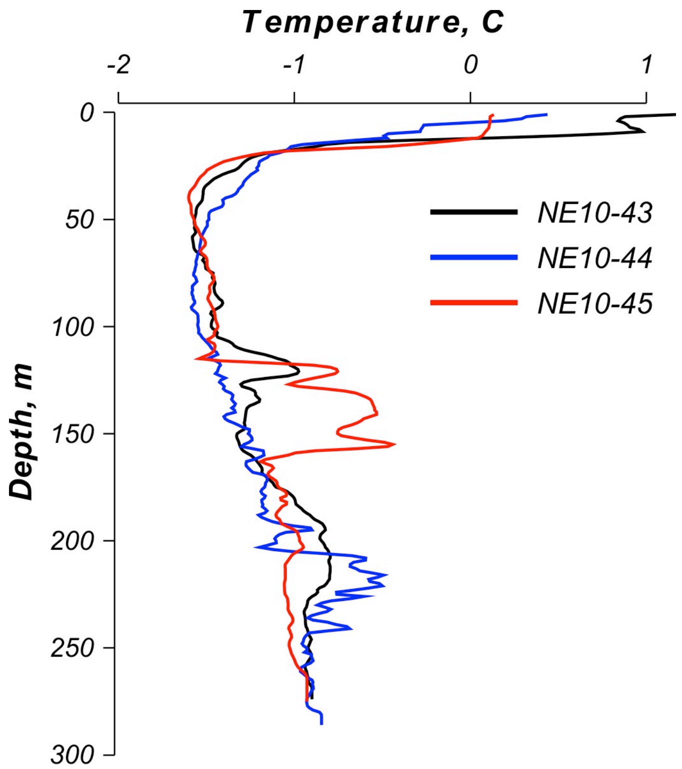


Fig. 5.11: Vertical distribution of temperature at the deep stations NE10-43, NE10-44 and NE10-45 carried out on September 20, 2010.

6. TRACER OCEANOGRAPHY – STABLE OXYGEN ISOTOPES

The aim of our subproject is to use stable oxygen ($\delta^{18}O$) isotopes of the water to study the formation of sea-ice and brine waters and the river water distribution on the Siberian shelf.

The Siberian shelves supply freshwater to the Arctic Ocean halocline at the same time as the main areas of sea-ice formation produce and export brine to the Arctic Ocean halocline and to the Arctic Ocean bottom and deep waters. An important question is therefore the feedback of these processes to the ongoing climate change, which may alter the ability of the Arctic Ocean halocline to insulate the atmosphere from the warm Atlantic layer and thereby maintain the perennial sea-ice cover.

This study is aimed to investigate the impact of brine waters on the hydrography of the Laptev Sea. The shelf regions are free of sea ice during summer when large quantities of river water spread onto the shelves. Melt water is also released during this time while sea-ice and brine waters are formed during winter. Since the Laptev Sea is one of the main production areas for Arctic sea ice, and large quantities of Arctic freshwater are released here by the Lena River, possible changes in the Laptev Sea may potentially also significantly influence the Arctic Ocean hydrography.

Our study is carried out on the basis of the oxygen isotope composition ($\delta^{18}O$) of the water in conjunction with hydrological data. River water in the Arctic is highly depleted in $\delta^{18}O$ relative to marine waters. The effect of sea-ice melting or formation can be separated from this source since sea-ice processes strongly influence salinity whereas the $\delta^{18}O$ signal remains nearly unaltered. On this basis winter brine production can be quantitatively evaluated based on $\delta^{18}O$ and salinity summer data.

Sampling was done by A. Nikulina, A. Novikhin I. Kryukova, I. Semeryuk and A. Loginova.

6.1. METHODS AND EQUIPMENT

The water samples for the stable oxygen analysis were taken from the Niskin bottles filled automatically at the certain depths. We took water samples immediately after the sampling for dissolved oxygen and prior to other water samples with a plastic tube put directly into the bottle to avoid significant gas exchange. The samples were kept in dark glass bottles of 100 ml volume with plastic stoppers and lids. Later the lids were sealed with a hot mixture of bee wax and paraffin to prevent stable oxygen isotope fractionation during storage and transportation period due to evaporation. The samples that were prepared for transport were kept in a cool place avoiding freezing.

The using of stable oxygen isotopes for water mass studies is based on the fact that the natural abundance of oxygen isotopes is ^{16}O = 99.76%, ^{17}O = 0.04% and ^{18}O = 0.2%. At that the measured ratio of ^{18}O /^{16}O (R) is given as the per mille deviation relative to the standard. In the case of ocean water this is the sea water standard SMOW (standard mean ocean water): $\delta^{18}O$ -sample = (R sample / R standard -1) x 1000.

Since ^{18}O is slightly heavier, a water molecule with $H_2{}^{18}O$ will evaporate less easily and later than its lighter counterpart but it will condense more easily and earlier than $H_2{}^{16}O$. Therefore there are isotopically different water masses. Most pronounced is the isotopic composition of river water (fed by evaporation and successive precipitation) with a $\delta^{18}O$ value for the Lena River of about -20‰. Atlantic water on the other hand has a $\delta^{18}O$ value not lower than 0.4‰.

6.2. First results

We took 258 water samples for $\delta^{18}O$ during the TRANSDRIFT XVII expedition to the Laptev Sea. Samples were taken at all of the water sampling stations down to the bottom. Due to the limited crane abilities, no samples could be taken from deptha greater than 48 m. Sampling depths were usually 2, 5, 10, 15, 20, 25, 30, and 40 m. Sampling of the deepest sample was as close to the bottom as possible in order to capture bottom layers or bottom currents. The exact sampling depth at each station can be found in the station list in the appendix, while all stations where samples were taken can be seen in Figure 6.1.

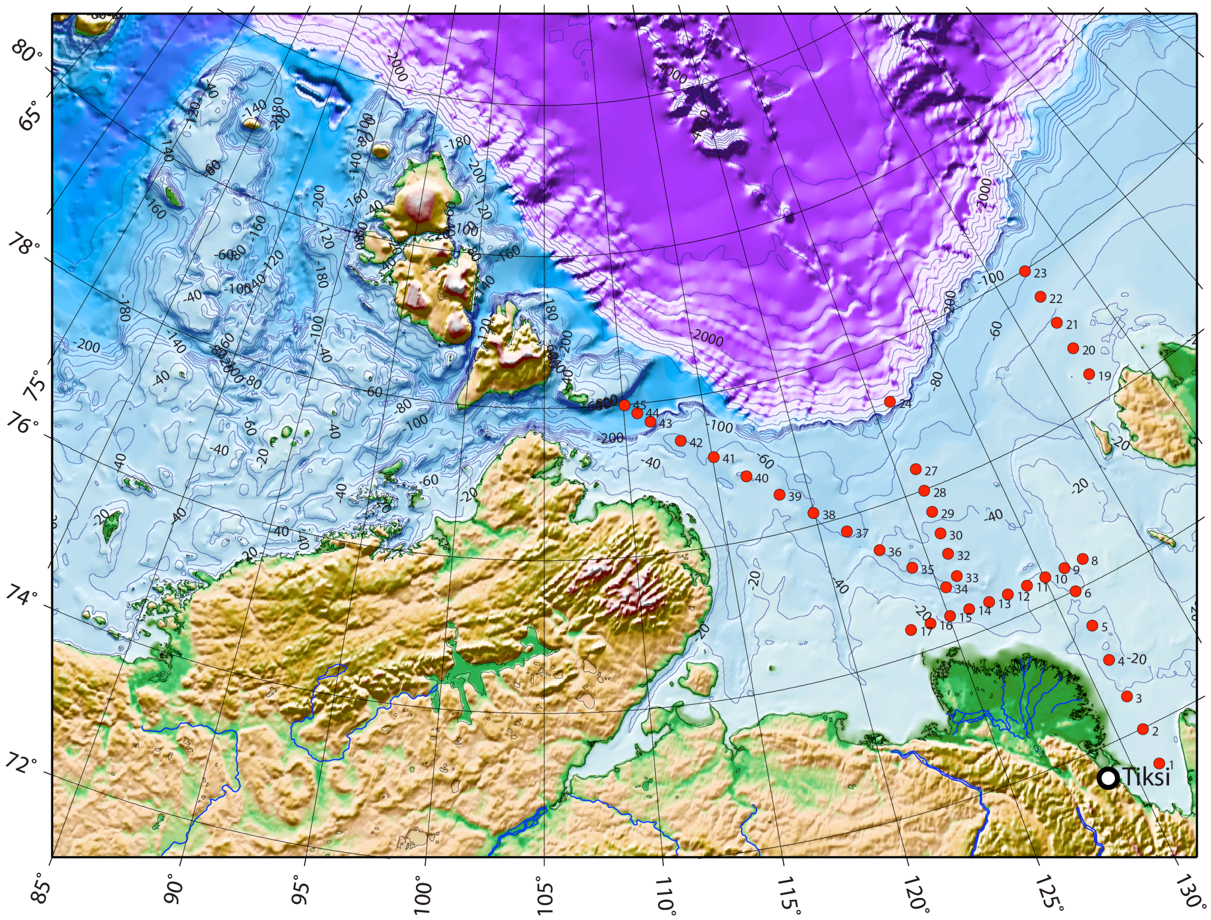


Fig. 6.1: All stations where stable oxygen isotope samples ($\delta^{18}O$) were taken during the TRANSDRIFT XVII cruise.

Further isotope measurements will be done within the year. Prior to isotope composition the exact salinity within the water samples will be determined with a salinometer (IFM-GEOMAR) with a precision of 0.003 and an accuracy of at least 0.005 in addition to CTD measurements. The analysis of the stable oxygen isotope ratio will be conducted with ion spectrometry at the Leibniz Laboratory for

Radiometric Dating and Isotope Research at Kiel University with the usual precision about ±0.05‰ in $\delta^{18}O$.

For our investigation we will use the calculated fractions of sea-ice meltwater/brine and river water in the water column. The fractions are calculated from the water mass balance based on $\delta^{18}O$ and salinity data for every sampling point. It is assumed that each sample is a mixture between marine water (f_{mar}), river-runoff (f_r) and sea-ice meltwater (f_i). The balance is governed by the following equations:

$$f_{mar} + f_r + f_i = 1,$$

$$f_{mar} * S_{mar} + f_r * S_r + f_i * S_i = S_{meas},$$

$$f_{mar} * O_{mar} + f_r * O_r + f_i * O_i = O_{meas},$$

where f_{mar}, f_r and f_i are the fractions of marine water, river-runoff and sea-ice meltwater in a water parcel, and S_{mar}, S_r, S_i, O_{mar}, O_r and O_i are the corresponding salinities and $\delta^{18}O$ values. S_{meas} and O_{meas} are the measured salinity and $\delta^{18}O$ of the water samples. For the Laptev Sea region a special selection of salinity and $\delta^{18}O$ end-member values is required (Bauch et al., 2003; Bauch et al., 2005) as it is shown in Table 6.1.

Table 6.1: Endmember values used for mass-balance calculations in the Laptev Sea

Endmember	**Salinity (PSU)**	**$\delta^{18}O$ (‰)**
Marine (f_{mar})	34.92	0.3
River (f_r)	0	-20
Ice (f_i)	0	-4

Past observations have shown that the circulation pattern within the shelf can strongly influence the structure of the halocline within the Arctic Ocean. Combined salinity and $\delta^{18}O$ data from the summers of 2007 and 2008 revealed a significant change in brine production in the Laptev Sea relative to the summer of 1994. While in 1994 maximal influence of sea-ice formation is seen within bottom waters, in 2007 the influence of sea-ice formation is highest within the surface layer with only a moderate influence of sea-ice formation on the bottom layer and in 2008 the intermediate water layer contains a significant brine signature (see Fig. 6.2). The observed changes if persistent or more predominant in the future may result in an altered export of waters from the Laptev Sea to the Arctic Ocean halocline.

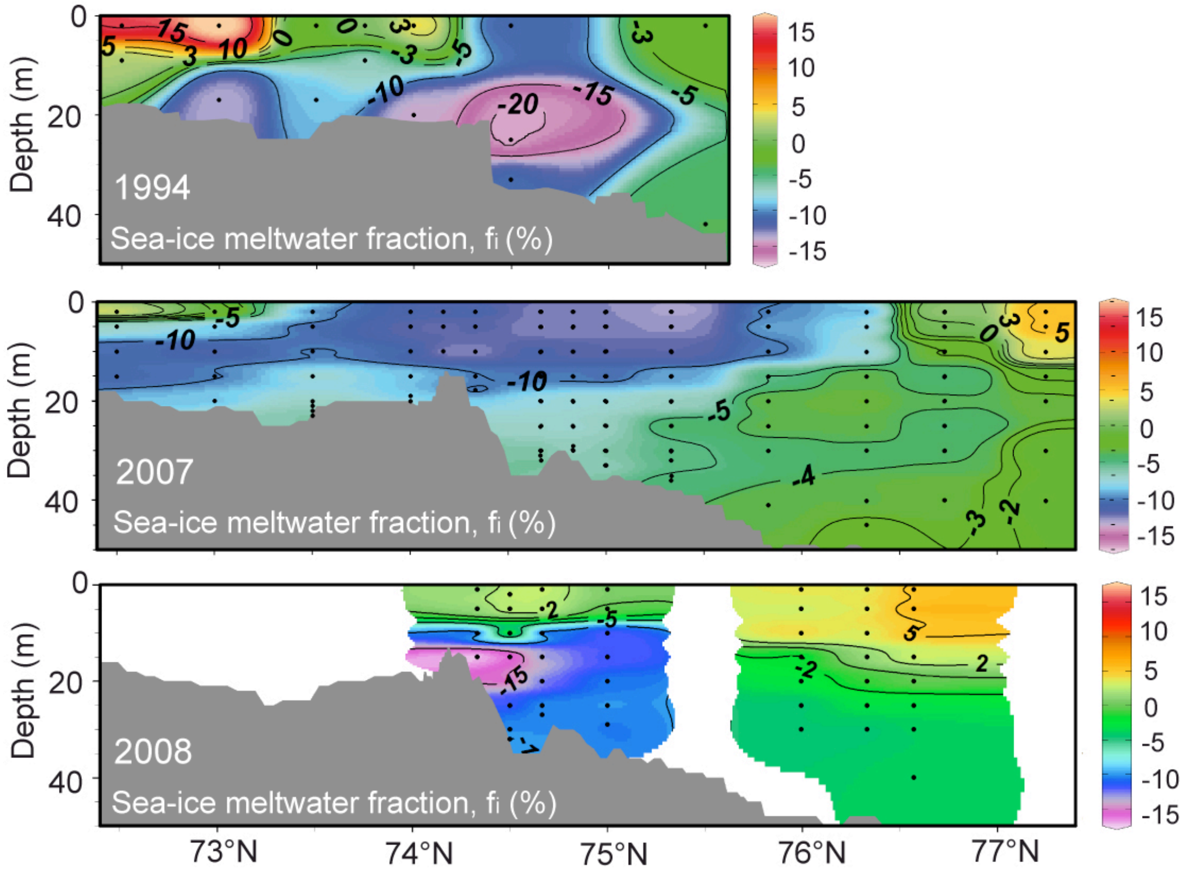


Fig. 6.2: Annual distribution of sea-ice meltwater fraction (brine signal) along the south-north transect from the Lena River valley to the outer shelf.

7. Investigations on Chromophoric dissolved organic matter

Chromophoric dissolved organic matter (CDOM) exists in all natural waters. Its source is the degradation of plant material of both terrestrial and aquatic origin. In coastal waters it occurs in large quantities due to runoff from rivers and it is responsible for a major part of the attenuation of photosynthetically available radiation (PAR). CDOM's light adsorption properties can result in both a positive and a negative feedback on aquatic organisms. In surface layers harmful UV light is attenuated, while deeper in the water column light is limited (Stedmon & Markager, 2001). Thus CDOM can play a substantial role in the biogeochemistry of natural waters merely through its influence on the aquatic light field (for a review see Blough & Del Vecchio, 2002). The runoff from the Lena to the Laptev Sea is characterized by high concentrations of CDOM. Based on results of recent studies, we assume that riverine CDOM mixes conservatively with seawater. During the TRANSDRIFT XVII expedition we collected CDOM data with which we will test this hypothesis, and determine if the CDOM concentration in the Laptev Sea can be used as a tracer for the spatial distribution, transport and mixing processes of river water on the Laptev Sea shelf. The determination of the CDOM concentration in water samples will be supplemented by in-situ sensor measurements (WETLabs, CDOM sensor) parallel to all CTD casts.

Sampling was done by A. Nikulina, A. Novikhin I. Kryukova, I. Semeryuk, A. Loginova, K. Wittbrodt, I. Ivanoschuk, O. Zhaden, S. Antonova and Y. Tropina.

7.1. Methods and equipment

Sampling was carried out along a transect across the Laptev Sea shelf (along 126°E), a south-north transect east of the Lena Delta and a transect running from the Lena Delta to the north-western Laptev Sea (Fig. 7.1). Samples were taken of water from different water depth (2 m, 10 m, 15 m, 20 m, 30 m, 40 m, 50 m, and last sample depth), filtered on board, and will be analyzed immediately after the expedition at the OSL.

Approximately 300 ml of seawater was filled in a pre-cleaned (with seawater from the same water sampler) bottles. Immediately after sampling the seawater was vacuum-filtered (with 250 ml NALGENE filtration set at approx. 400 mbar) through a Whatman GF/F glass microfiber filter (4.7 cm diameter) with a nominal pore size of approx. 0.7 µm. The filter was pre-washed with ~20 ml Milli-Q water and ~20 ml of the seawater sample. After washing the filter, 250 ml of seawater was filtered. 50 ml of the filtrate was used to rinse the storage bottles. The rest of the filtrate (200 ml) was filled into two storage bottles and stored dark and cold. The filter was air-dried and packed in aluminum foil. The CDOM analysis will be carried out on a SPECORD 200 spectrophotometer at the OSL.

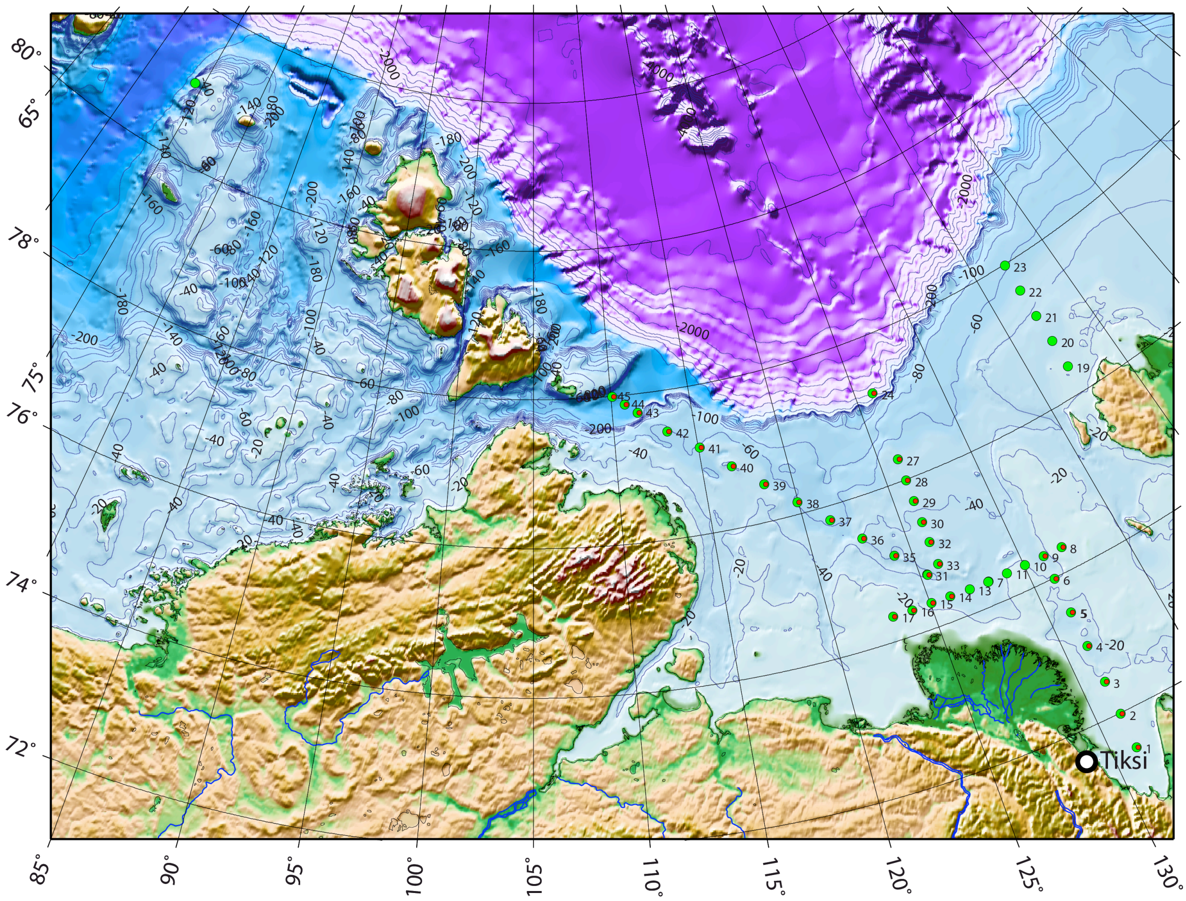


Fig. 7.1: All stations where CDOMsamples were taken are marked green, while all stations where the CDOM sensor was used (in addition) are marked red.

7.2. First results

In addition to the water samples, a CDOM sensor was used at several stations in the Laptev Sea. It is planned to calibrate this sensor with the direct measurements. It will be possible to determine the sensor's accuracy and the obtained data quality after processing the CDOM water samples in the OSL.

Figure 7.2 demonstrates the CDOM distribution at the 126°E and 137°E transects.

The analysis of the CDOM profiles revealed a quite good correlation of CDOM distribution with other water parameters such as DO, chlorophyll *a*, temperature and salinity. The river plume area is well recognizable using CDOM profiles.

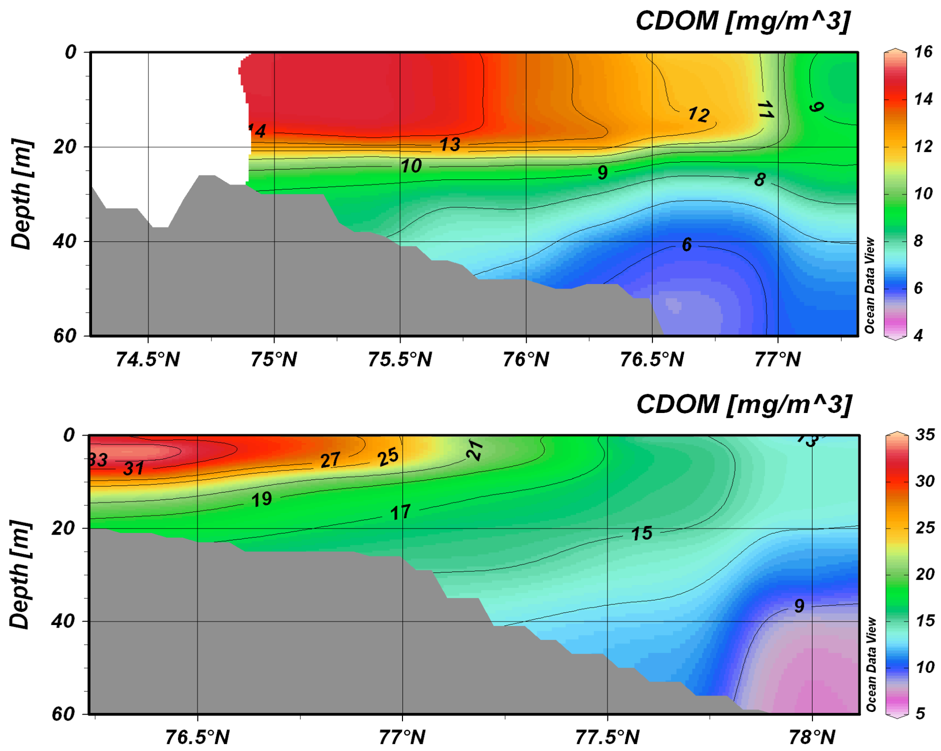


Fig. 7.2: CDOM distribution on the transect 126°00'E (upper panel) and 137°00'E (lower panel) in September 2010.

8. Sedimentologic investigations (suspended particulate matter, SPM)

Due to its influence on the availability of nutrients and the absorption of light, the distribution and concentration of SPM might have serious effects on the sensitive Arctic ecosystem. Increased SPM concentration via sediment re-suspension and river discharge, for example, might impede primary production by limiting light penetration.

The measurements were carried out to investigate the vertical and horizontal distribution of SPM on the Laptev Sea shelf as well as their dynamics in comparison to further TRANSDRIFT expeditions. They will be combined with the one-year monitoring data of the seafloor observatories.

During the TRANSDRIFT XVII expedition direct measurements (water samples) and indirect measurements (turbidity meter) were used to determine the SPM concentration in the water column. The turbidity meter was already connected to the CTD and measured the SPM concentration automatically at all stations, while the water samples were taken at defined stations and depths as shown in Figure 8.1. Throughout the cruise 225 SPM samples were collected at 35 stations. A detailed list of the depths in which the water samples were taken can be found in the complete sampling list in the appendix. The samples were taken by K. Wittbrodt, O. Zhaden, I. Ivanoshchuk, S. Antonova and Y. Tropina.

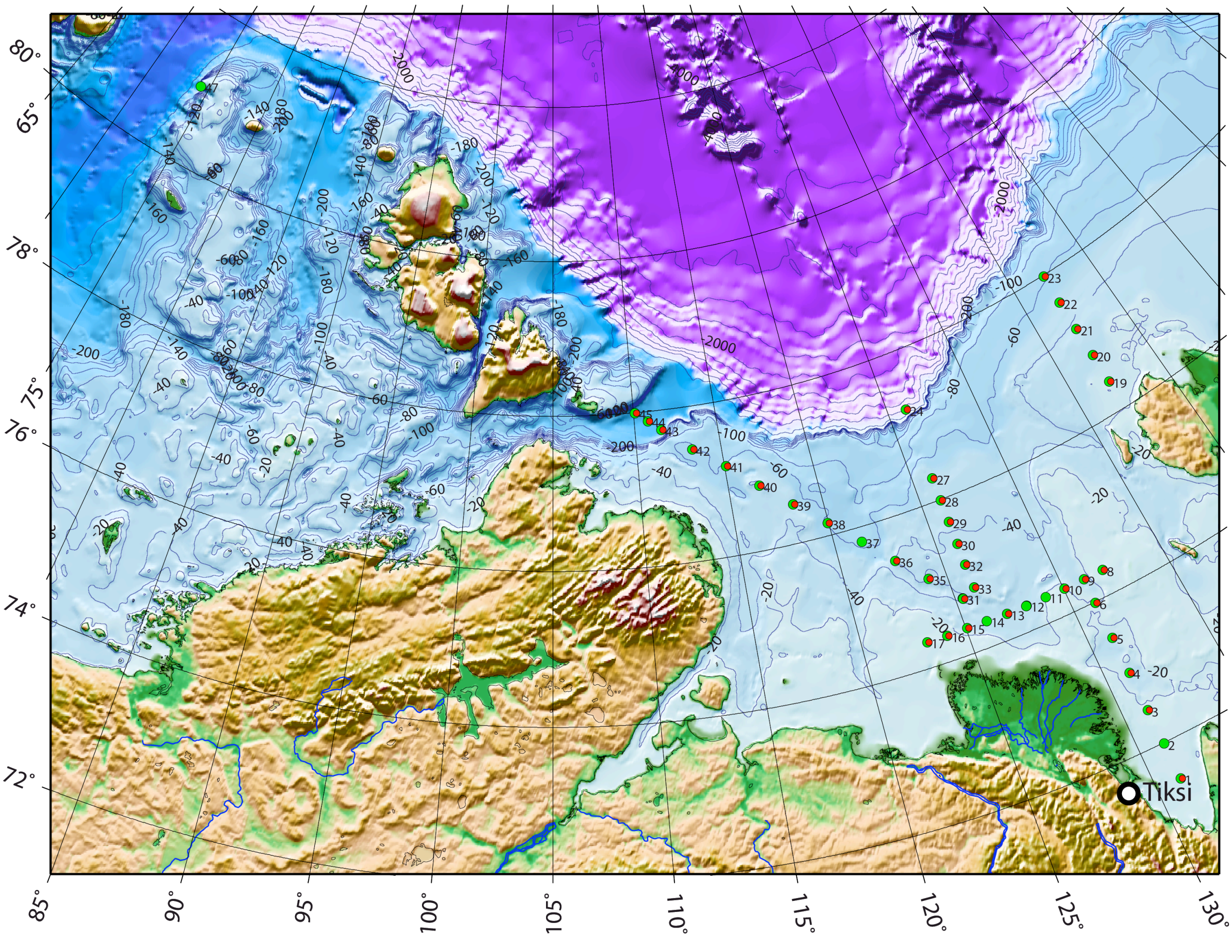


Fig. 8.1: All stations where SPM samples were taken are marked red, while all stations where the turbidity sensor was used (in addition) are marked green.

8.1. METHODS AND EQUIPMENT

Water samples were collected with the carousel water sampler at defined water depths and were poured into plastic bottles of 0.5 l each. They were stored on board and will be filtered through pre-weighed HVLP filters (MILLIPORE; 0.45 µm) in the OSL. The turbidity measurements will be correlated with the corresponding in-situ water samples to obtain accuracy by taking into account the effects of different mineralogy, varying particle darkness and salinity of ambient water on the response of the turbidity meter.

9. PARTICIPANTS OF TRANSDRIFT XVII EXPEDITION

#	Name	Nationality	Affiliation	Email
1	Antonova, Sofya	Russian	SPbU/POMOR	antonova.sofya@gmail.com
2	Dmitrenko, Igor	Russian	IFM-GEOMAR	idmitrenko@ifm-geomar.de
3	Greil, Florian	German	AWI	Florian.Greil@awi.de
4	Gukov, Alexander	Russian	Lena Delta Nature Reserve	sgukov@mail.ru
5	Ivanoshchuk, Igor	Russian	SPbU/POMOR	biostud@ngs.ru
6	Kirillov, Sergey	Russian	AARI	skirillov@aari.nw.ru
7	Klagge, Torben	German	IFM-GEOMAR	tklagge@ifm-geomar.de
8	Kryukova, Irina	Russian	SPbU/POMOR	Kryukova.Irina88@yandex.ru
9	Loginova, Alexandra	Russian	SPbU/POMOR	loginovaaleksandra@gmail.com
10	Martynov, Fedor	Russian	SPbU	fedor.martynov@gmail.com
11	Nikulina, Anna	Russian	IFM-GEOMAR	anikulina@ifm-geomar.de
12	Novikhin, Andrey	Russian	AARI	andrey.novikhin@gmail.com
13	Selyuzhenok, Valeria	Russian	SPbU/POMOR	lera.selyzenok@gmail.com
14	Semeryuk, Irina	Russian	SPbU/POMOR	irinasemeryuk@yandex.ru
15	Tropina, Yulia	Russian	SPbU/POMOR	juliatro@yahoo.com
16	Juhls, Bennet	German	IFM-GEOMAR	bjuhls@hotmail.com
17	Vollmer, Thorsten	German	IFM-GEOMAR	thorsten_vollmer@t-online.de
18	Wittbrodt, Kerstin	German	IFM-GEOMAR	k.wittbrodt@gmx.de
19	Zhaden, Oleg	Russian	SPbU/POMOR	zhaden@mail.ru

AARI	Arctic and Antarctic Research Institute, St. Petersburg, Russia
AWI	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
IFM-GEOMAR	Leibniz Institute of Marine Sciences, Kiel, Germany
POMOR	POMOR Master Program for Applied Polar and Marine Sciences
SPbU	St Petersburg State University, St. Petersburg, Russia

10. PARTICIPATING INSTITUTES

Arctic and Antarctic Research Institute (AARI)
38, Bering Street
199397 St. Petersburg, Russia

Alfred Wegener Institute for Polar and Marine Research (AWI)
Am Handelshafen 12
27570 Bremerhaven, Germany

Leibniz Institute for Marine Sciences IFM-GEOMAR
Wischhofstr. 1-3
24148 Kiel, Germany

Lena Delta Nature Reserve
Lena Delta Nature Reserve
28, ul. Fedorova
678400 Tiksi, Russia

Mainz Academy of Sciences, Humanities and Literature
Geschwister-Scholl-Str. 2
55131 Mainz, Germany

St. Petersburg State University
POMOR Master Program for Applied Polar and Marine Sciences
33, 10. line
199178 St. Petersburg, Russia

11. References

Aagaard, K., Coachman, L.K., and Carmack, E.C. (1981) *On the halocline of the Arctic Ocean*. Deep-Sea Research, 28: pp. 529-545.

Atlas of the Arctic (1985) Moscow, State Administrative Board for Geodesy and Cartography, Council of Ministers of the USSR, 204 pp. (in Russian).

Barber, D.G. and Massom, R.A. (2007) *The role of sea ice in Arctic and Antarctic polynyas*. In: Smith, W.O. and Barber, D.G. (eds.). Polynyas: Windows into Polar Ocean. Elsevier Series in Oceanography, 74, pp. 1-54.

Bauch, D., Erlenkeuser, H., Stanovoy, V., Simstich, J., and Spielhagen, R.F. (2003) Freshwater distribution and brine waters in the southern Kara Sea in summer 1999 as depicted by $\delta^{18}O$ results. In: Stein, R., Fahl, K., Fütterer, D.K., Galimov, E., and Stepanets, O. (eds.). Siberian river run-off in the Kara Sea: characterization, quantification, variability and environmental significance. Proceedings in Marine Science 6. Amsterdam: Elsevier, pp. 73-90.

Bauch, D., Erlenkeuser, H., and Andersen, N. (2005) Water mass processes on Arctic shelves as revealed from $\delta^{18}O$ of H_2O. Global and Planetary Change, 48(1-3): pp. 165-174.

Berezovskaya, S., Daqing, Y., and Hinzman, L. (2005) *Long-term annual water balance analysis of the Lena River*. Global and Planetary Change, 48(1-3): pp. 84-95.

Blough, N.V., and Del Vecchio, R. (2002) *Chromophoric DOM in the coastal environment*. In: Hansell, D.A. and Carlson, C.A. (eds.). Biogeochemistry of marine dissolved organic matter. Academic Press, pp. 509-546.

Buynevich, A.G., Rusanov, V.P., and Smagin, V.M. (1980) *Spreading of river waters in the Laptev Sea inferred from the distribution of hydrochemical elements*. Proceedings of the AARI, 358: pp. 116-125 (in Russian).

Chernigovsky, N.T. and Marshunova, M.S. (1965) *Climate of the Soviet Arctic (radiational regime)*. Leningrad: Gidrometeoizdat, 199 pp. (in Russian).

Ivanov, V.V. (1976) *Water balance and water resources of the Arctic mainland*. Proceedings of the AARI, 323: pp. 4-24 (in Russian).

Oradovsky, S.G. (1993) *Marine water hydrochemical analysis guide*. St. Petersburg: Gidrometeoizdat, 262 pp..

Polyakov, I.V., Beszczynska, A., Carmack, E.C., Dmitrenko, I.A., Farbarch, E., Frolov, I.E., Gerdes, R., Hansen, E., Holfort, J., Ivanov, V.V., Johnson, M.A., Karcher, M., Kauker, F., Morison, J., Orvik, K.A., Schauer, U., Simmons, H.L., Skagseth, O., Sokolov, V.T., Steele, M., Timokhov, L.A., and Walsh, J.E. (2005) *One more step toward a warmer Arctic*. Geophysical Research Letters, 32, L17605: doi:10.1029/2005GL02374.

Stedmon, C.A. and Markanger, S. (2001) *The optics of chromophoric dissolved organic matter (CDOM) in the Greenland Sea: an algorithm for differentiation between marine and terrestrial derived organic matter*. Limnol. Oceanogr. 46(8), pp. 2087-2093.

Stein, R. and Macdonald, R.W. (2004) *Organic carbon budget: Arctic Ocean versus global ocean*. In: Stein, R. and Macdonald, R.W. (eds.). The Arctic Ocean Organic Carbon Cycle: Present and Past. Berlin-Heidelberg-New York: Springer, 336 pp.

Zakharov, V.F. (1966) *The Role of flaw polynyas in hydrological and ice regimes of the Laptev Sea*. Okeanologiya, 6(6): pp. 1014-1022 (in Russian).

Zakharov, V.F. (1996) *Sea ice in the climate system*. St. Petersburg: Gidrometeoizdat, 213 pp. (in Russian).

12. APPENDIX

APPENDIX A: STATION LIST

Station name	Date station start [UTC]	Time station start [UTC]	Time station end [UTC]	Latitude station start [Dec. deg.]	Longitude station start [Dec. deg.]	Latitude station end [Dec. deg.]	Longitude station end [Dec. deg.]	Depth [m]	Type of station
NE10-01	09.09.2010	07:46	08:20	71.5027N	130.9979E	71.504447N	130.989847E	14	CTD/Ro-sette cast
NE10-02	09.09.2010	11:50	12:15	71.9983N	131.0002E	72.007450N	131.004932E	19	CTD/Ro-sette cast
NE10-03	09.09.2010	15:20	16:00	72.470N	131.00E	72.476760N	131.009430E	18	CTD/Ro-sette cast
NE10-04	09.09.2010	19:15	19:50	73.0015N	131.0033E	73.006252N	131.006158E	23,5	CTD/Ro-sette cast
NE10-05	09.09.2010	22:58	23:32	73.4996N	131.0003E	73.5008N	131.0090E	22	CTD/Ro-sette cast
NE10-06	10.09.2010	02:48	03:18	73.9975N	131.0004E	73.9975N	131.0001E	22.4	CTD/Ro-sette cast
NE10-07	10.09.2010	08:22	09:09	74.3299N	128.0083E	74.331477N	128.009853E	30	ANABAR recover
NE10-08	12.09.2010	10:30	11:10	74.335N	132.005E	74.337128N	131.981782E	14	CTD/Ro-sette cast
NE10-09	12.09.2010	12:52	13:19	74.3353N	131.0040E	74.3441N	131.0038E	23	CTD/Ro-sette cast
NE10-10	12.09.2010	15:45	16:20	74.3337N	129.9825E	74.3368N	129.9840E	18	CTD/Ro-sette cast
NE10-11	12.09.2010	18:00	18:30	74.3321N	128.9932E	74.329615N	128.951050E	16	CTD/Ro-sette cast
NE10-12	12.09.2010	19:55	21:15	74.3293N	127.9879E	74.3278N	127.9999E	32	ANABAR deploy
NE10-13	12.09.2010	22:50	23:20	74.3325N	127.0038E	74.3359N	126.9754E	33	CTD/Ro-sette cast
NE10-14	13.09.2010	00:57	01:18	74.3366N	125.9720E	74.3438N	125.9592E	31	CTD/Ro-sette cast
NE10-15	13.09.2010	03:00	03:46	74.3412N	124.9955E	74.3345N	124.9926E	23	CTD/Ro-sette cast
NE10-16	13.09.2010	05:30	06:18	74.3342N	123.9930E	74.3505N	123.9533E	16.5	CTD/Ro-sette cast
NE10-17	13.09.2010	07:55	08:24	74.3367N	122.9885E	74.3470N	122.9497E	12.5	CTD/Ro-sette cast
NE10-18	14.09.2010	04:04	04:17	76.5689N	126.0763E	76.5689N	126.0763E	53	OSL2D recover
NE10-19	16.09.2010	04:47	05:27	76.4000N	136.9987E	76.4042N	136.9984E	22	CTD/Ro-sette cast
NE10-20	16.09.2010	08:48	09:10	76.8003N	137.0039E	76.7954N	137.0006E	26	CTD/Ro-sette cast
NE10-21	16.09.2010	11:59	12:46	77.1996N	136.9980E	77.1913N	136.9798E	34	CTD/Ro-sette cast
NE10-22	16.09.2010	15:25	15:50	77.6009N	136.9948E	77.600822N	136.992477E	48	CTD/Ro-sette cast
NE10-23	16.09.2010	18:45	20:45	77.9984N	137.0044E	77.97461N	136.9574E	62	KOTEL-NYY deploy
NE10-24	17.09.2010	10:47	12:20	77.2514N	126.0016E	77.268312N	125.963707E	>1000	CTD/Ro-sette cast
NE10-25	17.09.2010			76.80N	126.00E				*Skipped*

Station name	Date station start [UTC]	Time station start [UTC]	Time station end [UTC]	Latitude station start [Dec. deg.]	Longitude station start [Dec. deg.]	Latitude station end [Dec. deg.]	Longitude station end [Dec. deg.]	Depth [m]	Type of station
NE10-26	17.09.2010	17:42	18:32	76.5699N	126.0867E	76.5655N	126.0558E	52	OSL2E deploy
NE10-27	17.09.2010	20:30	20:59	76.3016N	126.0010E	76.3048N	126.0104E	51	CTD/Ro-sette cast
NE10-28	17.09.2010	23:00	23:55	76.0005N	126.0007E	76.0013N	126.0349E	44	CTD/Ro-sette cast
NE10-29	18.09.2010	02:07	02:43	75.69971N	125.99902E	75.6799N	125.996E	43	CTD/Ro-sette cast
NE10-30	18.09.2010	04:46	05:30	75.4014N	125.9996E	75.4048N	125.9948E	39	CTD/Ro-sette cast
NE10-31	18.09.2010	09:30	10:00	74.72036N	125.2887E	74.7144N	125.2794E	44	KHA-TANGA recover
NE10-32	18.09.2010	12:33	14:28	75.1149N	125.9918E	75.1156N	125.9870E	36	CTD/Ro-sette cast
NE10-33	18.09.2010	16:30	17:00	74.8021N	125.9992E	74.8006N	125.9738E	23	CTD/Ro-sette cast
NE10-34	18.09.2010	18:15	18:54	74.7152N	125.2942E	74.7136N	125.2667E	44	KHA-TANGA deploy
NE10-35	19.09.2010	03:40	04:14	75.10250N	124.0342E	75.1052N	124.9174E	46.8	CTD/Ro-sette cast
NE10-36	19.09.2010	07:06	07:41	75.4576N	122.7190E	75.4702N	122.6977E	50	CTD/Ro-sette cast
NE10-37	19.09.2010	10:14	10:38	75.8190N	121.3488E	75.825N	121.3443E	63	CTD/Ro-sette cast
NE10-38	19.09.2010	13:35	14:14	76.1698N	119.8723E	76.1811N	119.8509E	60	CTD/Ro-sette cast
NE10-39	19.09.2010	17:24	18:10	76.5094N	118.2826E	76.5211N	118.2883E	48	CTD/Ro-sette cast
NE10-40	19.09.2010	21:45	22:15	76.8401N	116.6876E	76.8425N	116.6542E	40	CTD/Ro-sette cast
NE10-41	20.09.2010	01:08	02:07	77.16681N	114.9988E	77.168N	114.9487E	64	OSL4 deploy
NE10-42	20.09.2010	05:58	09:17	77.4488N	113.2050E	77.44984N	113.205557E	62	CTD/Ro-sette cast
NE10-43	20.09.2010	11:52	12:31	77.74812N	111.514490 E	77.75732N	111.50698E	272	CTD/Ro-sette cast
NE10-44	20.09.2010	14:00	14:50	77.8797N	110.7520E	77.8925N	110.7544E	292	CTD/Ro-sette cast
NE10-45	20.09.2010	16:15	17:00	77.9984N	110.0077E	78.0018N	109.9931E	287	CTD/Ro-sette cast
NE10-46	22.09.2010	14:35	14:50	81.0259N	73.0336E	81.0259N	73.0336E	518	ST. ANNA recover
NE10-47	22.09.2010	16:25	16:35	81.0102N	74.2011E	81.0674N	74.1865E	126	CTD cast
NE10-48	22.09.2010	17:00	17:35	81.0113N	73.7573E	81.011167N	73.702903E	378	CTD cast
NE10-49	22.09.2010	18:54	19:10	80.9999N	72.3210E	80.9998N	72.2908E	590	CTD cast
NE10-50	22.09.2010	20:32	20:53	80.9985N	70.3210E	81.001N	70.8128E	610	CTD cast
NE10-51	22.09.2010	22:45	23:30	81.00999N	69.4409E	81.00999N	69.4409E	578	CTD cast

APPENDIX B: STATION PROTOCOL & COMMENTS

Station name	Type of station	Comment on station (for CTD casts please see note 1 at the end of the list)	Comment of rosette operator
NE10-01	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-02	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-03	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-04	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-05	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-06	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-07	ANABAR recover/CTD	Used CTD SBE19+ (#5245) without rosette, with DO, fluorescence and turbidity sensor.	
NE10-08	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-09	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-10	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-11	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-12	ANABAR deploy	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-13	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	3rd bottle (10 m) --> pycnocline
NE10-14	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-15	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	3rd bottle (10 m) leaking, 5th bottle (21 m) not closed, strong current of approx. 1 kn, slight problems (stuck engine) of crane at upcast
NE10-16	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	Drift 1.1-1.5 kn to 345°
NE10-17	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	

Station name	**Type of station**	**Comment on station** (for CTD casts please see note 1 at the end of the list)	**Comment of rosette operator**
NE10-18	OSL2D recover/CTD	Mooring was horizontal, but in position as deployed. Released several times, but no recovery and also no dredging due to strong wind. After this steaming to Belkovsky Island and waiting for storm to be over. No rosette, but single CTD cast: plain CTD SBE19+ (#5152) without rosette using the winch and not the crane due to heavy weather, CDOM sensor attached to CTD.	
NE10-19	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	
NE10-20	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	1st bottle closed at 1 m, 5th (20 m) & 6th (25 m) did not close
NE10-21	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	Drifting of 1.5 kn to 240°
NE10-22	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	1st bottle closed at 1 m
NE10-23	KOTELNYY deploy	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	1st bottle closed at 1 m
NE10-24	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used.	4th bottle (15 m) pycnocline, 9th (48 m) and 10th (50 m) bottle did not close, 3rd bottle closed at 11 m
NE10-25		Station skipped during station work, winds too strong to operate any instrument safely. No samples taken, no CTD cast.	
NE10-26	OSL2E deploy/ CTD	Used only CTD SBE19+ (#5152) with CDOM sensor. Tube for delivering freshwater to CDOM sensor was cracked, so CDOM & conductivity values might not fit/reflect the correct depth of the instrument.	
NE10-27	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used. Tube for delivering freshwater to CDOM sensor was cracked, so CDOM & conductivity values might not fit/reflect the correct depth of the instrument.	1st bottle closed at 1 m, bottle position 8 (48 m) was occupied by bottle 9
NE10-28	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used. Tube for delivering freshwater to CDOM sensor was cracked, so CDOM & conductivity values might not fit/reflect the correct depth of the instrument.	4th bottle (15 m) pycnocline
NE10-29	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used. Tube for delivering freshwater to CDOM sensor was cracked, so CDOM & conductivity values might not fit/reflect the correct depth of the instrument.	5th bottle lost rubber but not leaking, pycnocline at 18-22 m

Station name	Type of station	**Comment on station** (for CTD casts please see note 1 at the end of the list)	Comment of rosette operator
NE10-30	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) with CDOM sensor was used. Tube for delivering freshwater to CDOM sensor was cracked, so CDOM & conductivity values might not fit/reflect the correct depth of the instrument.	5th bottle (20 m) pycnocline, CTD with CDOM got a broken tube
NE10-31	KHATANGA recover/CTD	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	Only CTD
NE10-32	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	Crane broken during first attempt, 1:45 hours repair time. Second attempt worked well, 5th bottle (20 m) pycnocline, 7th (30 m) bottle leaking
NE10-33	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	5th bottle (20 m) & 6th bottle (22 m) did not close
NE10-34	KHATANGA deploy/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	
NE10-35	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	8th (40 m) bottle leaking, pycnocline 17-20 m, drifting 1 kn to 300°
NE10-36	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	9th (48 m) bottle not closed
NE10-37	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	9th (45 m) bottle not closed
NE10-38	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	9th (48 m) bottle not closed
NE10-39	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	3rd (10 m) bottle empty --> leaking
NE10-40	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	1st (2 m) bottle & 7th (30 m) bottle empty --> leaking
NE10-41	OSL4 deploy/ CTD	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	1st (2 m) bottle & 7th (30 m) bottle leaking
NE10-42	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor.	Problem with crane caused by hydraulic leakage. ~4 hour repair time, after this cast worked well.
NE10-43	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) without additional sensors was used to take a complete water profile.	Additional cast with winch + plain CTD, 9th (47 m) bottle empty --> leaking
NE10-44	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. In addition the CTD SBE19+ (#5152) without additional sensors was used to take a complete water profile. During this station the CTD SBE19+ (#5152) was damaged (pin broken by Igor D.).	9th (45 m) bottle empty --> leaking
NE10-45	CTD/Rosette cast	Used CTD SBE19+ (#5245) on rosette, with DO, fluorescence and turbidity sensor. After rosette the same CTD (#5245) was used on the winch for a long cast to take a complete water profile, because #5152 was broken.	9th (45 m) bottle empty --> leaking
NE10-46	ST. ANNA recover/CTD	Used CTD SBE19+ (#5152) without additional sensors.	
NE10-47	CTD cast	Used CTD SBE19+ (#5245) without rosette, with DO, fluorescence and turbidity sensor.	
NE10-48	CTD cast	Used CTD SBE19+ (#5152) without additional sensors.	
NE10-49	CTD cast	Used CTD SBE19+ (#5152) without additional sensors.	

Station name	**Type of station**	**Comment on station** (for CTD casts please see note 1 at the end of the list)	**Comment of rosette operator**
NE10-50	CTD cast	Used CTD SBE19+ (#5152) without additional sensors.	
NE10-51	CTD cast	Used CTD SBE19+ (#5152) without additional sensors.	

Note 1: The ship's winch could not be used with our carousel water sampler (no space to hoist the sampler), so the water sampler was operated using the crane, which had a max. cable length of 50 m (in water). Due to that no water samples deeper than 50 m were taken on this cruise. On stations deeper than 60 m an additional CTD cast (plain CTD without rosette, using the winch) was performed to take a complete water column profile. That is why for many stations more than one CTD profile is available. For details please check the corresponding comment section of each station.

APPENDIX C: METEOROLOGICAL DATA FOR EACH STATION

Station name	Wind direction [°] (*** = no wind)	Wind speed [m/s]	Temperature [°C]	Air pressure [mm Hg]	Type of station
NE10-01	***	0	11	755	CTD/Rosette cast
NE10-02	***	0	4	756	CTD/Rosette cast
NE10-03	***	0	5	757	CTD/Rosette cast
NE10-04	90	4	3	757	CTD/Rosette cast
NE10-05	160	2	3	757	CTD/Rosette cast
NE10-06	***	0	2	759	CTD/Rosette cast
NE10-07	160	1	3	759	ANABAR recover
NE10-08	130	5	2	763	CTD/Rosette cast
NE10-09	120	5	3	763	CTD/Rosette cast
NE10-10	130	5	2	764	CTD/Rosette cast
NE10-11	150	5	3	763	CTD/Rosette cast
NE10-12	150	4	3	764	ANABAR deploy
NE10-13	130	6	2	764	CTD/Rosette cast
NE10-14	110	5	3	764	CTD/Rosette cast
NE10-15	110	5	3	763.5	CTD/Rosette cast
NE10-16	110	12	4	764	CTD/Rosette cast
NE10-17	140	7	3	761	CTD/Rosette cast
NE10-18	100	8	0	761	OSL2D recover
NE10-19	80	3	2.5	748	CTD/Rosette cast
NE10-20	50	8	1	748	CTD/Rosette cast
NE10-21	55	7	1	748	CTD/Rosette cast
NE10-22	40	4	2	748	CTD/Rosette cast
NE10-23	60	10	0	749	KOTELNYY deploy
NE10-24	180	5	-2	750	CTD/Rosette cast
NE10-25					*Skipped*
NE10-26	225	10	-1	755	OSL2E deploy
NE10-27	210	7	0	756	CTD/Rosette cast
NE10-28	250	7	0	756	CTD/Rosette cast
NE10-29	230	6	1	757	CTD/Rosette cast
NE10-30	180	5	1	757	CTD/Rosette cast
NE10-31	133	5	0	758	KHATANGA recover
NE10-32	120	3	1	758	CTD/Rosette cast
NE10-33	140	5	1	759	CTD/Rosette cast
NE10-34	140	5	1	759	KHATANGA deploy
NE10-35	120	6	2	760	CTD/Rosette cast
NE10-36	90	5	1	761	CTD/Rosette cast
NE10-37	120	6	5	763	CTD/Rosette cast
NE10-38	***	0	-2	765	CTD/Rosette cast
NE10-39	***	0	-4	766	CTD/Rosette cast
NE10-40	***	0	-3	768	CTD/Rosette cast
NE10-41	***	0	-2	769	OSL4 deploy
NE10-42	***	0	-2	770	CTD/Rosette cast
NE10-43	***	0	-3	771	CTD/Rosette cast
NE10-44	210	4	-2	771	CTD/Rosette cast
NE10-45	210	4	-2	771	CTD/Rosette cast
NE10-46	***	0	-8	775	ST. ANNA recover
NE10-47	***	0	-9	775	CTD cast
NE10-48	***	0	-9	771	CTD cast
NE10-49	***	0	-9	775	CTD cast
NE10-50	***	0	-9	765	CTD cast
NE10-51	***	0	-9	770	CTD cast

Appendix D: Sampling lists

Part 1: SPM, CDOM, Dissolved oxygen

Station name	SPM samples [amount]	SPM sample depths	CDOM samples [amount]	CDOM sample depths	CDOM (Roman) samples [amount]	CDOM (Roman) sample depths	Dissolved oxygen samples [amount]	Dissolved Oxygen sample depths
NE10-01	4	2, 5, 10, 14	4	2, 5, 10, 14			4	2, 5, 10, 14
NE10-02			4	2, 5, 10, 15			4	2, 5, 10, 15
NE10-03	4	2, 5, 10, 14	4	2, 5, 10, 14			4	2, 5, 10, 14
NE10-04	6	2, 5, 10, 15, 20, 22	6	2, 5, 10, 15, 20, 22			5	2, 5, 10, 20, 22
NE10-05	6	2, 5, 10, 15, 20, 23	6	2, 5, 10, 15, 20, 23			6	2, 5, 10, 15, 20, 23
NE10-06	6	2, 5, 10, 15, 20, 22	6	2, 5, 10, 15, 20, 22			6	2, 5, 10, 15, 20, 22
NE10-07								
NE10-08	4	2, 5, 10, 13	4	2, 5, 10, 13			4	2, 5, 10, 13
NE10-09	5	2, 5, 10, 15, 20	5	2, 5, 10, 15, 20			5	2, 5, 10, 15, 20
NE10-10	5	2, 5, 10, 15, 17					5	2, 5, 10, 15, 17
NE10-11							4	2, 5, 10, 15
NE10-12							7	2, 5, 10, 15, 20, 25, 30
NE10-13	5	2 ,5, 10, 20, 30					7	2, 5, 10, 15, 20, 25, 30
NE10-14			7	2, 5, 10, 15, 20, 25, 29			7	2, 5, 10, 15, 20, 25, 29
NE10-15	3	2, 5, 10	4	2, 5, 10, 15			4	2, 5, 10, 15
NE10-16	4	2, 5, 10, 15	4	2, 5, 10, 15			4	2, 5, 10, 15
NE10-17	3	2, 5, 10	3	2, 5, 10			3	2, 5, 10
NE10-18								
NE10-19	6	2, 5, 10, 15, 20, 21			2	2, 21	5	2, 5, 10, 15, 21
NE10-20	4	2 (1), 5, 10, 15			2	2, 18	4	2, 5, 10, 18
NE10-21	8	2, 5, 20, 15, 20, 25, 30, 32			2	2, 32	8	2, 5, 20, 15, 20, 25, 30, 32
NE10-22	7	2(1), 5, 10, 20, 30, 40, 48			2	2, 48	9	2(1), 5, 10, 15,20, 25, 30, 40, 48
NE10-23	7	2(1), 5, 10, 20, 30, 40, 48			2	2, 48	9	2(1), 5, 10, 15,20, 25, 30, 40, 48
NE10-24	8	2, 5, 10 (11), 15, 25, 30,40, 48	7	2, 5, 10(11), 15, 25, 30, 40	2	2, 40	7	2, 5, 10(11), 15, 25, 30, 40
NE10-25								
NE10-26								
NE10-27	7	2(1), 5, 10, 15, 20, 25, 40	7	2(1), 5, 10, 15, 20, 25, 40	2	2, 48	8	2(1), 5, 10, 15,20, 25, 40, 48
NE10-28	9	2, 5, 10, 15, 20, 25, 30, 40, 42	9	2, 5, 10, 15, 20, 25, 30, 40, 42	2	2, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-29	9	2, 5, 10, 15, 20, 25, 30, 40, 42	9	2, 5, 10, 15, 20, 25, 30, 40, 42	2	2, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-30	8	2, 5, 10, 15, 20, 25, 30, 37	8	2, 5, 10, 15, 20, 25, 30, 37	2	2, 37	8	2, 5, 10, 15, 20, 25, 30, 37
NE10-31								
NE10-32	6	2, 5, 10, 15, 20, 25	6	2, 5, 10, 15, 20, 25	2	2, 25	6	2, 5, 10, 15, 20, 25
NE10-33	4	2, 5, 10, 15	4	2, 5, 10, 15	2	2, 15	4	2, 5, 10, 15

Station name	SPM samples [amount]	SPM sample depths	CDOM samples [amount]	CDOM sample depths	CDOM (Roman) samples [amount]	CDOM (Roman) sample depths	Dissolved oxygen samples [amount]	Dissolved Oxygen sample depths
NE10-34	9	2, 5, 10, 15, 20, 25, 30, 40, 42	9	2, 5, 10, 15, 20, 25, 30, 40, 42	2	2, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-35	9	2, 5, 10, 15, 20, 25, 30, 40, 48	9	2, 5, 10, 15, 20, 25, 30, 40, 48	2	2, 48	9	2, 5, 10, 15,20, 25, 30, 40, 48
NE10-36	8	2, 5, 10, 15, 20, 25, 30, 40	8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-37			8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-38	7	5, 10, 15, 20, 25, 30, 40	8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-39	8	5, 10, 15, 20, 25, 30, 40, 45	8	5, 10, 15, 20, 25, 30, 40, 45	1	45	8	5, 10, 15,20, 25, 30, 40, 45
NE10-40	6	5, 10, 15, 20, 25, 40	5	5, 10, 20, 25, 40	1	40	6	5, 10, 15, 20, 25, 40
NE10-41	7	5, 10, 15, 20, 25, 40, 45	7	5, 10, 15, 20, 25, 40, 45	1	45	7	5, 10, 15, 20, 25, 40, 45
NE10-42	9	2, 5, 10, 15, 20, 25, 30, 40, 45	9	2, 5, 10, 15, 20, 25, 30, 40, 45	2	2, 45	9	2, 5, 10, 15,20, 25, 30, 40, 45
NE10-43	8	2, 5, 10, 15, 20, 25, 30, 40	8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-44	8	2, 5, 10, 15, 20, 25, 30, 40	8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-45	8	2, 5, 10, 15, 20, 25, 30, 40	8	2, 5, 10, 15, 20, 25, 30, 40	2	2, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-46								
NE10-47								
NE10-48								
NE10-49								
NE10-50								
NE10-51								

PART 2: OXYGEN ISOTOPES, NUTRIENTS

Station name	$\delta^{18}O$ samples [amount]	$\delta^{18}O$ sampling depth	Nutrient samples [amount]	Nutrient sampling depths
NE10-01	4	2, 5, 10, 14	4	2, 5, 10, 14
NE10-02	4	2, 5, 10, 15	4	2, 5, 10, 15
NE10-03	4	2, 5, 10, 14	4	2, 5, 10, 14
NE10-04	5	2, 5, 10, 15, 22	6	2, 5, 10, 15, 20, 22
NE10-05	5	2, 5, 10, 15, 23	6	2, 5, 10, 15, 20, 23
NE10-06	5	2, 5, 10, 15, 22	6	2, 5, 10, 15, 20, 22
NE10-07				
NE10-08	4	2, 5, 10, 13	4	2, 5, 10, 13
NE10-09	5	2, 5, 10, 15, 20	5	2, 5, 10, 15, 20
NE10-10	4	2, 5, 10, 15	5	2, 5, 10, 15, 17
NE10-11	4	2, 5, 10, 15	4	2, 5, 10, 15
NE10-12	7	2, 5, 10, 15, 20, 25, 30	7	2, 5, 10, 15, 20, 25, 30
NE10-13	7	2, 5, 10, 15, 20, 25, 30	7	2, 5, 10, 15, 20, 25, 30
NE10-14	7	2, 5, 10, 15, 20, 25, 29	7	2, 5, 10, 15, 20, 25, 29
NE10-15	4	2, 5, 10, 15	4	2, 5, 10, 15
NE10-16	4	2, 5, 10, 15	4	2, 5, 10, 15
NE10-17	3	2, 5, 10	3	2, 5, 10
NE10-18				
NE10-19	5	2, 5, 10, 15, 21	5	2, 5, 10, 15, 21
NE10-20	4	2, 5, 10, 18	4	2, 5, 10, 18
NE10-21	8	2, 5, 20, 15, 20, 25, 30, 32	8	2, 5, 20, 15, 20, 25, 30, 32
NE10-22	9	2(1), 5, 10, 15,20, 25, 30, 40, 48	9	2(1), 5, 10, 15,20, 25, 30, 40, 48
NE10-23	9	2(1), 5, 10, 15,20, 25, 30, 40, 48	9	2(1), 5, 10, 15,20, 25, 30, 40, 48
NE10-24	7	2, 5, 10(11), 15, 25, 30, 40	7	2, 5, 10(11), 15, 25, 30, 40
NE10-25				
NE10-26				
NE10-27	8	2(1), 5, 10, 15,20, 25, 40, 48	8	2(1), 5, 10, 15,20, 25, 40, 48
NE10-28	9	2, 5, 10, 15,20, 25, 30, 40, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-29	9	2, 5, 10, 15,20, 25, 30, 40, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-30	8	2, 5, 10, 15, 20, 25, 30, 37	8	2, 5, 10, 15, 20, 25, 30, 37
NE10-31				
NE10-32	6	2, 5, 10, 15, 20, 25	6	2, 5, 10, 15, 20, 25
NE10-33	4	2, 5, 10, 15	4	2, 5, 10, 15
NE10-34	9	2, 5, 10, 15,20, 25, 30, 40, 42	9	2, 5, 10, 15,20, 25, 30, 40, 42
NE10-35	9	2, 5, 10, 15,20, 25, 30, 40, 48	9	2, 5, 10, 15,20, 25, 30, 40, 48
NE10-36	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-37	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-38	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-39	8	5, 10, 15,20, 25, 30, 40, 45	8	5, 10, 15,20, 25, 30, 40, 45
NE10-40	6	5, 10, 15, 20, 25, 40	6	5, 10, 15, 20, 25, 40
NE10-41	7	5, 10, 15, 20, 25, 40, 45	7	5, 10, 15, 20, 25, 40, 45
NE10-42	9	2, 5, 10, 15,20, 25, 30, 40, 45	9	2, 5, 10, 15,20, 25, 30, 40, 45
NE10-43	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-44	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-45	8	2, 5, 10, 15,20, 25, 30, 40	8	2, 5, 10, 15,20, 25, 30, 40
NE10-46				
NE10-47				
NE10-48				

Station name	$\delta^{18}O$ samples [amount]	$\delta^{18}O$ sampling depth	Nutrient samples [amount]	Nutrient sampling depths
NE10-49				
NE10-50				
NE10-51				

PART 3: CHLOROPHYLL *A*, ZOOPLANKTON, PHYTOPLANKTON

Station name	Chlorophyll *a* samples [amount]	Chlorophyll *a* sampling depths	Zooplankton nets [amount]	Net depth	Phytoplankton nets [amount]	Phytoplankton net depth	Zooplankton nets (DNA) [amount]	Zooplankton net depth	Macrobenthos and bottom biocoenosis
NE10-01	4	2, 5, 10, 14	1	0-13 m			1	0-13 m	X
NE10-02	4	2, 5, 10, 15							X
NE10-03	4	2, 5, 10, 14	1	0-13 m	1	0-13 m			X
NE10-04	6	2, 5, 10, 15, 20, 22							X
NE10-05	6	2, 5, 10, 15, 20, 23			1	0-15 m			X
NE10-06	6	2, 5, 10, 15, 20, 22							X
NE10-07									
NE10-08	4	2, 5, 10, 13	1	0-14 m	1	0-14 m			X
NE10-09	5	2, 5, 10, 15, 20							X
NE10-10	5	2, 5, 10, 15, 17	1	0-18 m					X
NE10-11									
NE10-12	7	2, 5, 10, 15, 20, 25, 30	1	0-31 m					
NE10-13	7	2, 5, 10, 15, 20, 25, 30	1	0-30 m	1	0-11 m			
NE10-14									
NE10-15	4	2, 5, 10, 15	1	0-19 m			1	0-19 m	
NE10-16	4	2, 5, 10, 15	1	0-18 m					
NE10-17	3	2, 5, 10	1	0-12 m	1	0-12 m			X
NE10-18									
NE10-19	5	2, 5, 10, 15, 21	1	0-22 m	1	0-22 m			X
NE10-20	4	2, 5, 10, 18							X
NE10-21	8	2, 5, 20, 15, 20, 25, 30, 32	1	0-30 m	1	0-19 m	1	0-30 m	X
NE10-22	9	2(1), 5, 10, 15,20, 25, 30, 40, 48							X
NE10-23	9	2(1), 5, 10, 15,20, 25, 30, 40, 48	1	0-55 m	1	0-18 m	1	0-55 m	
NE10-24	7	2, 5, 10(11), 15, 25, 30, 40	1	0-160 m	1	0-14 m	1	0-170 m	
NE10-25									
NE10-26									
NE10-27	7	2(1), 5, 10, 15,20, 25, 40							
NE10-28	9	2, 5, 10, 15,20, 25, 30, 40, 42	1	0-42 m	1	0-15 m	1	0-42 m	X
NE10-29	9	2, 5, 10, 15,20, 25, 30, 40, 42	2	0-42 m 0-17 m					
NE10-30	8	2, 5, 10, 15, 20, 25, 30, 37	1	0-39 m			1	0-39 m	X
NE10-31									
NE10-32	6	2, 5, 10, 15, 20, 25	1	0-29 m					X
NE10-33	4	2, 5, 10, 15			1	0-16 m			X
NE10-34	9	2, 5, 10, 15,20, 25, 30, 40, 42	1	0-37 m					X
NE10-35	9	2, 5, 10, 15,20, 25, 30, 40, 48			1	0-17 m			X
NE10-36	8	2, 5, 10, 15,20, 25, 30, 40	1	0-47 m					X
NE10-37	8	2, 5, 10, 15,20, 25, 30, 40							X
NE10-38	8	2, 5, 10, 15,20, 25, 30, 40	1	0-51 m	1	0-16 m			X
NE10-39	8	5, 10, 15,20, 25, 30, 40, 45			1	0-20 m			X
NE10-40	6	5, 10, 15, 20, 25, 40	1	0-35 m					X

Station name	Chlorophyll *a* samples [amount]	Chlorophyll *a* sampling depths	Zooplankton nets [amount]	Net depth	Phytoplankton nets [amount]	Phytoplankton net depth	Zooplankton nets (DNA) [amount]	Zooplankton net depth	Macrobenthos and bottom biocoenosis
NE10-41	7	5, 10, 15, 20, 25, 40, 45	1	0-50 m	1	0-11 m	1	0-50 m	X
NE10-42	9	2, 5, 10, 15,20, 25, 30, 40, 45	1	0-50 m					X
NE10-43	8	2, 5, 10, 15,20, 25, 30, 40							
NE10-44	8	2, 5, 10, 15,20, 25, 30, 40	1	0-250 m	1	0-16 m			
NE10-45	8	2, 5, 10, 15,20, 25, 30, 40							
NE10-46									X
NE10-47									
NE10-48									
NE10-49									
NE10-50									
NE10-51									

Appendix E: Recovery sheets and drawings of all recovered seafloor observatories

Mooring "ANABAR 09"

deployed during TRANSDRIFT XVI, recovered during TRANSDRIFT XVII

Deployed:	**2009-09-16, 17:20 UTC**
Recovered:	**2010-09-10, 8:30 UTC**
Position GPS60:	**N74°19,9176' E128°0,162'; Decimal: N74.33196° E128.00270°**
Depth:	**32,8 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG135
  Memory: 64 Mbyte Flash-memory
  Serial: 9271

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 9207

- CTD RBR XR-420 CTTu
  Memory: 8 Mbyte Flash-memory
  Serial: 14606

- CTD RBR XR-420 CTTu
  Memory: 8 Mbyte Flash-memory
  Serial: 14605

- CTD Seabird 37 IMP
  Memory: 2 Mbyte Flash-memory
  Serial: 37IMP46569-5388

- Release IXSEA OCEANO 2500
  Serial: 004

- Release IXSEA OCEANO 2500
  Serial: 005

Sampling & duration of instrument data set:

- the ADCPs were programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes. Both ADCPs measured/recorded for the complete deployment time. The ADCPs internal clocks had a shift of < than 1 minute to UTC time after recovery.
  The ADCP 1200 kHz showed a compass-error of ~11° after recovery, the ADCP 300 kHz showed a huge compass error, and it was not possible to recalibrate the fluxgate compass on site. The current direction data of the uplooking ADCP might be wrong! Correlating the overlapping water mass that was measured by both ADCPs (up- & downlooking) revealed a difference of approx. 50° between both moorings.

- the CTD SBE37IMP was programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes. It recorded data for the complete deployment time. The CTDs internal clocks had a shift of < than 2 minutes to UTC time after recovery.
- the CTDs from RBR are both programmed to take a full sample (temperature, conductivity, turbidity) every 30 minutes, both recorded these data also for the complete deployment time. Due to heavy bio-fouling on the turbidity as well as the salinity sensors of the RBR-CTDs the turbidity data from April/March on should be handled as incorrect. The CTDs internal clocks had a shift of < than 1 minute to UTC time after recovery.

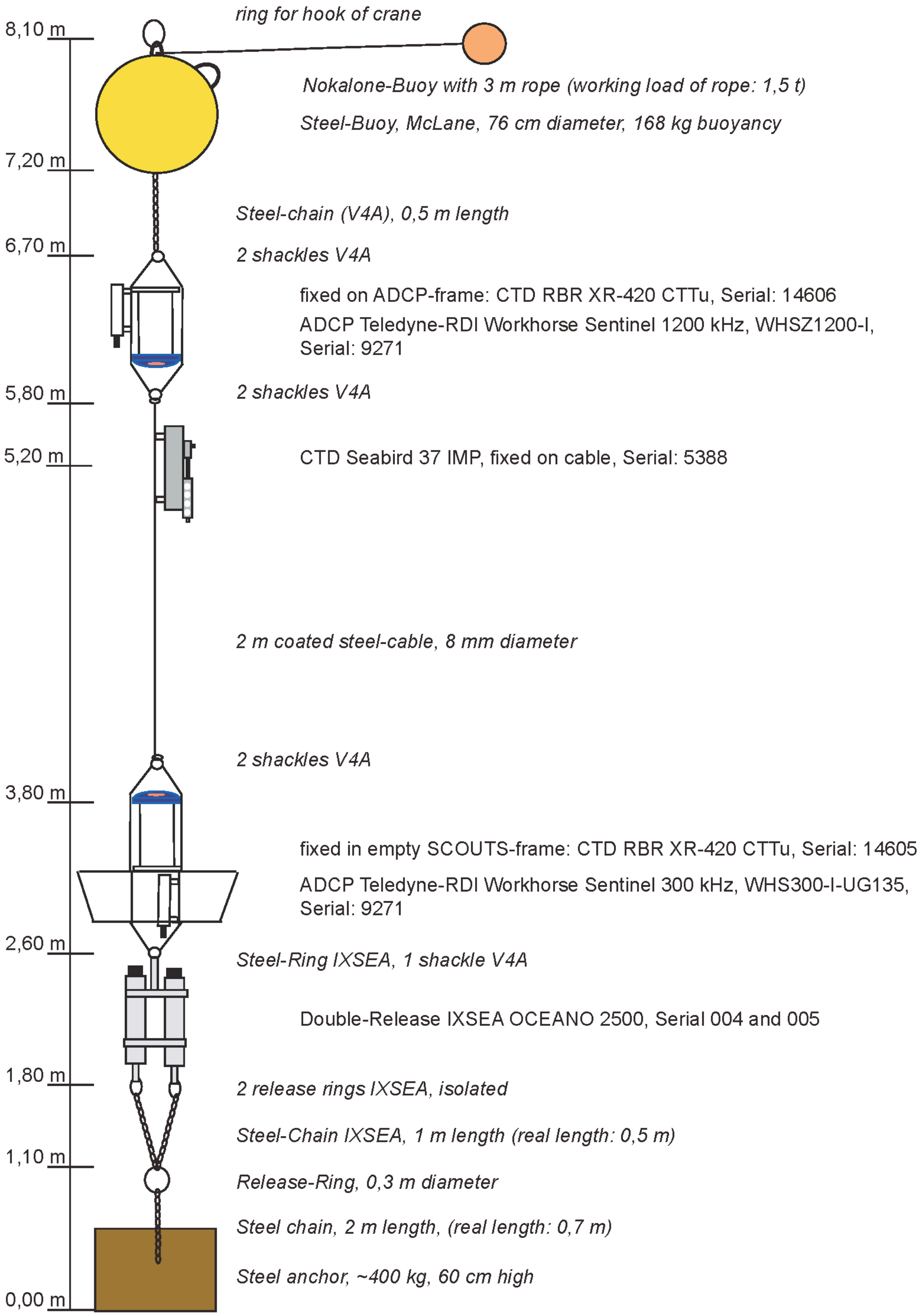
All parameters taken by this mooring:

- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring
- Conductivity
- Temperature
- Turbidity
- Pressure

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 004**	**Releaser # 005**
ARM	1663	1664
RELEASE	1655	1655
RELEASE-PINGER (Pinger after release: 3 min)	1656	1656
DIAGNOSTIC	1649	1649
PINGER ON	1647	1647
PINGER OFF	1648	1648

While triangulation and recovery both releasers where pinged, but only releaser #004 responded: #005 neither responded to diagnostics nor to release. *#005 needs to be checked on deck before redeployment!*


8,10 m
ring for hook of crane
Nokalone-Buoy with 3 m rope (working load of rope: 1,5 t)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
7,20 m
Steel-chain (V4A), 0,5 m length
6,70 m
2 shackles V4A
fixed on ADCP-frame: CTD RBR XR-420 CTTu, Serial: 14606
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I, Serial: 9271
5,80 m
2 shackles V4A
5,20 m
CTD Seabird 37 IMP, fixed on cable, Serial: 5388
2 m coated steel-cable, 8 mm diameter
2 shackles V4A
3,80 m
fixed in empty SCOUTS-frame: CTD RBR XR-420 CTTu, Serial: 14605
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG135, Serial: 9271
2,60 m
Steel-Ring IXSEA, 1 shackle V4A
Double-Release IXSEA OCEANO 2500, Serial 004 and 005
1,80 m
2 release rings IXSEA, isolated
Steel-Chain IXSEA, 1 m length (real length: 0,5 m)
1,10 m
Release-Ring, 0,3 m diameter
Steel chain, 2 m length, (real length: 0,7 m)
Steel anchor, ~400 kg, 60 cm high
0,00 m

Mooring "KHATANGA 09"

deployed during TRANSDRIFT XVI, recovered during TRANSDRIFT XVII

Deployed: **2009-09-16, 08:40 UTC**

Recovered: **2010-09-16, 12:30 UTC**

Position GPS60: **N74°42,942' E125°16,9464'; Decimal: N74.71570 E125.28244**
Depth: **45 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG135
  Memory: 64 Mbyte Flash-memory
  Serial: 9226

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 9208

- CTD RBR XR-420 CTTu
  Memory: 8 Mbyte Flash-memory
  Serial: 14604

- CTD RBR XR-420 CT
  Memory: 8 Mbyte Flash-memory
  Serial: 14607

- CTD Seabird 37 IMP
  Memory: 2 Mbyte Flash-memory
  Serial: 37IMP46569-5387

- Release IXSEA OCEANO 2500
  Serial: 002

- Release IXSEA OCEANO 2500
  Serial: 003

Sampling:

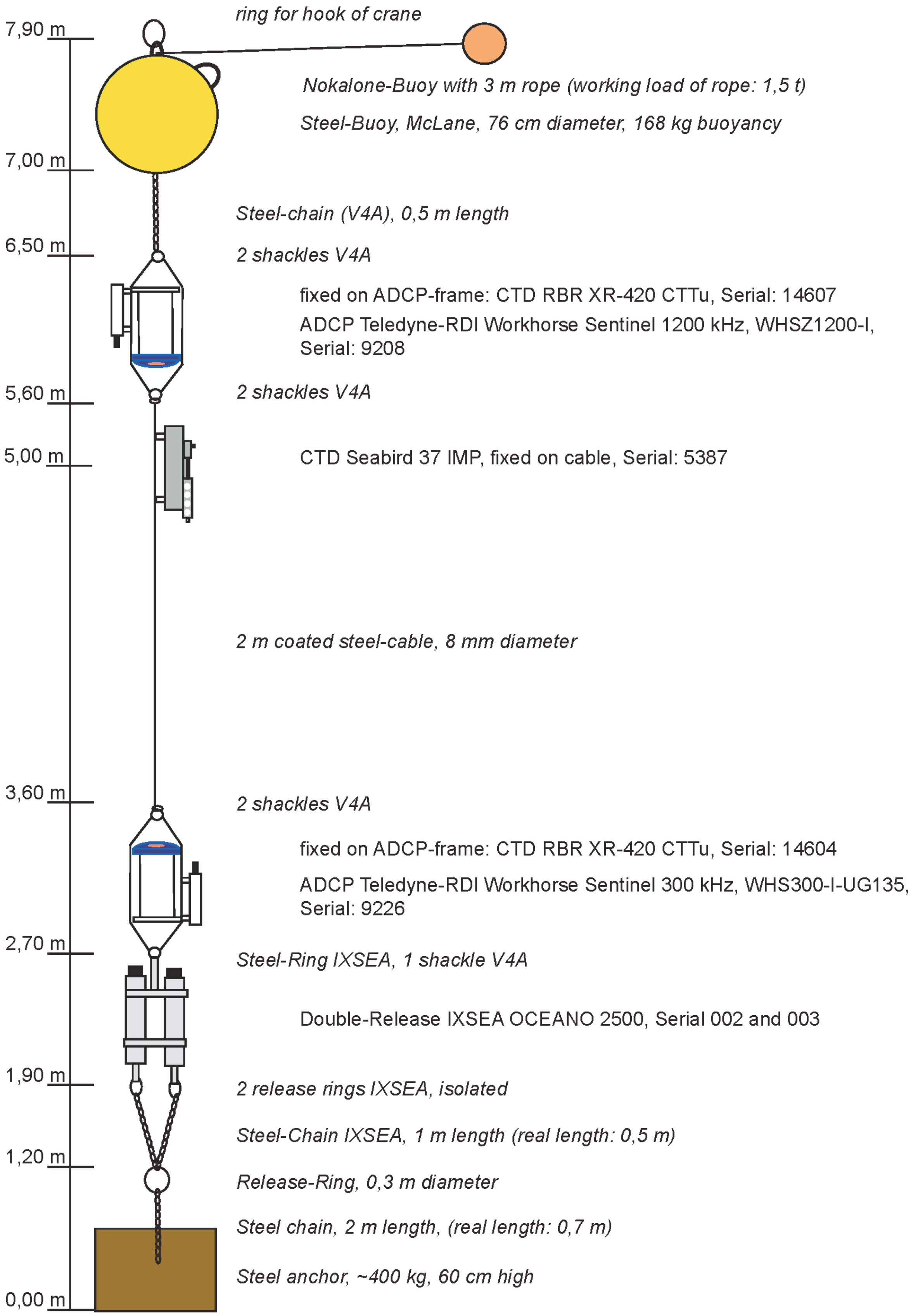
- the ADCPs were programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes; after recovery both ADCPs were still pinging, the clock drift of both was < then 1 minute
- the CTD SBE37IMP was programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes
- the CTDs from RBR were both programmed to take a full sample every 30 minutes. For the RBR logger with serial #14607 this is temperature and conductivity, while #14604 had an additional turbidity sensor. After recovery the internal clock of #14607 showed a drift of + 3 minutes to UTC, the clock of #14604 showed a drift of +2 minutes to UTC.

All parameters taken by this mooring:

- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring
- Conductivity
- Temperature
- Turbidity
- Pressure

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 002**	**Releaser # 003**
ARM	1661	1662
RELEASE	1655	1655
RELEASE-PINGER (Pinger after release: 3 min)	1656	1656
DIAGNOSTIC	1649	1649
PINGER ON	1647	1647
PINGER OFF	1648	1648


7,90 m
7,00 m
6,50 m
5,60 m
5,00 m
3,60 m
2,70 m
1,90 m
1,20 m
0,00 m
ring for hook of crane
Nokalone-Buoy with 3 m rope (working load of rope: 1,5 t)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
Steel-chain (V4A), 0,5 m length
2 shackles V4A
fixed on ADCP-frame: CTD RBR XR-420 CTTu, Serial: 14607
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I, Serial: 9208
2 shackles V4A
CTD Seabird 37 IMP, fixed on cable, Serial: 5387
2 m coated steel-cable, 8 mm diameter
2 shackles V4A
fixed on ADCP-frame: CTD RBR XR-420 CTTu, Serial: 14604
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG135, Serial: 9226
Steel-Ring IXSEA, 1 shackle V4A
Double-Release IXSEA OCEANO 2500, Serial 002 and 003
2 release rings IXSEA, isolated
Steel-Chain IXSEA, 1 m length (real length: 0,5 m)
Release-Ring, 0,3 m diameter
Steel chain, 2 m length, (real length: 0,7 m)
Steel anchor, ~400 kg, 60 cm high

Mooring "ST. ANNA"

deployed during Arctica-Kara-2009, recovered during TRANSDRIFT XVII

Deployed:	**September 2009**
Recovered:	**2010-09-22, 14:15 UTC**
Position:	**N81°01.417' E73°02.524'; Decimal: N81.02362° E73.04207°**
Depth:	**521 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, deployed in 110 m depth
  Memory: 128 Mbyte Flash-memory
  Serial: 12667

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, deployed in 350 m depth
  Memory: 128 Mbyte Flash-memory
  Serial: 3845

- CTD Seabird 37, deployed in 160 m depth
  Memory: 2 Mbyte Flash-memory
  Serial: 4703

- CTD Seabird 37, deployed in 180 m depth
  Memory: 2 Mbyte Flash-memory
  Serial: 3812

- CTD Seabird 37, deployed in 240 m depth
  Memory: 2 Mbyte Flash-memory
  Serial: 6928

- CTD Seabird 37, deployed in 300 m depth
  Memory: 2 Mbyte Flash-memory
  Serial: 3814

- CTD Seabird 37, deployed in 400 m depth
  Memory: 2 Mbyte Flash-memory
  Serial: 3811

- CTD Sea & Sun, CTD48M + Turbidity, deployed in 480 m depth
  Serial: 352

- Release IXSEA OCEANO 2500S-DI, deployed in 500 m depth
  Serial: 006

- Release IXSEA OCEANO 2500S-DI, deployed in 500 m depth
  Serial: 008

Sampling:

- the ADCPs were both programmed using 4 m cell size (bin), each ADCP having 27 depth cells with 50 pings/ensemble. Both ADCPs are downlooking.
- the CTDs SBE37 were all programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes. The lowest SBE37, # 3811, was deployed upside down and stopped working in February 2010, most likely due to strong sedimentation inside the pump tube.
- the CTD48M+Turbidity was programmed to take a sample every 30 minutes. The clock drifted approx. 2 minutes during deployment.

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 006**	**Releaser # 008**
ARM	1903	1905
RELEASE	1955	1955
RELEASE-PINGER (Pinger after release: 3 min)	1956	1956
DIAGNOSTIC	1949	1949
PINGER ON	1947	1947
PINGER OFF	1948	1948

APPENDIX F: DEPLOYMENT SHEETS AND DRAWINGS OF ALL DEPLOYED SEAFLOOR OBSERVATORIES

Mooring "ANABAR 10"

deployed during TRANSDRIFT XVII

Deployed: **2010-09-12, 21:00 UTC**

Position GPS60: **N74°19,8605' E128°00,1494'; Decimal: N74.331009° E128.002490°**

Depth: **30 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG176
  Memory: 64 Mbyte Flash-memory
  Serial: 14378

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 9207

- CTD RBR XR-420 CTTu with Hydrowiper
  Memory: 8 Mbyte Flash-memory
  Serial: 17150

- CTD RBR XR-420 CTTu with Hydrowiper
  Memory: 8 Mbyte Flash-memory
  Serial: 17151

- CTD Seabird 37 SMP, 100 m pressure sensor
  Memory: 2 Mbyte Flash-memory
  Serial: 37SMP49347-5663

- Release IXSEA OCEANO 2500S-DI
  Serial: 068

- Release IXSEA OCEANO 2500S-DI
  Serial: 069

Sampling:

- the ADCPs are programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes
- the CTD SBE37IMP is programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes
- the CTDs from RBR are both programmed to take a full sample (temperature, conductivity, turbidity) every 30 minutes

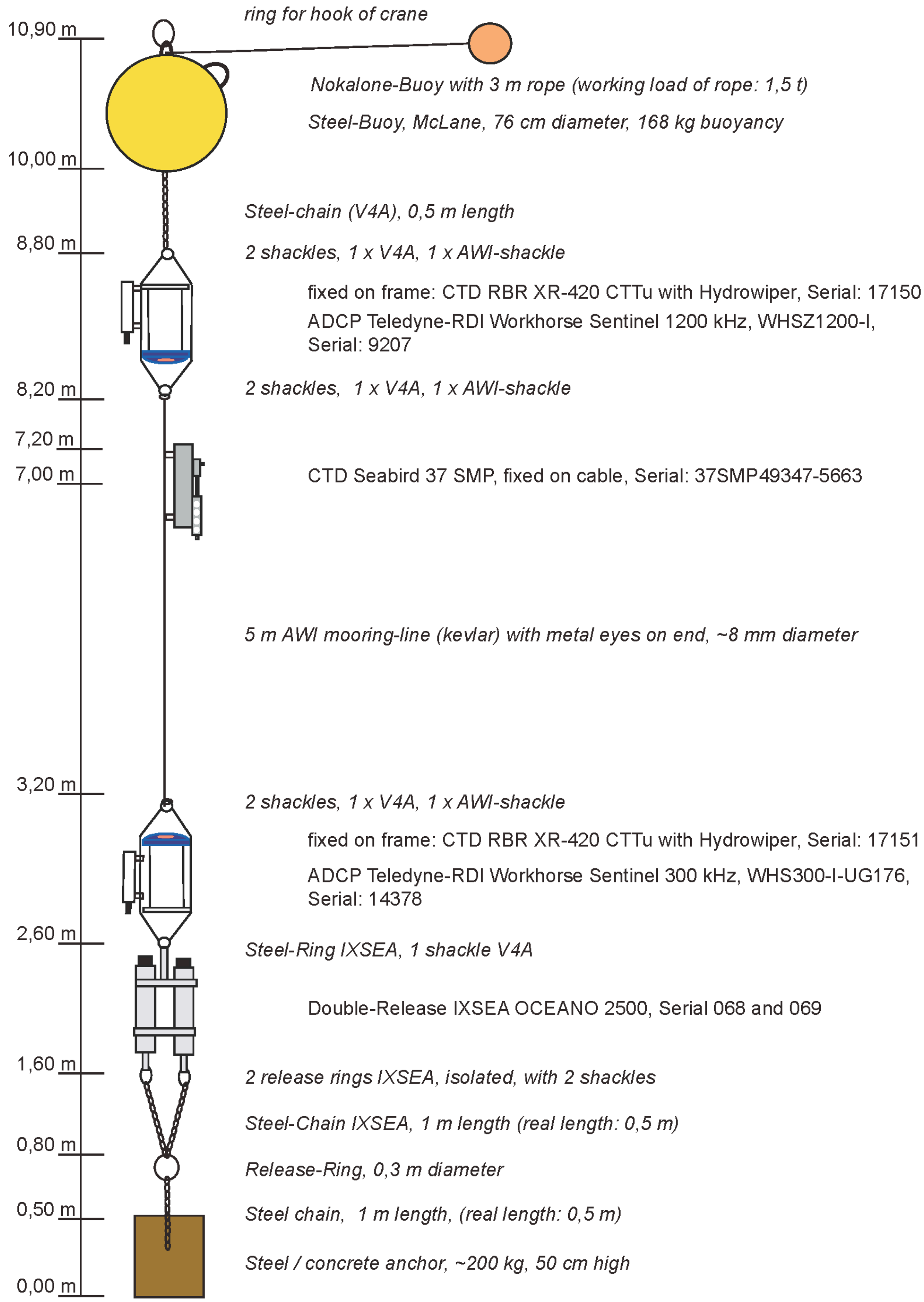
All parameters taken by this mooring:

- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)

- distance to the surface above the mooring
- Conductivity
- Temperature
- Turbidity
- Pressure

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 068**	**Releaser # 069**
ARM	193A	193B
RELEASE	1955	1955
RELEASE-PINGER (Pinger after release: 3 min)	1956	1956
DIAGNOSTIC	1949	1949
PINGER ON	1947	1947
PINGER OFF	1948	1948


10,90 m
10,00 m
8,80 m
8,20 m
7,20 m
7,00 m
3,20 m
2,60 m
1,60 m
0,80 m
0,50 m
0,00 m
ring for hook of crane
Nokalone-Buoy with 3 m rope (working load of rope: 1,5 t)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
Steel-chain (V4A), 0,5 m length
2 shackles, 1 x V4A, 1 x AWI-shackle
fixed on frame: CTD RBR XR-420 CTTu with Hydrowiper, Serial: 17150
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I, Serial: 9207
2 shackles, 1 x V4A, 1 x AWI-shackle
CTD Seabird 37 SMP, fixed on cable, Serial: 37SMP49347-5663
5 m AWI mooring-line (kevlar) with metal eyes on end, ~8 mm diameter
2 shackles, 1 x V4A, 1 x AWI-shackle
fixed on frame: CTD RBR XR-420 CTTu with Hydrowiper, Serial: 17151
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG176, Serial: 14378
Steel-Ring IXSEA, 1 shackle V4A
Double-Release IXSEA OCEANO 2500, Serial 068 and 069
2 release rings IXSEA, isolated, with 2 shackles
Steel-Chain IXSEA, 1 m length (real length: 0,5 m)
Release-Ring, 0,3 m diameter
Steel chain, 1 m length, (real length: 0,5 m)
Steel / concrete anchor, ~200 kg, 50 cm high

Mooring “KHATANGA 10”
deployed during TRANSDRIFT XVII

Deployed: **2010-09-18, 19:07 UTC**

Position GPS60: **N74°42,529' E125°14,958'; Decimal: N74.70882° E125.24928°**
Depth: **42 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 9208

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 14458

- ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz WHSZ1200-I;
  Memory: 64 Mbyte Flash-memory
  Serial: 14456

- CTD RBR XR-420 CTTu with Hydrowiper
  Memory: 8 Mbyte Flash-memory
  Serial: 17152

- CTD RBR XR-420 CT
  Memory: 8 Mbyte Flash-memory
  Serial: 17153

- CTD Seabird 37 SMP
  Memory: 2 Mbyte Flash-memory
  Serial: 7878

- CTD Seabird 37 SMP
  Memory: 2 Mbyte Flash-memory
  Serial: 7879

- Release IXSEA OCEANO 2500
  Serial: 062

- Release IXSEA OCEANO 2500
  Serial: 065

Sampling:
- the ADCPs are programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes
- the CTD SBE37SMP is programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes

- the CTDs from RBR are both programmed to take a full sample every 30 minutes (temperature, conductivity, turbidity)

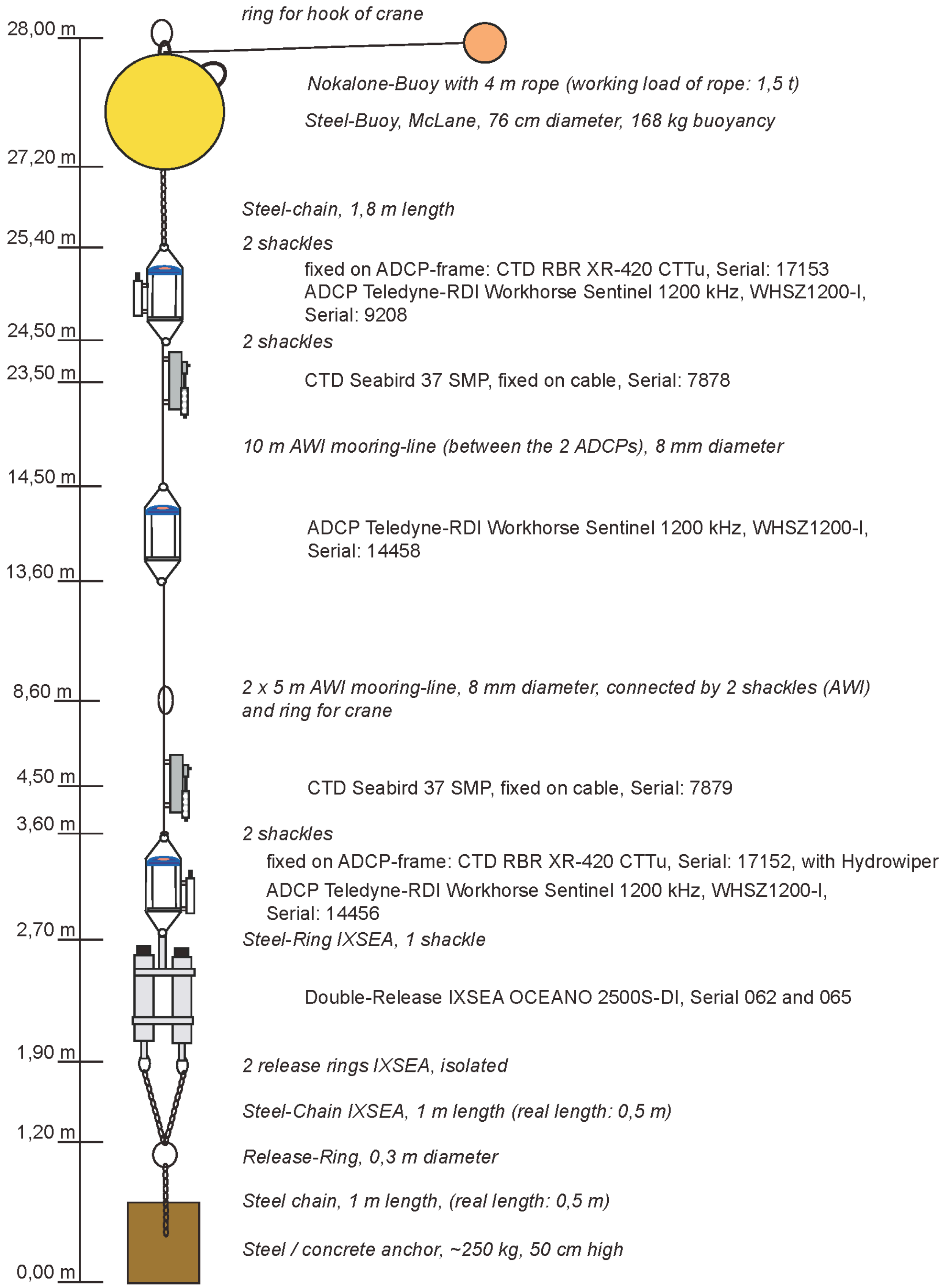
All parameters taken by this mooring:

- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring
- Conductivity
- Temperature
- Turbidity
- Pressure

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 062**	**Releaser # 065**
ARM	1936	1939
RELEASE	1955	1955
RELEASE-PINGER (Pinger after release: 3 min)	1956	1956
DIAGNOSTIC	1949	1949
PINGER ON	1947	1947
PINGER OFF	1948	1948

***Note**: after deployment releaser #062 responded very badly, and couldn't be used for triangulation from each triangulation point. It responded (one could hear the response via Hydrophone), but the TT801 didn't recognizes the signal. Only sometimes the TT801 recognized the signal, but interpreted it with a very huge error (like showing a distance of > 11 km, while the true distance was ~300 m). The other release, #065, worked well on all these distances for triangulation and diagnostics.*


28,00 m
27,20 m
25,40 m
24,50 m
23,50 m
14,50 m
13,60 m
8,60 m
4,50 m
3,60 m
2,70 m
1,90 m
1,20 m
0,00 m
ring for hook of crane
Nokalone-Buoy with 4 m rope (working load of rope: 1,5 t)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
Steel-chain, 1,8 m length
2 shackles
fixed on ADCP-frame: CTD RBR XR-420 CTTu, Serial: 17153
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I,
Serial: 9208
2 shackles
CTD Seabird 37 SMP, fixed on cable, Serial: 7878
10 m AWI mooring-line (between the 2 ADCPs), 8 mm diameter
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I,
Serial: 14458
2 x 5 m AWI mooring-line, 8 mm diameter, connected by 2 shackles (AWI)
and ring for crane
CTD Seabird 37 SMP, fixed on cable, Serial: 7879
2 shackles
fixed on ADCP-frame: CTD RBR XR-420 CTTu, Serial: 17152, with Hydrowiper
ADCP Teledyne-RDI Workhorse Sentinel 1200 kHz, WHSZ1200-I,
Serial: 14456
Steel-Ring IXSEA, 1 shackle
Double-Release IXSEA OCEANO 2500S-DI, Serial 062 and 065
2 release rings IXSEA, isolated
Steel-Chain IXSEA, 1 m length (real length: 0,5 m)
Release-Ring, 0,3 m diameter
Steel chain, 1 m length, (real length: 0,5 m)
Steel / concrete anchor, ~250 kg, 50 cm high

Mooring "KOTELNYY10"
deployed during TRANSDRIFT XVII

Deployed: **2010-09-16, 20:14 UTC**

Position GPS60: **N77°58,47' E137°057,442'; Decimal: N77.97461° E136.95738°**

Depth: **61 m**

Devices:
- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG176
  Memory: 64 Mbyte Flash-memory
  Serial: 14278

- CTD Seabird 37 SMP, 100 m pressure sensor
  Memory: 2 Mbyte Flash-memory
  Serial: 37SMP53002-6723

- CTD Seabird 37 SMP, 100 m pressure sensor
  Memory: 2 Mbyte Flash-memory
  Serial: 37SMP53002-6726

- Release IXSEA OCEANO 2500S-DI
  Serial: 063

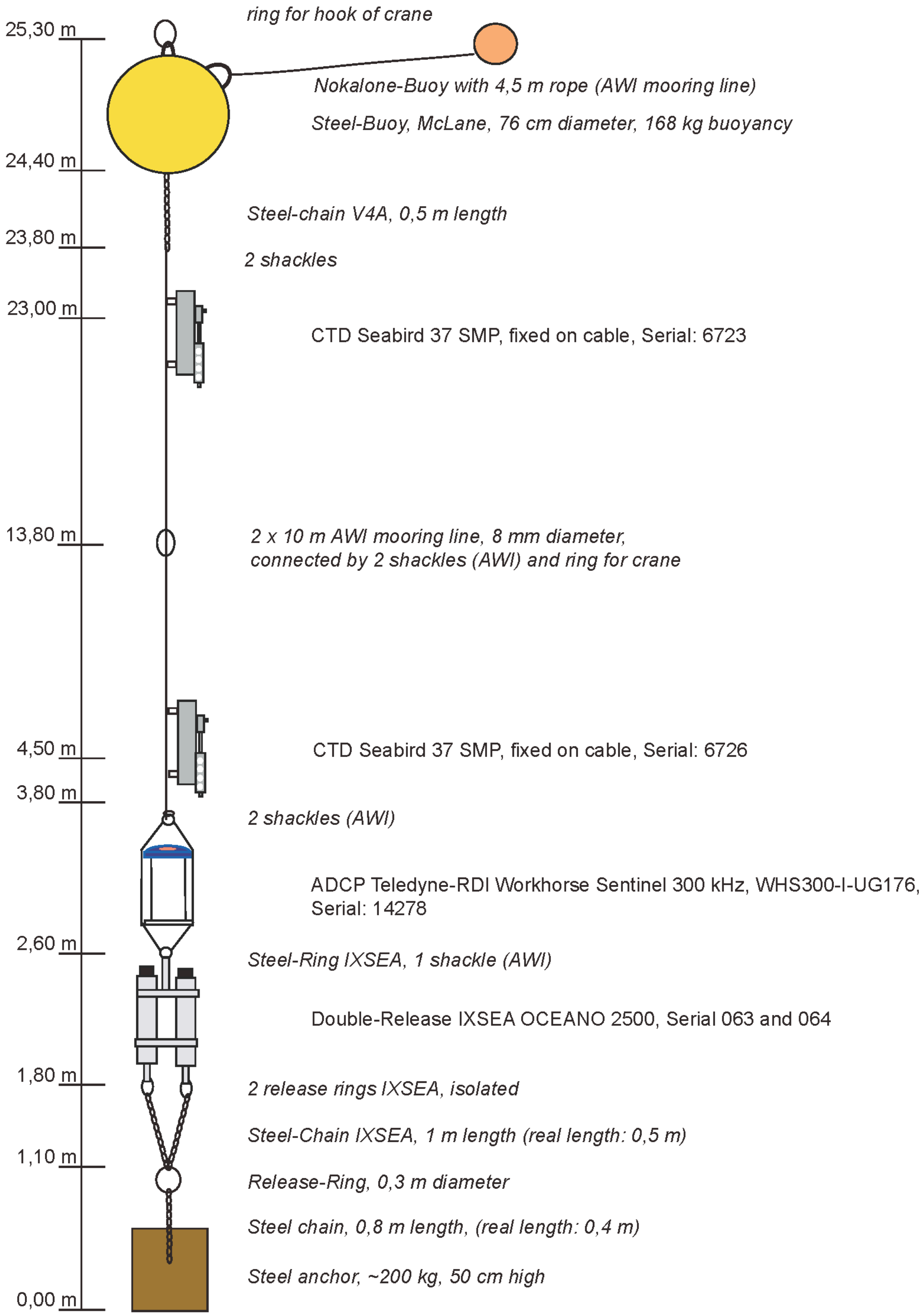
- Release IXSEA OCEANO 2500S-DI
  Serial: 064

Sampling:
- the ADCP is programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes
- the CTDs SBE37SMP are programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes

All parameters taken by this mooring:
- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring
- Conductivity
- Temperature
- Pressure

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 063**	**Releaser # 064**
ARM	1937	1938
RELEASE	1955	1955
RELEASE-PINGER (Pinger after release: 3 min)	1956	1956
DIAGNOSTIC	1949	1949
PINGER ON	1947	1947
PINGER OFF	1948	1948



25,30 m
ring for hook of crane
Nokalone-Buoy with 4,5 m rope (AWI mooring line)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
24,40 m
Steel-chain V4A, 0,5 m length
23,80 m
2 shackles
23,00 m
CTD Seabird 37 SMP, fixed on cable, Serial: 6723
13,80 m
2 x 10 m AWI mooring line, 8 mm diameter,
connected by 2 shackles (AWI) and ring for crane
4,50 m
CTD Seabird 37 SMP, fixed on cable, Serial: 6726
3,80 m
2 shackles (AWI)
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG176,
Serial: 14278
2,60 m
Steel-Ring IXSEA, 1 shackle (AWI)
Double-Release IXSEA OCEANO 2500, Serial 063 and 064
1,80 m
2 release rings IXSEA, isolated
Steel-Chain IXSEA, 1 m length (real length: 0,5 m)
1,10 m
Release-Ring, 0,3 m diameter
Steel chain, 0,8 m length, (real length: 0,4 m)
Steel anchor, ~200 kg, 50 cm high
0,00 m

Mooring "OSL2E"

deployed during TRANSDRIFT XVII

Deployed: **2010-09-17, 18:05 UTC**

Position GPS60: **76°33.930'N, 126°03.346'E; Decimal: N76.56551° E126.05577°**

Depth: **53 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG176
  Memory: 64 Mbyte Flash-memory
  Serial: 14379

- CTD Seabird SBE37SMP
  Memory: 8 Mbyte Flash-memory
  Serial: 7880

- CTD Seabird SBE37SMPs
  Memory: 8 Mbyte Flash-memory
  Serial: 7881

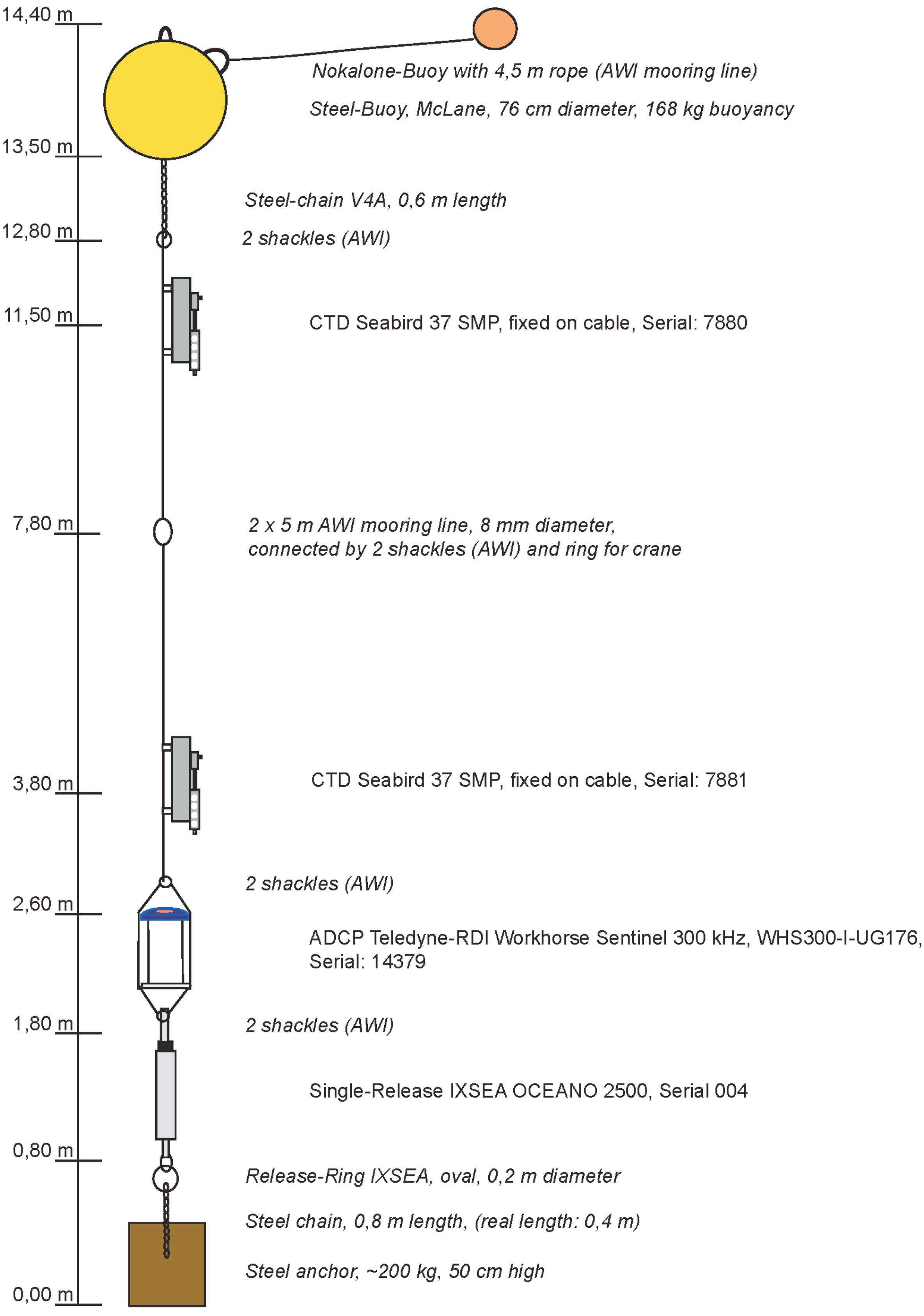
- Release IXSEA OCEANO 2500S-DI (AR)
  Serial: 004

Sampling:
- the ADCP is programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes
- both CTD SBE37SMP are programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes

All parameters taken by this mooring:
- Conductivity
- Temperature
- Pressure
- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 004**
ARM	1663
RELEASE	1655
RELEASE-PINGER (Pinger after release: 3 min)	1656
DIAGNOSTIC	1649
PINGER ON	1647
PINGER OFF	1648


14,40 m
13,50 m
12,80 m
11,50 m
7,80 m
3,80 m
2,60 m
1,80 m
0,80 m
0,00 m
Nokalone-Buoy with 4,5 m rope (AWI mooring line)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
Steel-chain V4A, 0,6 m length
2 shackles (AWI)
CTD Seabird 37 SMP, fixed on cable, Serial: 7880
2 x 5 m AWI mooring line, 8 mm diameter,
connected by 2 shackles (AWI) and ring for crane
CTD Seabird 37 SMP, fixed on cable, Serial: 7881
2 shackles (AWI)
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG176,
Serial: 14379
2 shackles (AWI)
Single-Release IXSEA OCEANO 2500, Serial 004
Release-Ring IXSEA, oval, 0,2 m diameter
Steel chain, 0,8 m length, (real length: 0,4 m)
Steel anchor, ~200 kg, 50 cm high

Mooring "OSL4"
deployed during TRANSDRIFT XVII

Deployed: **2010-09-20, 02:22 UTC**

Position GPS60: **77°10.199'N, 114°55.025'E; Decimal: N77.16999° E114.91709°**

Depth: **64 m**

Devices:

- ADCP Teledyne-RDI Workhorse Sentinel 300 kHz WHS300-I-UG176
  Memory: 64 Mbyte Flash-memory
  Serial: 9226

- CTD Seabird SBE37SMP
  Memory: 8 Mbyte Flash-memory
  Serial: 7926

- CTD Seabird SBE37SMP
  Memory: 8 Mbyte Flash-memory
  Serial: 7927

- Release IXSEA OCEANO 2500S-DI
  Serial: 002

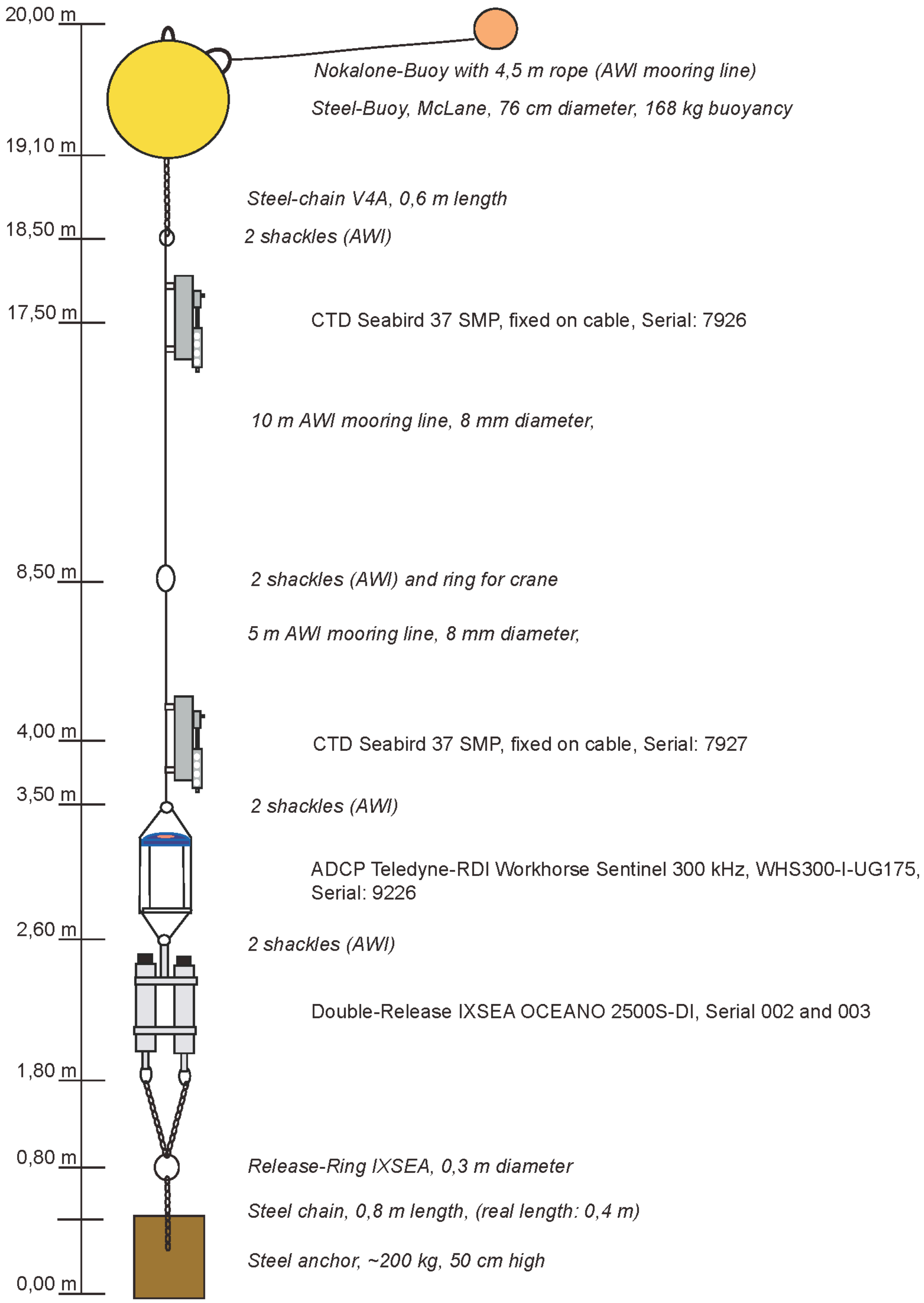
- Release IXSEA OCEANO 2500S-DI
  Serial: 003

Sampling:
- the ADCP is programmed to take a full sample (direction and velocity of the currents in the whole water column above the instrument, distance to the surface above the instrument) every 30 minutes
- both CTD SBE37SMP are programmed to take a full sample (pressure, temperature, conductivity) every 15 minutes

All parameters taken by this mooring:
- Conductivity
- Temperature
- Pressure
- velocity of currents (in the whole water column above mooring)
- direction of currents (in the whole water column above mooring)
- distance to the surface above the mooring

Releaser:

CAF: 12,0 kHz, PFR: 12,0 kHz, FR0: 9,0 kHz, FR1: 11,5 kHz	**Releaser # 002**	**Releaser # 003**
ARM	1661	1662
RELEASE	1655	1655
RELEASE-PINGER (Pinger after release: 3 min)	1656	1656
DIAGNOSTIC	1649	1649
PINGER ON	1647	1647
PINGER OFF	1648	1648


20,00 m
19,10 m
18,50 m
17,50 m
8,50 m
4,00 m
3,50 m
2,60 m
1,80 m
0,80 m
0,00 m
Nokalone-Buoy with 4,5 m rope (AWI mooring line)
Steel-Buoy, McLane, 76 cm diameter, 168 kg buoyancy
Steel-chain V4A, 0,6 m length
2 shackles (AWI)
CTD Seabird 37 SMP, fixed on cable, Serial: 7926
10 m AWI mooring line, 8 mm diameter,
2 shackles (AWI) and ring for crane
5 m AWI mooring line, 8 mm diameter,
CTD Seabird 37 SMP, fixed on cable, Serial: 7927
2 shackles (AWI)
ADCP Teledyne-RDI Workhorse Sentinel 300 kHz, WHS300-I-UG175,
Serial: 9226
2 shackles (AWI)
Double-Release IXSEA OCEANO 2500S-DI, Serial 002 and 003
Release-Ring IXSEA, 0,3 m diameter
Steel chain, 0,8 m length, (real length: 0,4 m)
Steel anchor, ~200 kg, 50 cm high

APPENDIX G: SHIP DRAWINGS AND DECK PLANS

МИНИСТЕРСТВО ТРАНСПОРТА РОССИЙСКОЙ ФЕДЕРАЦИИ

ГОСУДАРСТВЕННОЕ ГИДРОГРАФИЧЕСКОЕ ПРЕДПРИЯТИЕ

Адрес: 190031, Санкт–Петербург
Московский пр.,12
Телекс: 121345 PTB SU, факс: 3103768
Телефоны: (812) 310–37–68, (812) 310–39–70

MINISTRY OF TRANSPORT OF RUSSIA

STATE HYDROGRAPHIC DEPARTMENT

Moskovskiy pr., 12
St. Petersburg, 190031, Russia
Telex: 121345 PTB SU, fax: 3103768
Phone: (812) 310–37–68, (812) 310–39–70

HYDROGRAPHIC SURVEY VESSELS

DMITRIY OVTSYN
DMITRIY LAPTEV
EDWARD TOLL
NIKOLAI KOLOMEITSEV
VALERIAN ALBANOV
VLADIMIR SUHOTSKIY
SERGEI KRAVKOV
NIKOLAI JEVGENOV
FEDOR MATISEN
GEORGIY MAKSIMOV
IVAN KIREJEV
PAVEL BASHMAKOV
JAKOV SMIRNITSKIY

OUTLINE SPECIFICATION

MAIN DIMENSIONS

		DMITRY OVTSIN-class	FJODOR MATISEN-class
Length over all	m	67.00	68.74
Length between rpendiculars	m	60.00	60.56
b._adth moulded	m	11.87	12.40
Depth moulded	m	6.00	6.04
Draught at L/2 in salt water	m	4.13	4.16
Tonnage, gross	GRT	1134	1213
Displacement abt.	tonnes	1630	1700
Crew+scientists		20+22	20+28
Speed	knots	14.0	14.0

MACHINERY

The propulsion machinery consists of a six-cylinder four-stroke turbocharged diesel engine, make Deutz RBV6M 358 with an output of 1,470 kW (2,000 bhp) at 5.25 r/s, coupled via a Spiroflex coupling to a four-bladed KaMeWa controllable pitch propeller. Electricity is generated by three 150 kVA diesel generating sets and a 185 kVA shaft alternator. In addition there is a 65 kVA emergency unit. Steam is generated by a 800/350 kg/h at 490 kPa boiler.

Main engine and other machinery remote controlled from a central control room.

PERFORMANCE

The vessel is built of welded steel construction with ice strengthening. This together with the excellent seakeeping ability secures operation in all conditions. In addition to the c.p. propeller there is a bow thruster and a Maierform-type passive antirolling stabilizing tank system.

The vessel is a silent ship and has good manouverability on a speed range starting of around 4 knots.

The stores are sufficient for 40 days consumption of 52 crew members. The fuel tank capacities allow for continuous running of the engines for 36 days. Depending on the version there are high standard accommodation for 42/48 crew members making it possible to perform also long sailings.

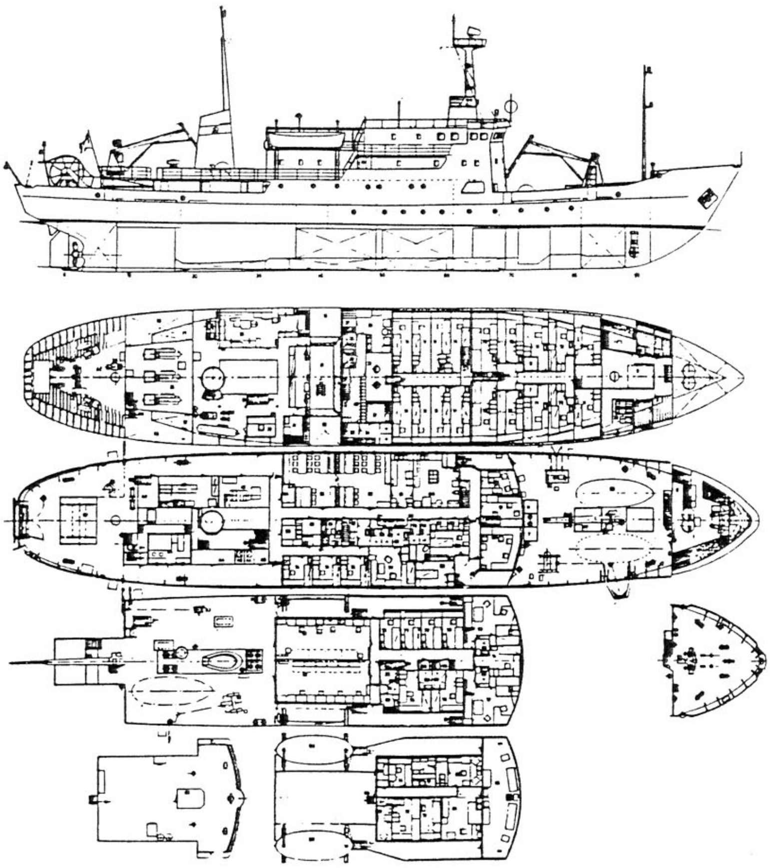
There are the following research spaces and laboratories:

— hydrographic research centre 27 m²
— plotting room 15 m²
— hydrological laboratory 16.5 m²
— rough laboratory 9 m²
— photographic laboratory 4.5 m²

CAPACITIES

Diesel oil	260 tonnes
Lubricating oil	6 tonnes
Fresh water	160 tonnes
Cargo	abt. 100 tonnes

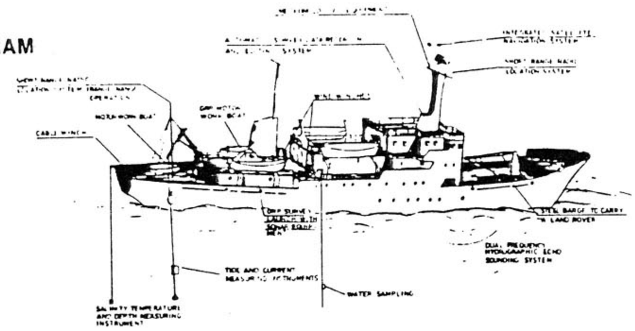
GENERAL ARRANGEMENT



EXPLANATIONS

10 sample store
18 stabilizing tank
22 control room
23 engine room
32 gyro and gravity room
33 sauna
41 sample workshop
48 seismic equipment store
50 photolaboratory
51 hydrogeochemical
52 plotting room
53 computer centre
54 seismic equipment store
55 geological lab.
56 hydrophysical lab.
57 seismic winch
62, 63 mess
87 echo sounding centre
91 cable winch
92 twin-drum wire winch
93 cable winch
94 wire winch

OPERATIONAL DIAGRAM



HYDROGRAPHIC VERSION