MOSJ-ICE 2014

R/V *Lance*

22 - 31 July 2014

Kongsfjorden & Rijpfjorden

Contents

General

The MOSJ-ICE 2014 cruise started in Longyearbyen on 22. July and ended in Longyearbyen on 31. July. The Kongsfjorden and Rijpfjorden oceanographic transects are serviced by the Norwegian Polar Institute every summer and used to monitor long term changes in phytoplankton and zooplankton as well as trophic structure of the Arctic marine ecosystem of this area. In additional to the standard pelagic sampling experimental work was conducted in both Kongsfjorden and Rjipfjorden. This year the geological sampling was also included at selected stations in Kongsfjorden and Rjipfjorden. In addition participants from the Indian National Centre for Antarctic and Ocean Research successfully put out a mooring with oceanographic instruments close to Kb3 in Kongsfjorden.

The Kongsfjorden transect extends from the inner parts of Kongsfjorden into central Fram Strait and is part of the environmental monitoring program of Svalbard and Jan Mayen (www.mosj.npolar.no). The position of the western-most Hausgarten station (HGIV) had to be taken further east as planned due to heavy ice conditions in Fram Strait. The Rijpfjorden transect extends from the inner parts of Rijpfjorden into the Nansen basin and is run by the Centre for Ice, Climate and Ecosystems (ICE) at the Norwegian Polar Institute. Due to heavy ice conditions on the shelf north of Rijpfjorden only stations R1-R4 could be sampled (Figure 1). Station R1 had to be shifted north due to consolidated fast-ice in the inner part of Rijpfjorden while station R4 was taken slightly further south due to heavy pack ice on the northern shelf. The gained shiptime from the shortened Rijpfjorden transect was used to conduct an additional oceanographic transect on the shelf north-west of Hinlopen Strait (new transect = NTr). An overview of pelagic and geological stations sampled during the MOSJ-ICE 2014 cruise can be found in Table 1 and the locations of all stations are shown in Figure 2.

Samplelog (MOSJ2014 samplelog 20082014.xlsx) is stored at Marinedatabase NPI, http://api.npolar.no/biology/marine/sample/ (contact Anette Wold to get username and password).

The standard pelagic survey included:
Oceanographic sampling (salinity, temperature and density)
Water samples (DIC/AT, Methane, CDOM, $\delta^{18}O$, Particle absorption, Chl a, POC/PON, BSi, Nutrients)
Phytoplankton taxonomy
Meso & macro zooplankton taxonomy

The experimental work included:
Dilution experiments to estimate microzooplankton grazing rates
The influence of incubation time and water masses on P-I curves
Photosynthetic quantum yield (Fv/Fm)
Zooplankton fecal pellets production
Zooplankton respiration rates

The marine geology work included:
Surface sediment samples (living foraminifera)
Down core sediment samples for paleo-reconstructions
Sea ice biomarker IP_{25} and other structurally similar compounds, collectively called Highly Branched Isoprenoids/HBIs.

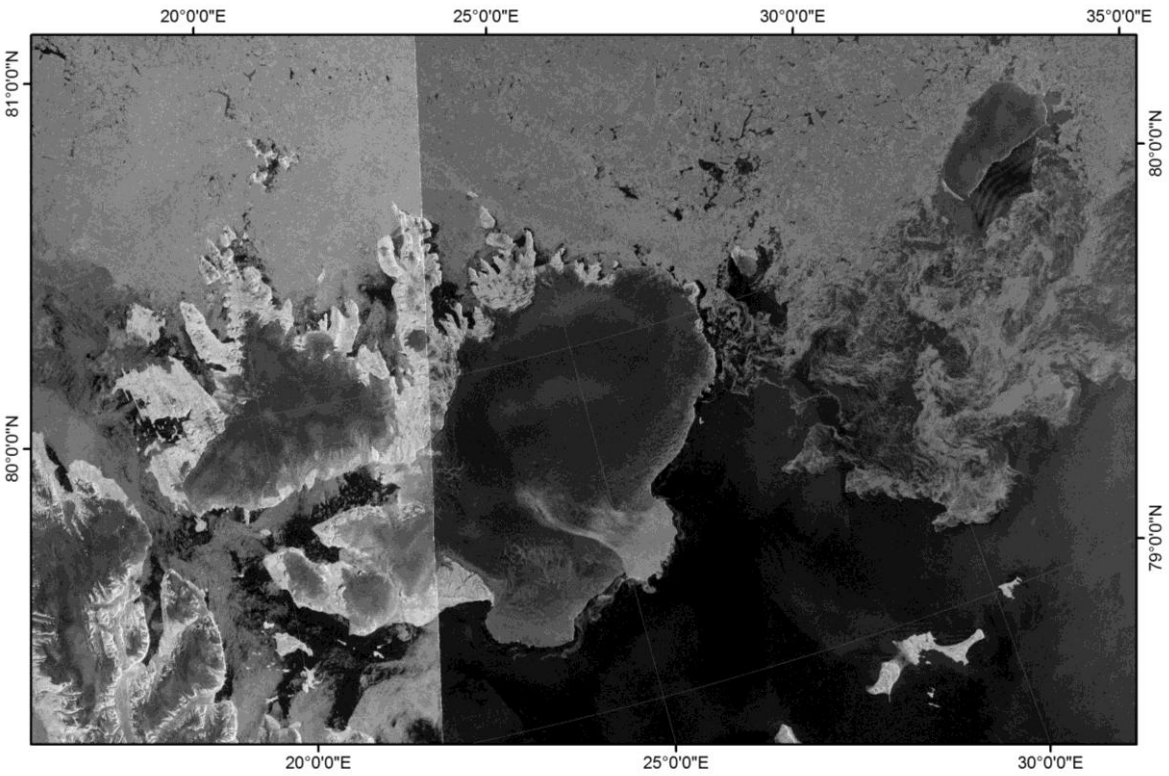


Figure 1. Sea Ice cover north of Nordaustlandet 23 July. RADARSAT-2 images provided by NSC/KSAT under the Norwegian-Canadian RADARSAT agreement 2013 © MacDonald, Dettwiler and Associates

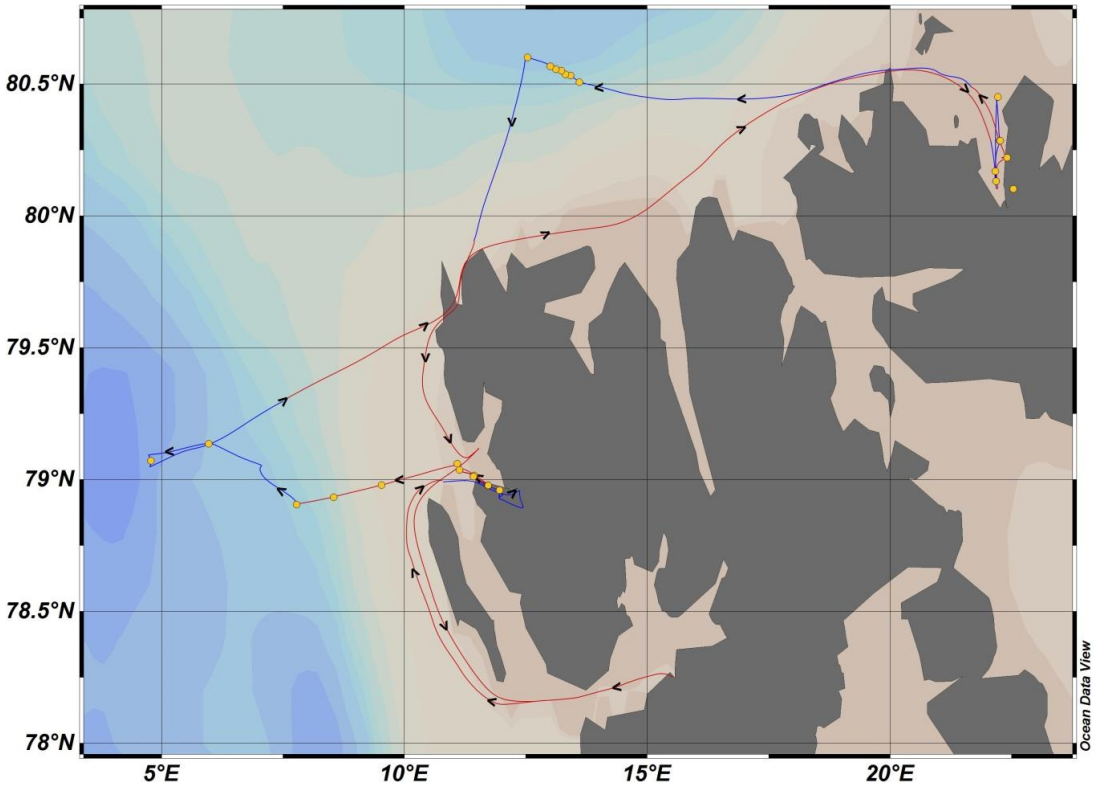


Figure 2. Stations sampled and cruise track during MOSJ-ICE cruise 2014

List of stations

Table 1: Overview of stations sampled during the MOSJ-ICE cruise in 2014.

Station	Latitude N (dec.)	Longitude E (dec.)	Bottom depth (m)	Date	Time	Sampling
Kb7	78.97	12.38	67	23.07.2014	02:38	Pelagic
Kb6	78.93	12.39	55	23.07.2014	04:52	Pelagic
Kb5	78.90	12.44	77	23.07.2014	07:19	Pelagic
Kb3	78.96	11.96	330	23.07.2014	13:10	Pelagic & Geology
Kb2	78.98	11.72	303	23.07.2014	20:31	Pelagic & Geology
Kb1	79.01	11.43	350	23.07.2014	22:20	Pelagic & Geology
Kb0	79.04	11.13	313	24.07.2014	01:40	Pelagic & Geology
FM	79.01	11.09	333	27.07.2014	11:08	Geology
V12	78.98	09.55	224	24.07.2014	14:30	Pelagic
V10	78.97	08.55	295	24.07.2014	20:00	Pelagic
V6	78.91	07.77	1130	24.07.2014	21:50	Pelagic
KH	79.05	07.01	1317	25.07.2014	03:16	Pelagic
HG-I	79.14	06.01	1269	25.07.2014	08:47	Pelagic
HG-IVb	79.09	04.72	1860	25.07.2014	14:10	Pelagic
R1b	80.13	22.18	185	27.07.2014	03:32	Pelagic & Geology
R2	80.17	22.17	166	27.07.2014	07:16	Pelagic & Geology
R3	80.28	22.26	229	27.07.2014	10:40	Pelagic
R4b	80.45	22.22	86	27.07.2014	13:17	Pelagic
NTr1	80.51	13.60	203	29.07.2014	10:25	Pelagic
NTr2	80.53	13.43	345	29.07.2014	12:09	Pelagic
NTr4	80.53	13.22	599	29.07.2014	14:05	Pelagic
NTr6	80.57	12.99	799	29.07.2014	16:15	Pelagic
NTr7	80.60	12.53	1042	29.07.2014	17:50	Pelagic

Physical Oceanography

Vladimir Pavlov and Olga Pavlova (NPI)

The aim of the oceanographic survey was to do targeted measurements covering the following key topics:
1) Distribution of hydrography and movement of water in the Kongsfjorden and Rijpfjorden of Svalbard.
2) Heat flux from the Atlantic Water up to melt water layer and ice, and the factors governing this flux to the north of Svalbard.

Instruments

Data were collected using a range of instruments:
CTD for collection of vertical profiles of conductivity (salinity), temperature and associated parameters like chlorophyll, radiance etc. The CTD rosette is also equipped with water sampling bottles. A total of 25 profiles were made, see Table 1 for an overview of the main stations.
ADCP (acoustic doppler current profiler) was used for measuring water currents throughout the water column, by ship-mounted ADCP 150 kHz (upper ~200 m)

Hydrographic structure

Vertical Sections

Positions of the CTD stations and transects are presented in Figures 3, 4 and Table 1. The vertical sections (Figure 5) are presented for the Transect **A** in the Kongsfjorden and eastern part of the Fram Strait. The major physical features found at this section include the area of high temperature and high salinity water in the surface layer over the slope and in the central part of the Kongsfjorden. At the stations V10, V12 we observe the temperature of 6.8° C and salinity more than 35 psu near the surface. Such high temperature in the surface layer can be related with summer heating and high salinity can be associated with convection processes in the last winter. Temperatures in the surface layer in the western (station HG-IV) and eastern parts of the transect are much lower. In the western part it could be explained by melting of the sea ice and in the eastern part (stations Kb5-Kb7) by melting of glaciers. Below 1000 m, in the western part of the transect, the temperatures are negative and hydrography has the typical Arctic Water characteristics. Vertical distribution of fluorescence shows that maximum values (7-8 mg m^{-3}) of this characteristic, associated with chlorophyll maximum concentration, are in the layer of 25-30 m (stations KH, V6, V10 and V12). In the western (station HG-IV) and eastern (stations Kb1-Kb7) parts of this transect the fluorescence is much lower.
Figure 6 shows the vertical distribution of temperature, salinity and fluorescence at the Transect **B** in Rijpfjorden. Due to very heavy sea-ice conditions in this area we only did 4 CTD stations in the fjord (Figure 6). Water temperature was negative for the whole transect in Rjipfjorden (Figure 6) except very thin surface layer (stations R1-R3) where temperature is positive due to summer heating, but not more than 1.2^0 C. In the deep part of the Rijpfjorden the temperature is near freezing point. Due to the melting of sea ice, salinity in the upper layer is very low (24-29 psu). At the depth of 5-7 m the strong halocline was formed. The salinity deeper 70 m is uniform (34.5-34.7 psu).
Vertical transect in the Rijpfjorden indicates that maximum fluorescence takes place at the same depths (25-30 m) as in the Kongsfjorden but values of the fluorescence here is much higher, more than 44 mg/m^3 at the station R3 (Figure 6).
At the end of the cruise the last CTD Transect **C**, from Svalbard shelf to the north through the slope, was done (Figures 3). Figure 7 shows the vertical distribution of temperature, salinity and

fluorescence at the Transect **C**. Here we find the layer of the Atlantic Water extending vertically (from 20 to 500 m) with a core at the depth of about 100 m. Maximum temperature of the Atlantic Water (>6 °C) is observed at the depth of 25 m (station NTr02). Salinity in the upper thin layer is low (near 33 psu) due to the sea-ice melting. Between this layer and the Atlantic waters the strong halocline exists. The Atlantic Water has salinity more than 35 psu. Below 700 m there is a layer of the bottom Arctic Water with negative temperatures and relatively low salinity. It is difficult to determine the cross-slope horizontal extent of the Atlantic Water mass to the north because this transect is not long enough.

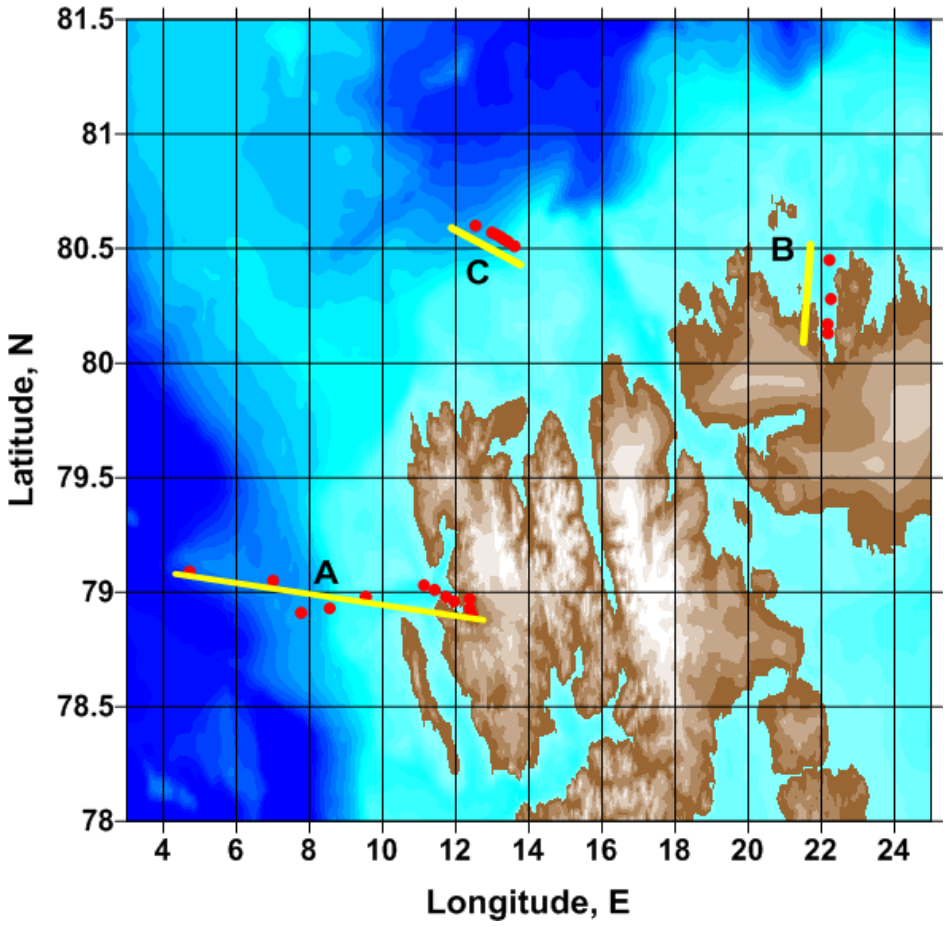


Figure 3 Transects locations and CTD station positions.

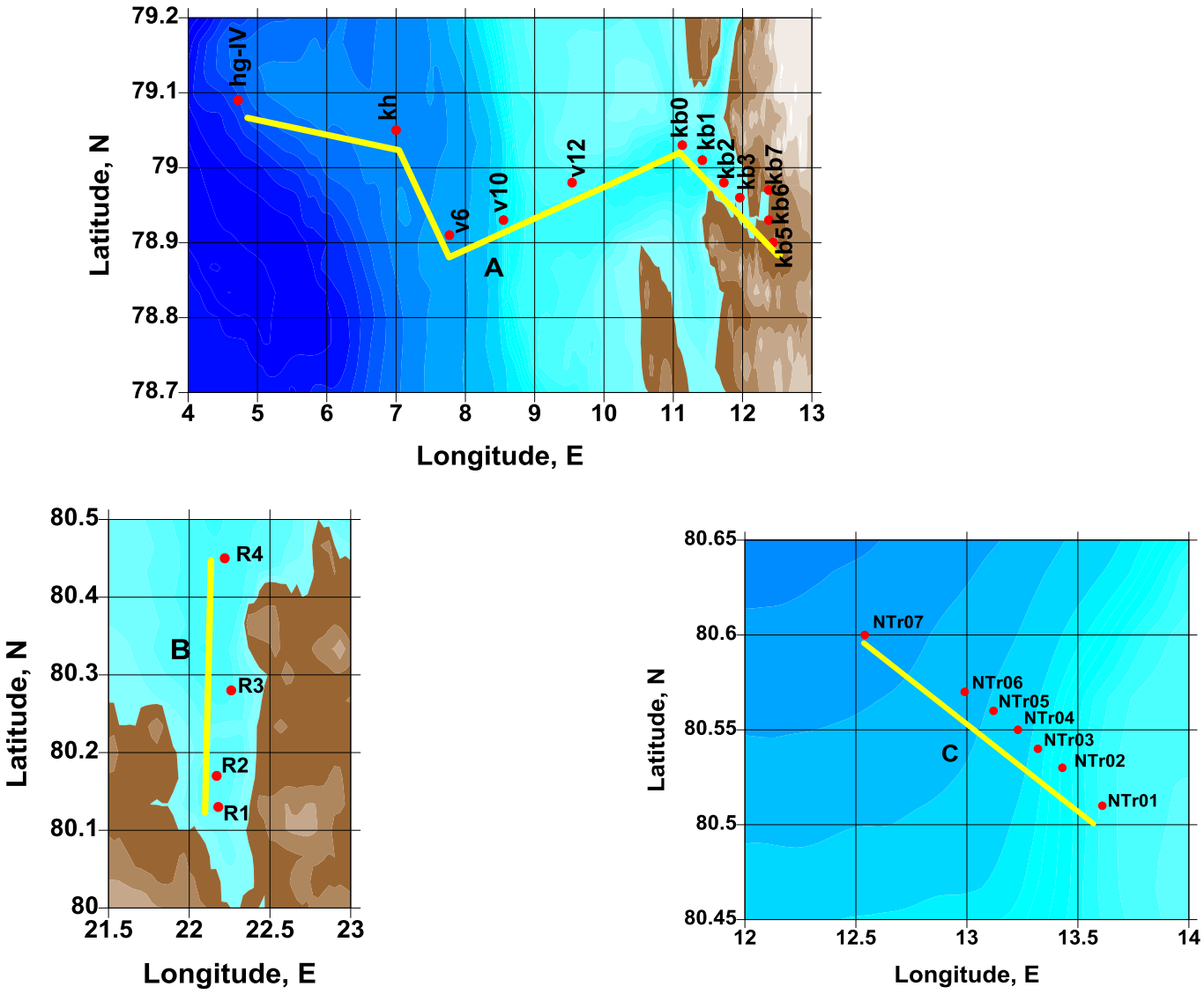


Figure 4 CTD station numbers at the transects.

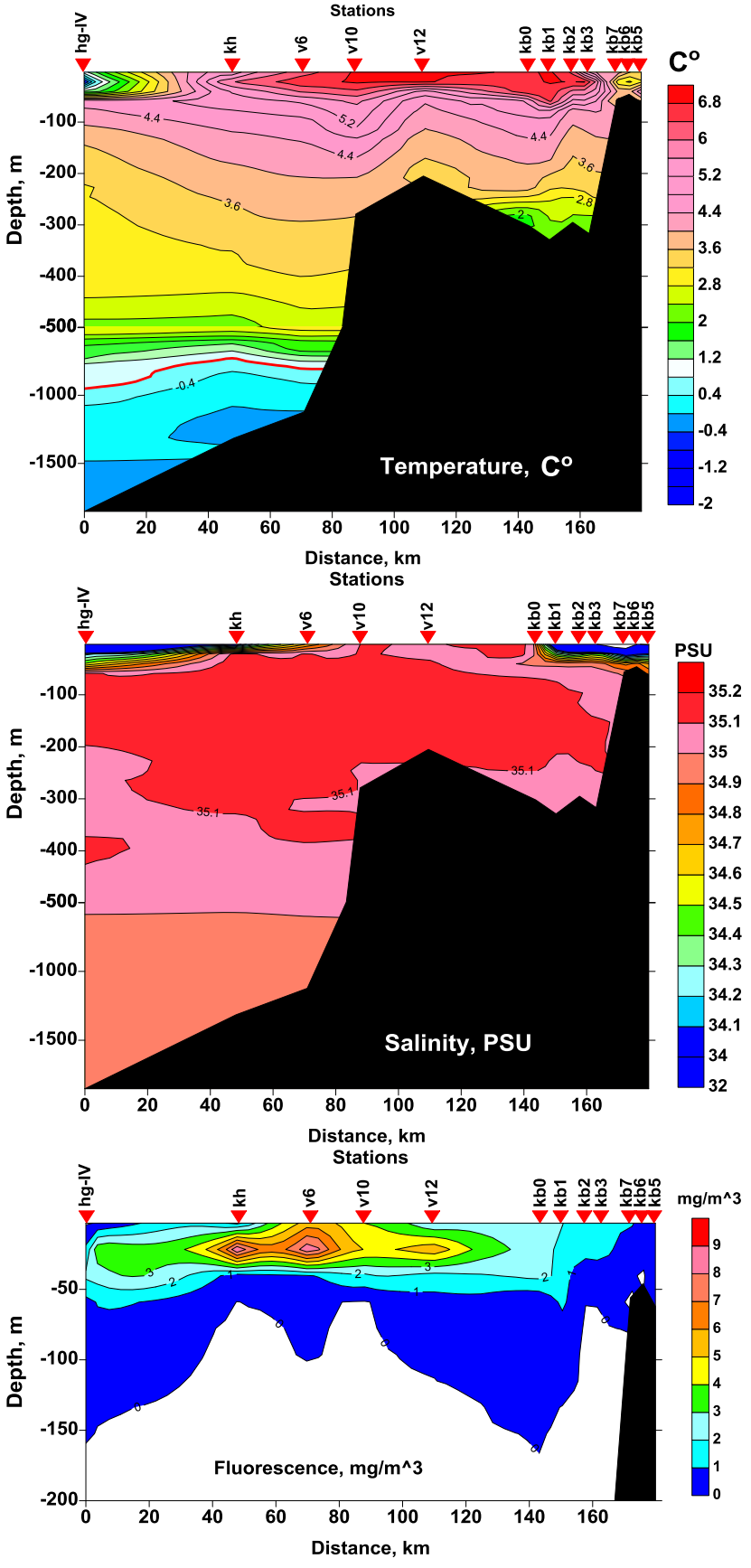
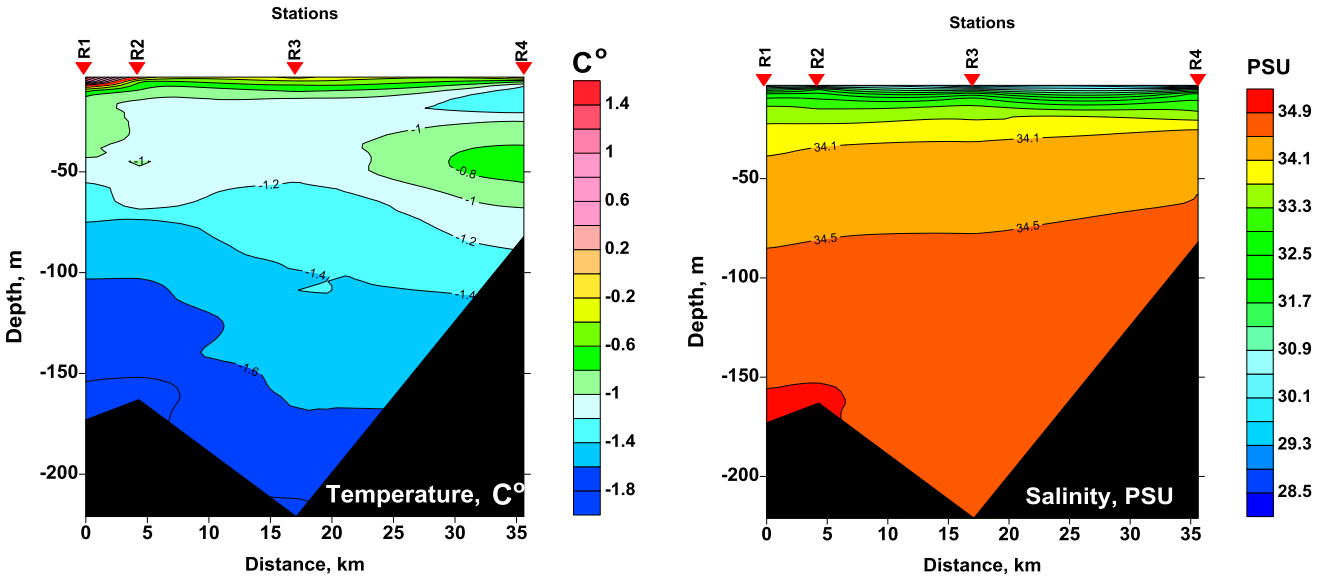

Stations
hg-IV
kh
v6
v10
v12
kb0
kb1
kb2
kb3
kb7
kb6
kb5
C°
6.8
6
5.2
4.4
3.6
2.8
2
1.2
0.4
-0.4
-1.2
-2
Depth, m
-100
-200
-300
-400
-500
-1000
-1500
Temperature, C°
0
20
40
60
80
100
120
140
160
Distance, km
Stations
PSU
35.2
35.1
35
34.9
34.8
34.7
34.6
34.5
34.4
34.3
34.2
34.1
34
32
Salinity, PSU
Distance, km
Stations
mg/m^3
9
8
7
6
5
4
3
2
1
0
-50
-150
-200
Fluorescence, mg/m^3
Distance, km

Figure 5 Temperature, salinity and fluorescence distribution at the Transect **A** in the Kongsfjorden. Station positions are shown in Figures 3, 4 and Table 1.



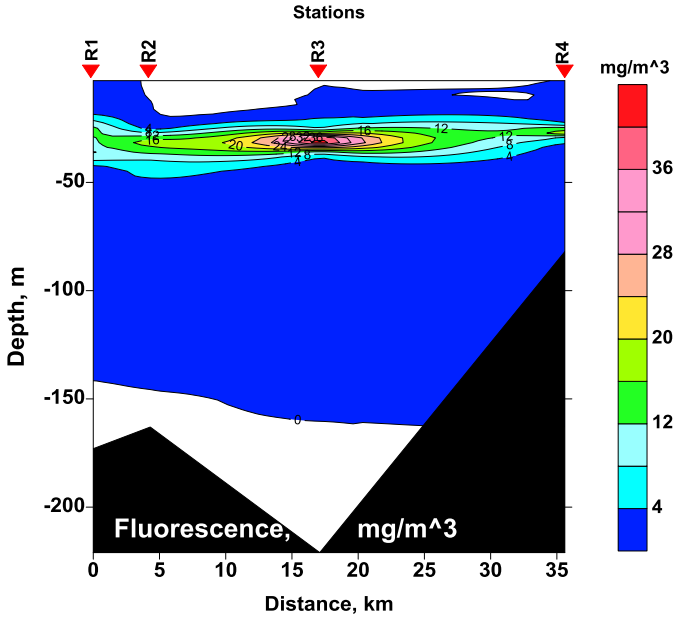


Figure 6 Temperature, salinity and fluorescence distribution at the Transect **B** in the Rijpfjorden. Station positions are shown in Figures 3, 4 and Table 1.

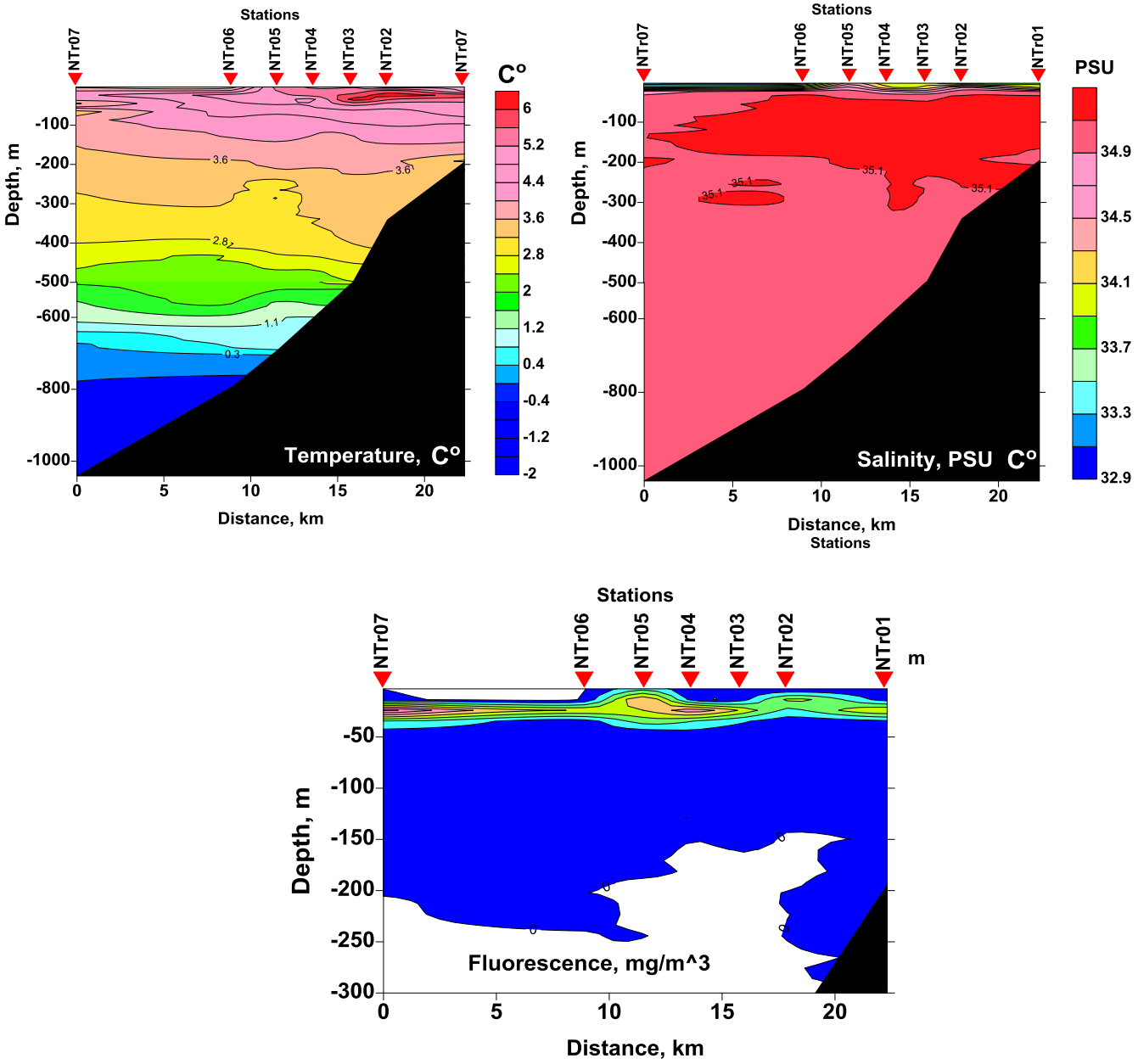


Figure 7 Temperature, salinity and fluorescence distribution at the Transect **C** through continental slope. Station positions are shown in Figures 1, 2 and Table 1.

Results of the VMADCP observations

Figures 8-10 show the results of currents observations in the different areas along the ship track. In the shallow areas of the Kongsfjorden, along the northern and southern coast, the currents have direction into fjord, and in the deep part of the fjord the direction of currents is opposite (Figure 8). Current velocities are relatively small (5-10 cm/s). Figure 9 shows vertical structure of the currents at transect in the Kongsfjorden and eastern part of the Fram Strait. In the eastern part of the Fram Strait, in the layer of 0-120 m, there is a current with north direction and velocities 10-15 cm/s. This current is the eastern periphery of the West Spitsbergen Current.

Figure 9a shows the transect crossing the West Spitsbergen Current. Maximal velocities of the north-east currents at transect (40-45 cm/s) we observe over the slop between isobaths 300-1000 m.

Figure 9b shows vectors of currents averaged in the layer 20-60 m at transect crossing Hinlopen trench. In the western part of this trench the currents have southern direction to the Barents Sea and velocities 10-15 cm/s. In the eastern part the currents have opposite northern direction from the Barents Sea with the same velocities 10-15 cm/s (Figure 10).

Vectors of currents (averaged in layer 20-60 m) at transect, crossing slope in the area north of Svalbard, are shown in Figure 11. In the shelf zone to north of Svalbard the currents velocities are relatively high, range 15-17 cm/s, and their directions are changeable from south to south-west. Over continental slope the currents velocities are increased dramatically and reach 30- 40 cm/s. Currents here have north-east direction along isobaths.

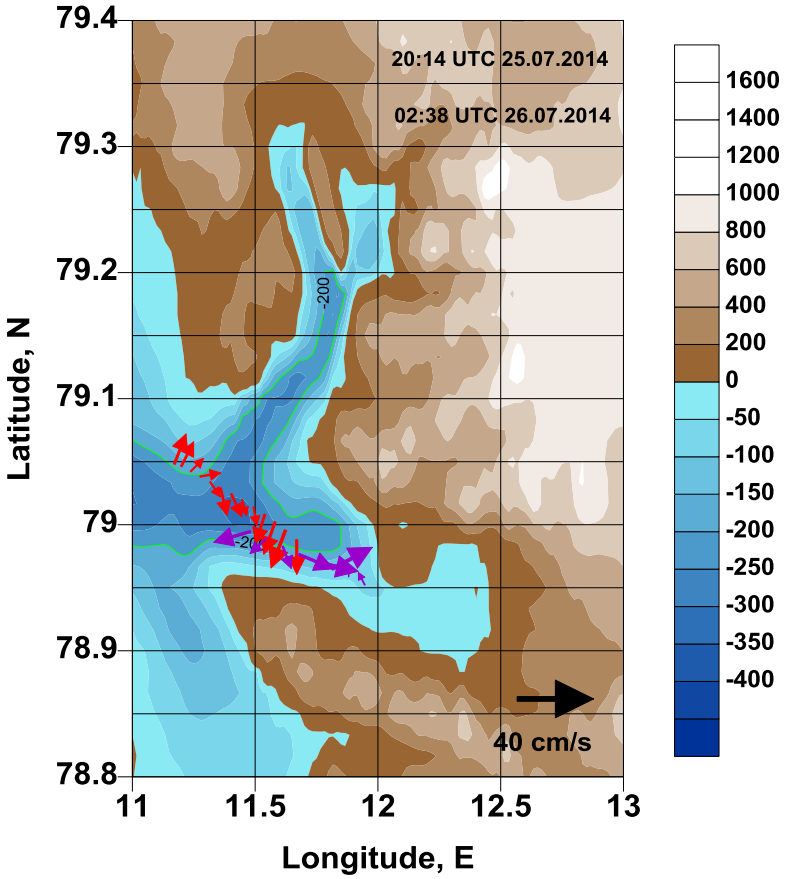


Figure 8 Vectors of current in the Konsgfjorden (averaged in layer 20-60 m) based on VM ADSP data.

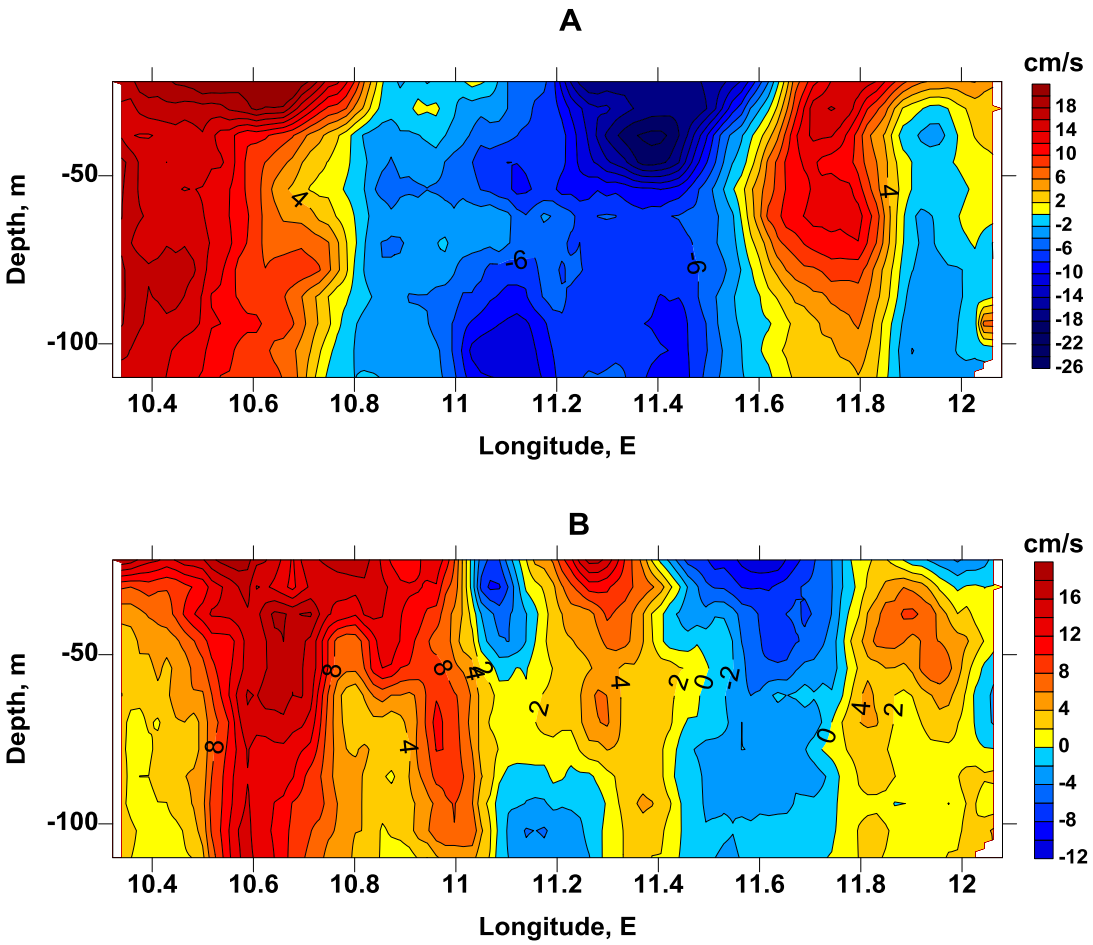


Figure 9 Vertical structure of west-east (**A**) and south- north (**B**) components of vectors of current in the Konsfjorden. Red and yellow indicate to north (**B**) and east (**A**), blue to south (**B**) and west (**A**).

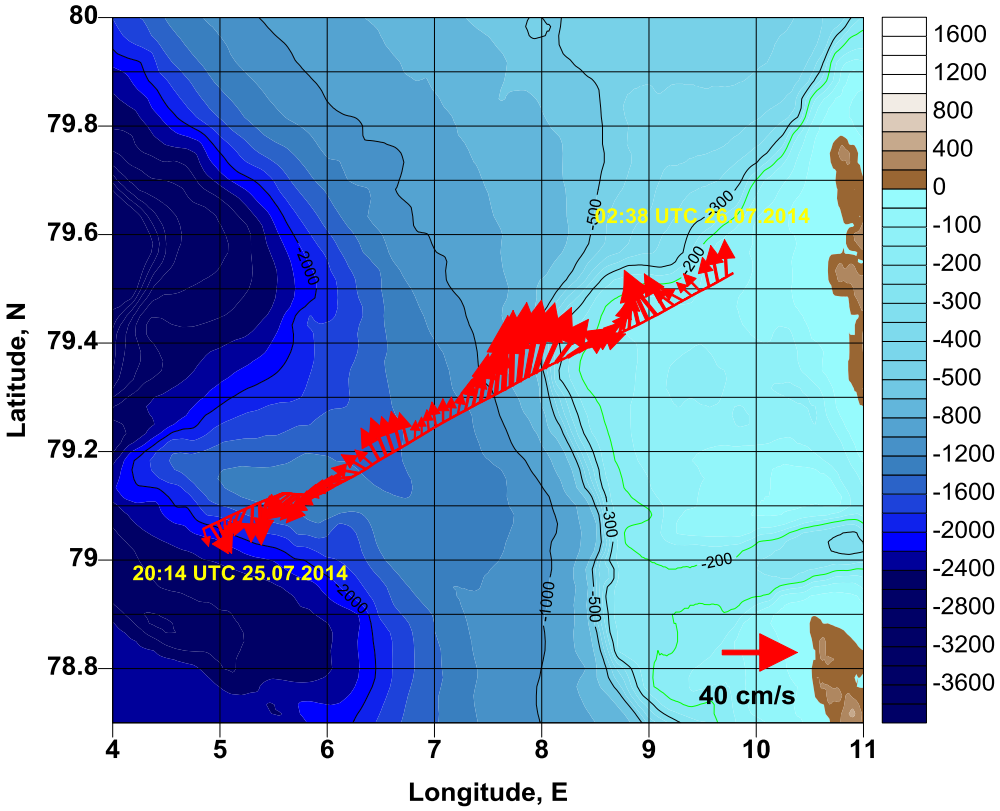


Figure 10 Vectors of currents (averaged in layer 20-60 m) at the transect crossing the West-Spitsbergen Current. Black lines show the isobaths. Green line shows the isobaths of 200 m.

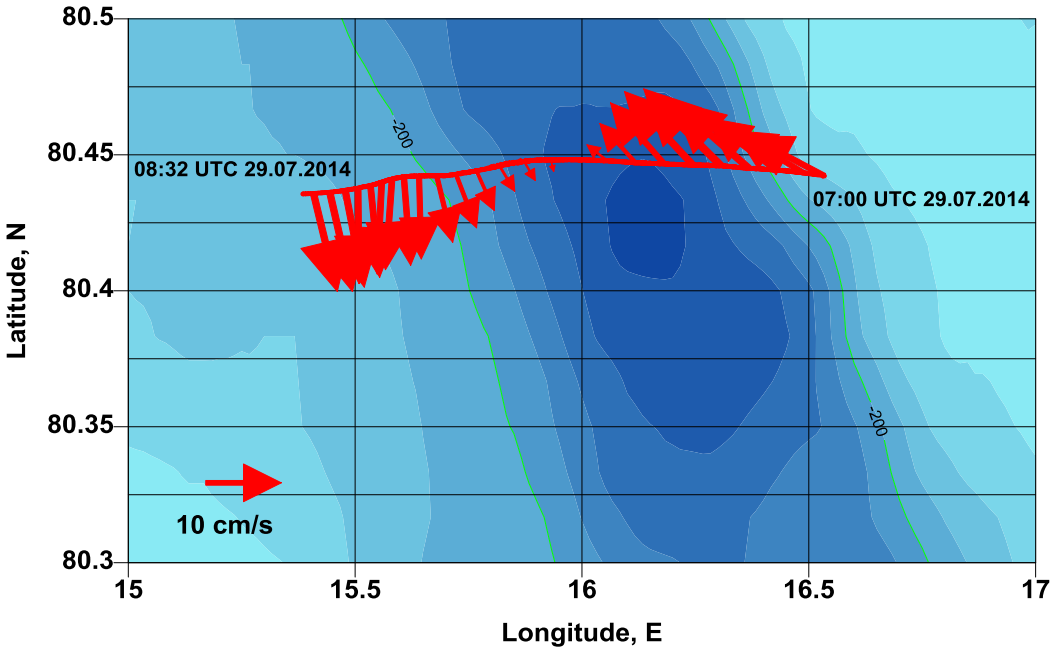


Figure 11 Vectors of currents (averaged in layer 20-60 m) at the transect crossing Hinlopen trench. Green line shows the isobaths of 200 m.

Pelagic ecosystem monitoring in Kongsfjorden and Rijpfjorden

Philipp Assmy, Pedro Duarte, Laura Halbach, Hanna Kauko, Anette Wold (NPI); Svein Kristiansen (UiT); Józef Wiktor, Józef Wiktor jr., Agnieszka Tatarek, Kasia Dmoch (IOPAS)

The oceanographic transect work included sampling and processing of water samples for analysis of several biogeochemical state variables and phyto- and zooplankton species composition (Table 2).

Table 2. Overview of samples taken during the MOSJ-ICE cruise in 2014.

Sample type	Sample #	Status	Analysis	Responsible
Chlorophyll *a*	122	analyzed	On board *Lance*	P. Assmy
POC/PON	94	NPI, Philipp's office	HI Fløedevigen	P. Assmy
BSi	94	NPI, Philipp's office	HI Fløedevigen	P. Assmy
Part. absorption	83	*Lance* -80°C freezer	NPI	M. Granskog
Nutrients	163	*Lance* -20°C freezer	UiT	S. Kristiansen
Ammonium	163	analyzed	On board *Lance*	S. Kristiansen
CDOM	149	UNIS fridge, LYR	NPI	M. Granskog
$\Delta^{18}O$	156	UNIS fridge, LYR		M. Granskog
DIC/AT	134	UNIS fridge, LYR	HI Tromsø	M. Chierici
Methane	91	UNIS fridge, LYR	HI Tromsø	M. Chierici
Phytopl. tax	125	*Oceania*	IOPAS	J. Wiktor
20 µm net	14	*Oceania*	IOPAS	J. Wiktor
Bacteria	122	*Lance* -80°C freezer	Uni Research	A. Larsen
Zoopl. tax	102	*Oceania*	IOPAS	S. Kwasniewski
Zoopl. tax MIK	17	*Lance*	NPI	A. Wold

Biogeocehmical variables and phytoplankton

Chlorophyll and ammonium samples were analyzed directly on board RV *Lance*. Samples for phyto- and zooplankton taxonomy and abundance were loaded onto RV *Oceania* in Longyearbyen and will be analyzed at IOPAS in Poland. MIK net samples will analysed either at NPI in Tromsø or at IMR in Bergen. Particulate organic carbon and nitrogen (POC/PON), biogenic silica (BSi) and nutrient samples will be analyzed at the UiT by Svein Kristiansen while dissolved inorganic carbon and total alkalinity (DIC/AT) as well as methane samples will be analyzed at HI in Tromsø by Melissa Chierici and Agneta Fransson. Bacteria samples will be send to Uni Research in Bergen and analyzed with flow cytometry by Aud Larsen. Colored dissolved organic matter (CDOM), particulate absorption and $\Delta^{18}O$ will be analyzed at NPI by Mats Granskog and Alexey Pavlov.
Chlorophyll concentrations inside Kongsfjorden (stations Kb5-Kb0) were generally very low (Figure 12) which can be partly attributed to the late, nutrient-deplete summer situation and partly to the high turbidity inside Kongsfjorden due to the high sediment loads associated with freshwater run-off from the adjacent glaciers which extended well out into the outer parts of Kongsfjorden in 2014. Higher concentrations were found on the shelf. Highest concentrations were associated with subsurface maxima at the shelf-break (station V6) and towards the ice edge (stations HG-I and HG-IV). Maximum chlorophyll concentrations were about twice as high as in Kongsfjorden and a band of high chlorophyll concentration was situated at subsurface depths between 20 and 50 m inside Rijpfjorden. Both the depth and the magnitude of the subsurface chlorophyll maximum increased towards the fjord mouth (station R4).

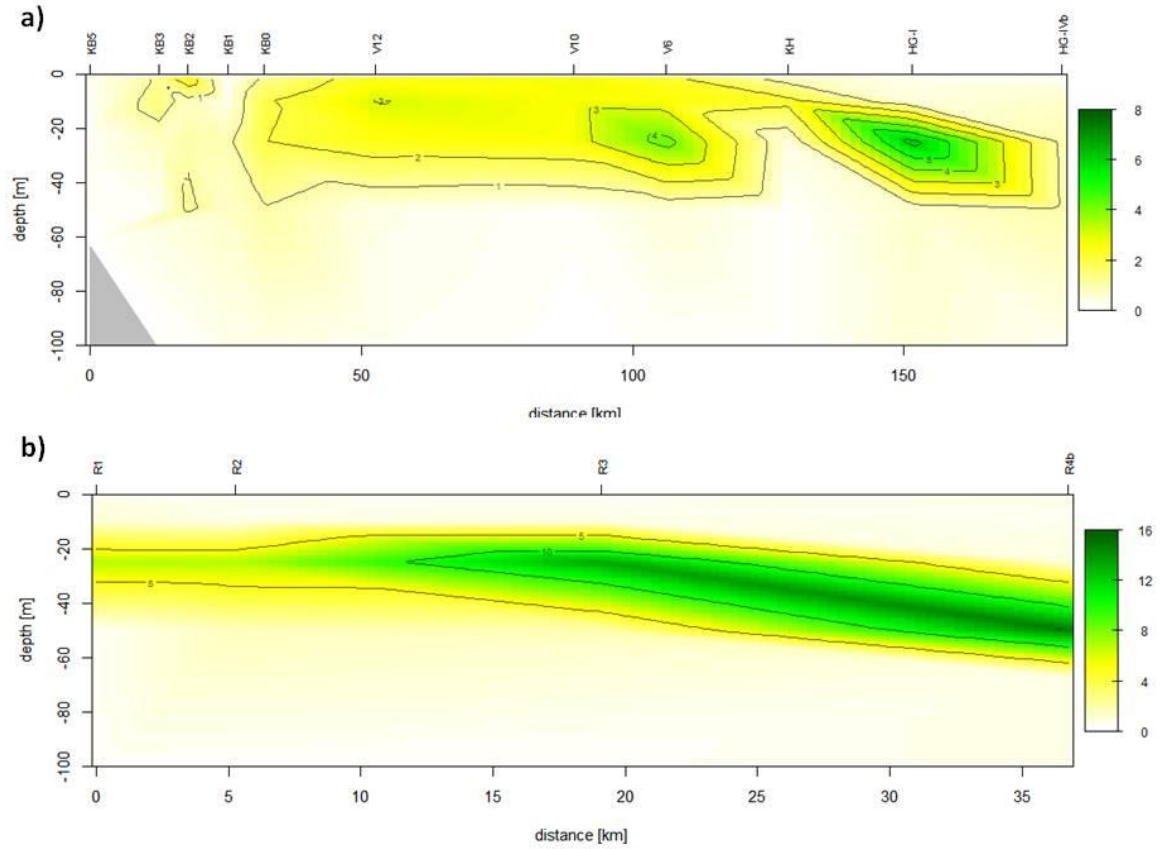


Figure 12. Vertical distribution of chlorophyll concentration as a function of depth and distance from most inner stations in a) Kongsfjorden and b) Rijpfjorden sections. Color scale is in µg Chl *a* L^{-1}.

Live plankton material, obtained with a 20 µm hand net, was investigated under light and epifluorescent microscopy immediately after collection. Particular attention was given to the taxonomic composition and trophic status of unidentified flagellates and naked dinoflagellates, as these delicate taxa are often difficult to identify in fixed material. Dominant species were photographed and in case of unidentified taxa autofluorescence and light microscopy pictures were taken that can be later used, during enumeration of the quantitative samples, to determine if the unidentified taxa of flagellates and dinoflagellates (mainly Gymnodiniales) often dominating protists community are auto- or heterotrophic. Live plankton observations also revealed grazing by heterotrophic protists, copepods and bivalve larvae on phytoplankton (Figure 13).

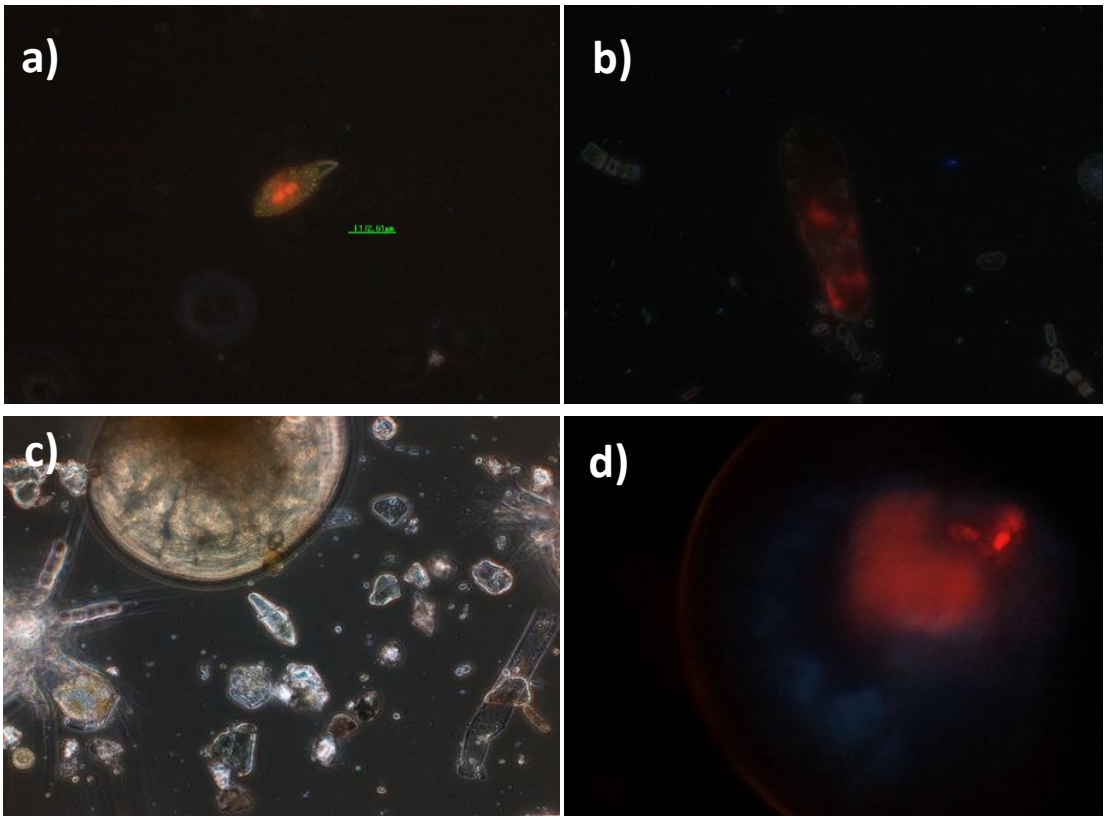


Figure 13. Epifluorescencemicrograph of a) gymnodinoid dinoflagellate with ingested autotrophic prey (red autofluorescence signal), b) fluorescence of undigested chlorophyll in copepod fecal pellet and c) light and d) epifluorescence pictures of bivalve larvae with phytoplankton prey.

Onboard microscopic observations also revealed clear differences between plankton communities inside Kongsfjorden and those on the shelf and out in Fram Strait (Figure 14 and 15).

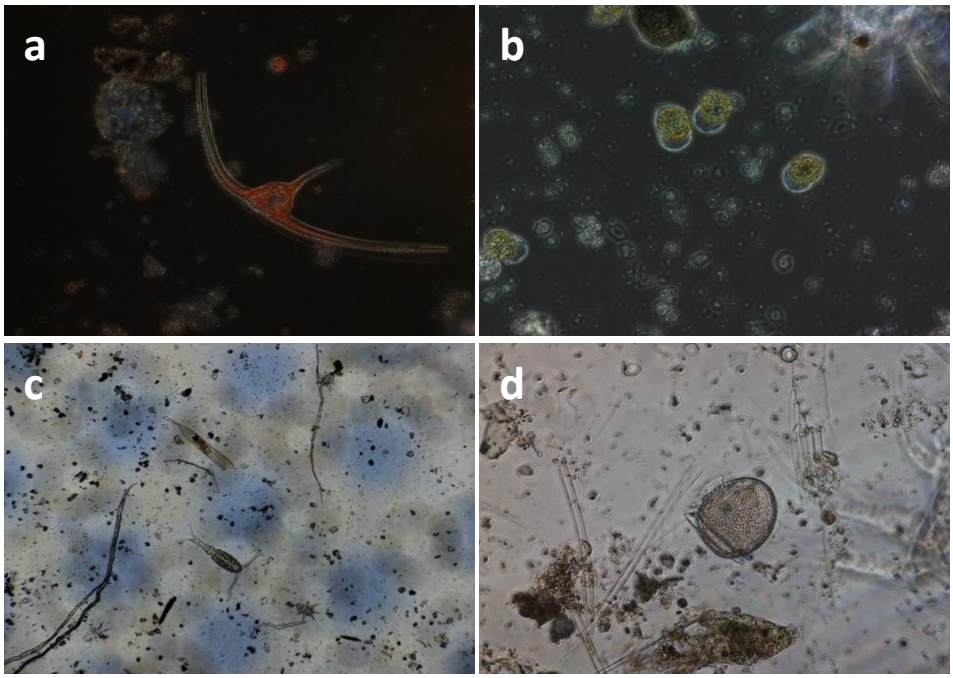


Figure 14. Fjord community: a) phototrophic dinoflagellate *Ceratium arcticum*, b) phototrophic dinoflagellate *Scrippsiella* sp., c) overview picture showing large tintinnid ciliate, cyclopoid copepod *Oithona similis* and copepod nauplius, d) heterotrophic dinoflagellate *Dinophysis* sp. Note large amount of glacier-derived mineral particles in pictures b-d.

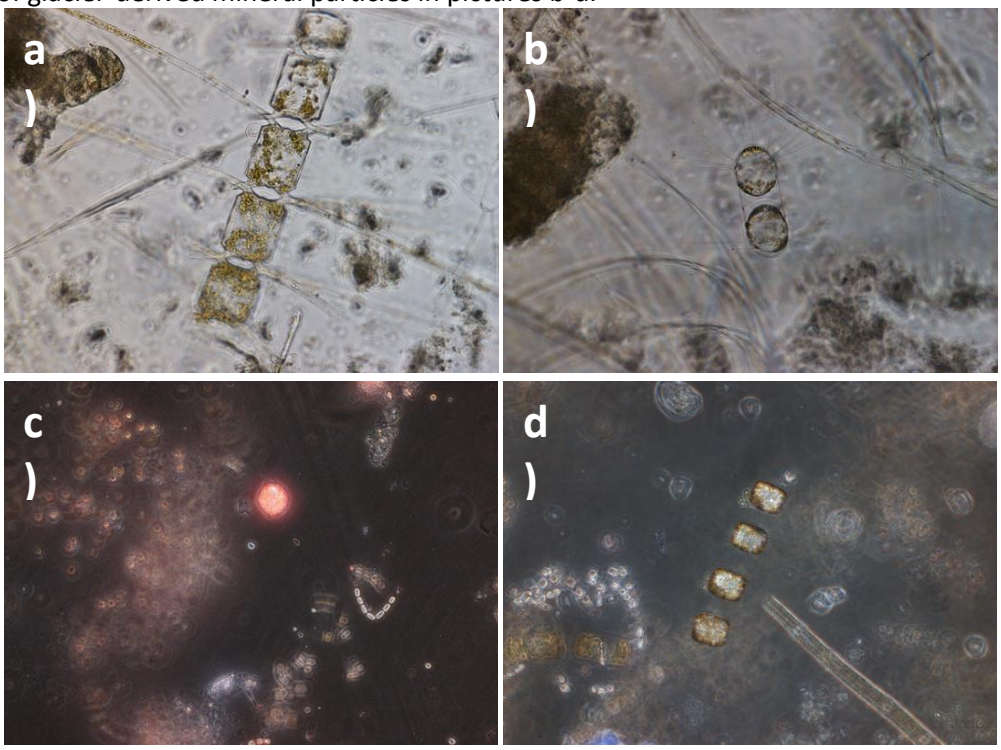


Figure 15. Open ocean community: a) the diatom *Chaetoceros* sp., b) the diatom *Corethron hystrix*, c) overview picture showing *Phaeocystis pouchetii* colony (left), autotrophic dinoflagellate (red autofluorescence) and chain-forming *Chaetoceros* species (likely *C. socialis*), d) chain-forming diatom *Thalassiosira* sp.

Zooplankton

Anette Wold, Joseph Wictor Jr., Kasia Dmoch, Pernilla Carlsson

Mesozooplankton was sampled with multiple plankton sampler (MPS, Hydro-Bios Kiel), consisting of five closing nets with 0.25 m^2 opening and 200 µm mesh size. Macrozooplankton was sampled with a Midwater Isaak Kit Trawls (MIK) with 3.14 m^2 opening and 1500 µm mesh from the total water column. The standard depths for MPS samples was as follows:
Bottom depth <600m; bottom-200m, 200-100m, 100-50m, 50-20m, 20-0m
Bottom depth >600m; bottom-600m, 600-200m, 200-50m, 50-20m, 20-0m
All MPS samples were preserved immediately after sampling and stored on 4% formaldehyde solution buffered with hexamintetrahydrat. The MIK samples were splitted in two, half of the samples were frozen and half were stored on 4% formaldehyde solution. The frozen samples will be sent to Padmini Dalpadado, IMR for examination of gonad status of krill while the taxonomical sampled will be analysed either at NP or at IMR. Both mesozooplankton (MPS) and macrozoolankton (MIK) was collected at all stations in Kongsfjorden and Rjipfjorden and at every other station (NTr01, NTr04, NTr07) for the cross shelf transect north of Hinlopen (New Transect).

Very preliminary results:
Compared to earlier years the abundance of krill (*Thysanoess* spp.) was high both in Kongsfjorden and Rjipfjorden. We even caught relative high numbers of small specimen of *Thysanoessa* spp. in the MPS net at both locations. At some of the intermediate depthlayers at the Hausgaarten stations and at cross shelf transect north of Hinlopen (New Transect) the nets were clogged with a mix of diatoms and *Phaeocystis pouchetti.* These depths layer contained very little zooplankton either due to clogging of the nets or because zooplankton avoided these layers.

Additional sampling:
Cline limacine was collected in Rjipfjorden (R1b, R2, R3) and kept live in 50 L container for experimental work by Lauris Boissonnot at UNIS.
Limacina helicina was collected in Rjipfjorden (R1b, R2, R3) and stored at 90% ethanol for the Ocean Acidification project (Agnetha Fransson and Melissa Chierichi)

Experimental work

Phytoplankton growth and microzooplankton grazing rates

Philipp Assmy, Laura Halbach (NPI)

Microzooplankton (largely composed of protozoa) consume a large fraction of marine primary production and are an important link to higher tropic levels. At four stations (V12, HGIV, R3 and NTr1) during the MOSJ-ICE cruise in 2014 we have conducted experiments to estimate phytoplankton growth and microzooplankton grazing rates in natural plankton communities based on the serial dilution method by Landry and Hassett (1982). The method is based on the assumption that phytoplankton growth rates are unaffected by dilution of ambient seawater with filtered seawater while phytoplankton mortality rates are a function of encounter rates with grazers (microzooplankton) which is dependent on dilution.

Experimental water was collected with a 30L trace-metal-clean GO-FLO bottle from the chlorophyll maximum. Part of the collected water was filtered over 0.2 µm to obtain filtered seawater (Figure16) and subsequently used to dilute the remaining seawater at the desired dilution steps in 2L polycarbonate bottles.

Figure 16: Filtration setup for filtered seawater used in the dilution experiments.

Seven dilution steps (10, 20, 30, 40, 50, 60, and 75% of ambient seawater) were chosen plus triplicate bottles of 100% ambient seawater with and without 10 individuals of *Calanus glacialis* added. All bottles were amended with 0.5 mL Guillard medium to give nutrient levels roughly corresponding to winter values. An additional three 100% ambient seawater without nutrient addition were also included. All 16 bottles were incubated for 24 h (or 38 h at station R3) in a plankton wheel on deck *Lance* (Figure 17).

Light levels inside the bottles were adjusted with neutral density screens to levels representative of the surface mixed layer. Light levels as well as temperature were monitored at 2 min intervals with loggers. Triplicate samples for Chl *a*, flow cytometry (bacteria and pico- and nanoeukaryotes) and phytoplankton taxonomy were taken from 100% ambient seawater at the start of the experiment and the initial concentrations deduced from the dilution steps. Final samples were taken from each dilution bottle for the above parameters. Individuals of *C. glacialis* were transferred into cryovials at the end of the incubation and stored at -80°C.

Figure 17. Plankton wheel covered with screens to mimic ambient light levels in the surface layer.

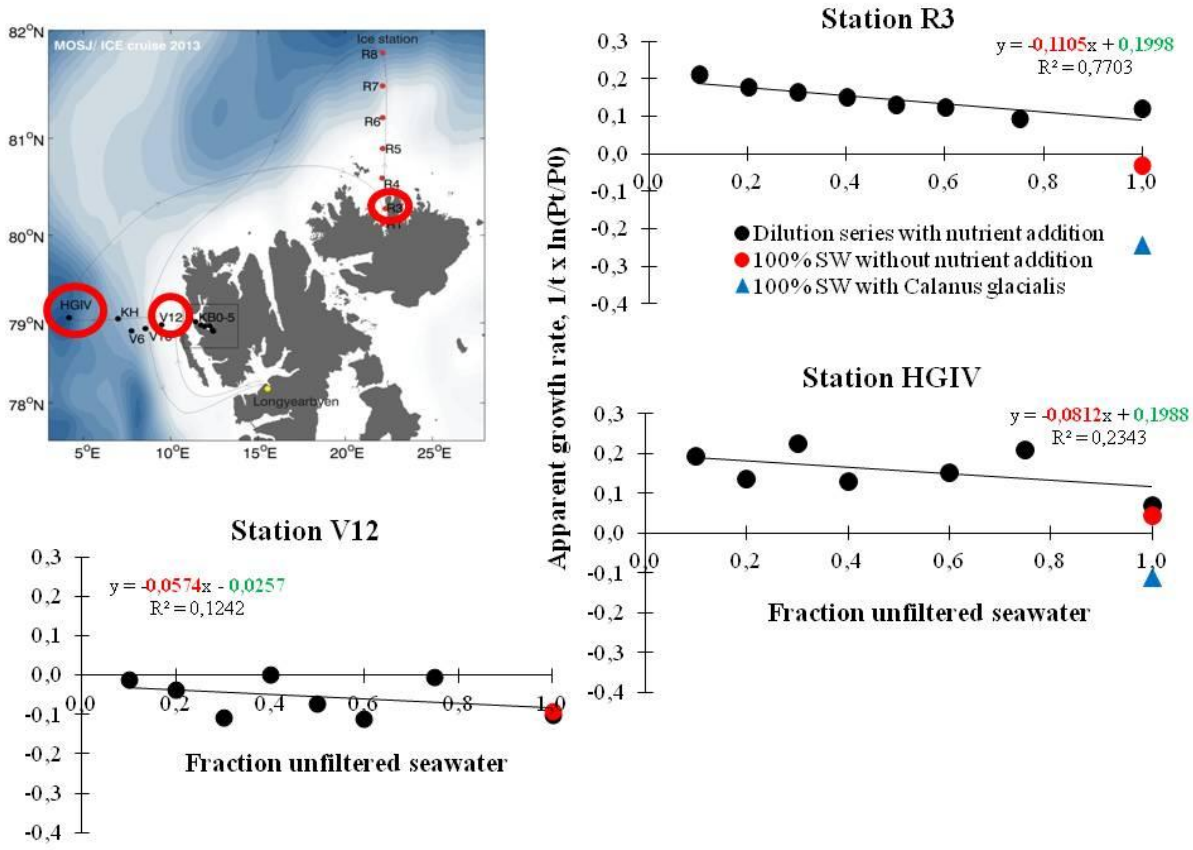


Figure 18. Three out of the four serial dilution experiments conducted during the MOSJ-ICE 2014 cruise. The slope of the regression line (marked in red) indicates the microzooplankton grazing rate and the y-axis intercept (marked in green) indicates the phytoplankton growth rate.

Preliminary results from the first three serial dilution experiments indicate that microzooplankton grazing rates were relatively similar at the three stations (range from 0.06 to 0.11 d^{-1}) but phytoplankton growth rates were significantly lower at station V12 (~0.03 d^{-1}) compared to stations HGIV and R3 (~0.2 d^{-1}) (Figure 18). The lower phytoplankton growth rates at station V12 could be attributed to the senescent status of the phytoplankton observed with microscopy at station V12 and could be indicative of a post-bloom situation compared to the healthy status and higher biomass levels observed at stations HGIV and R3. This further supported by the fact that no appreciable differences in apparent growth rate between the nutrient amended and un-amended 100% seawater

treatment at V12 were observed. In contrast, at stations R3 and HGIV apparent growth rates in the nutrient amended 100% seawater treatment were considerably and slightly elevated, respectively, as compared to the 100% seawater treatment without nutrient addition. The addition of 10 individuals of *C. glacialis* at stations HGIV and R3 had a pronounced effect on phytoplankton stocks, with negative apparent growth rates that were significantly lower compared to the nutrient amended and un-amended treatments.

The influence of incubation time and water masses on P-I curves

Pedro Duarte, Philipp Assmy (NPI)

Previous work has shown that the response of PI-curves to the incubation period varies with the characteristics of the pelagic ecosystem and is related to the light regime experienced by the phytoplankton. We have therefore conducted short-term photosynthesis irradiance (P-I) experiments at three stations associated with different water masses: station HG-IV in central Fram Strait and station R3 inside Rijpfjorden representative of an Atlantic and Arctic water masses respectively and station NTr1 on the shelf north of Svalbard.

P-I curves were performed at 10 irradiance levels ranging from 0 – 1096 µmol photons m^{-2} s^{-1} (one measurement was carried out at 1743.6 µmol photons m^{-2} s^{-1} in experiment R3 by mistake) and at three time intervals (0.75, 1.5 and 2 hours for the R3 experiment; 0.83, 1.75 and 3.08 hours for the HG-IV experiment; 0.75, 1.7 and 3.17 hours for the NTr1 experiment) in a photosynthetron (Figure 19) connected to the ships seawater supply. A fourth set of flasks was incubated at similar PAR levels and used for Pulse Amplifier Modulation measurements (see below). During the first experiment the incubator was not covered with a black plastic to subtract ambient irradiance. Therefore, these results will be discarded. Table 3 lists light intensities used in the incubations with water from R3 and NTr1 stations and for each of the incubation times.

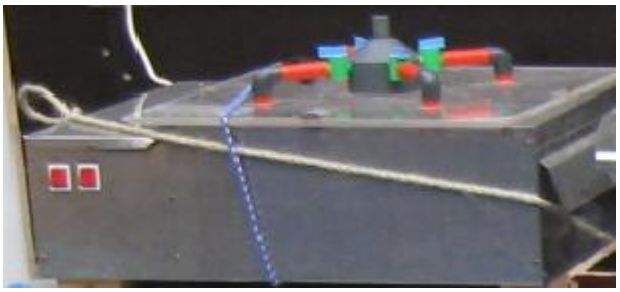


Figure 19. Image of the photosynthetron. The left switches are for turning on/off a fan for the replacement of air heated up by the light source and the PAR light bulb. On the top, the water intake and the vales for its distribution within the incubator are shown.

The incubation tubes were spiked with ^{14}C to measure gross primary production at the respective irradiance levels and incubation periods. We chose the ^{14}C method as it is sensitive enough to detect signals at the short incubation intervals and the low biomass concentration we expect in summer. After incubation, samples were filtered onto polycarbonate filters, acid fumed and scintillation cocktail added. The samples were stored on board RV *Lance* and upon her return to Tromsø in late September will be analyzed with the scintillation counter at the University of Tromsø. At the beginning of each experiment, water used in the incubations was sampled for chlorophyll a and inorganic carbon.

Table 3 Photosynthetically active radiation (PAR in mol photons m^{-2} s^{-1}) used in incubations conducted with water from stations R3 and NTr1 and with different incubation times.

Experiment	R3			NTr1		
N.	**0.83 h**	**1.75 h**	**3.08 h**	**0.75 h**	**1.7 h**	**3.17 h**
1	4.2	3.3	3.3	4.2	3.3	3.3
2	13.3	11.6	11.6	13.3	11.6	11.6
3	23.2	23.2	21.6	23.2	23.2	21.6
4	41.5	41.5	41.5	41.5	41.5	41.5
5	66.4	1743.6	83	83	66.4	83
6	116.2	-	99.6	116.2	116.2	99.6
7	215.9	174.4	199.3	199.3	215.9	174.4
8	332.1	398.5	398.5	348.7	398.5	398.5
9	680.8	647.6	664.2	597.8	680.8	647.6
10	1096	1079.4	1096	996.3	1096	1079.4
11	0	0	0	0	0	0

Photosynthetic quantum yield (Fv/Fm) (Phyto-PAM)

Pedro Duarte, Philipp Assmy (NPI)

The Phyto-PAM was used to measure chlorophyll concentrations, quantum yields and obtain Rapid Light Curves (RLCs) for most of the water samples collected at various depths in the stations depicted in Table 1 and also for samples from the various P-I and plankton wheel experiments. Initially, RLCs were obtained for all samples. However, after a large number of time-consuming measurements, it became clear that obtained RLCs were not reliable exhibiting strange patterns, possibly, related with the low chlorophyll values and fluorescence yields of most samples. Therefore, we decided to focus only on the phothosynthetic quantum yield.

Preliminary analysis of obtained results suggests a parabolic relationship of the quantum yield with depth, in spite of the large variability observed (Figure 19). Maximum values were obtained in the depth range 15 - 50 m. This is consistent with the range of depths where chlorophyll concentrations were maximal (Figure 12).

Quantum yields of samples incubated in the photosynthetron at light intensities similar to those depicted in Table 3, suggest a declining trend with incubation light level. This is expected as a result of increasingly activation of photosystems under higher light levels.

The results presented in Figure 20 and 21 will be analysed together with the results from the water samples, with emphasis on the chlorophyll concentrations and phytoplankton species composition to allow a better understanding of the causes of the observed chlorophyll distribution patterns and their relationship with photosynthetic capacity.

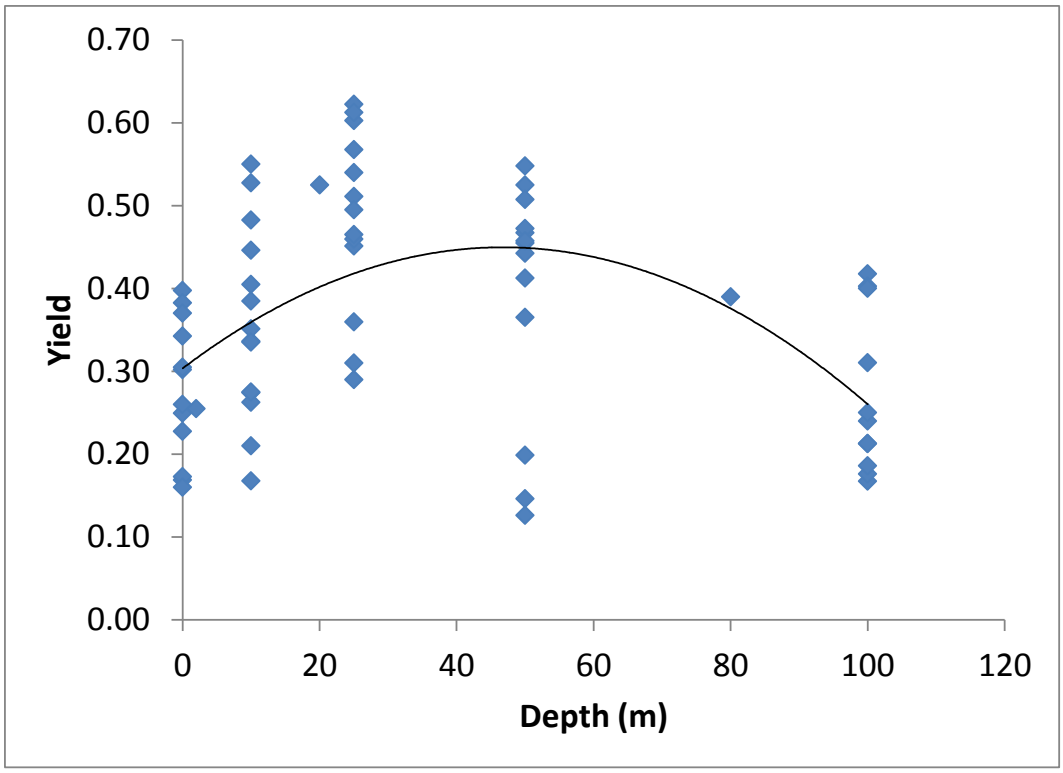


Figure 20. Photosynthetic quantum yield as a function of sample depth for all analysed samples.

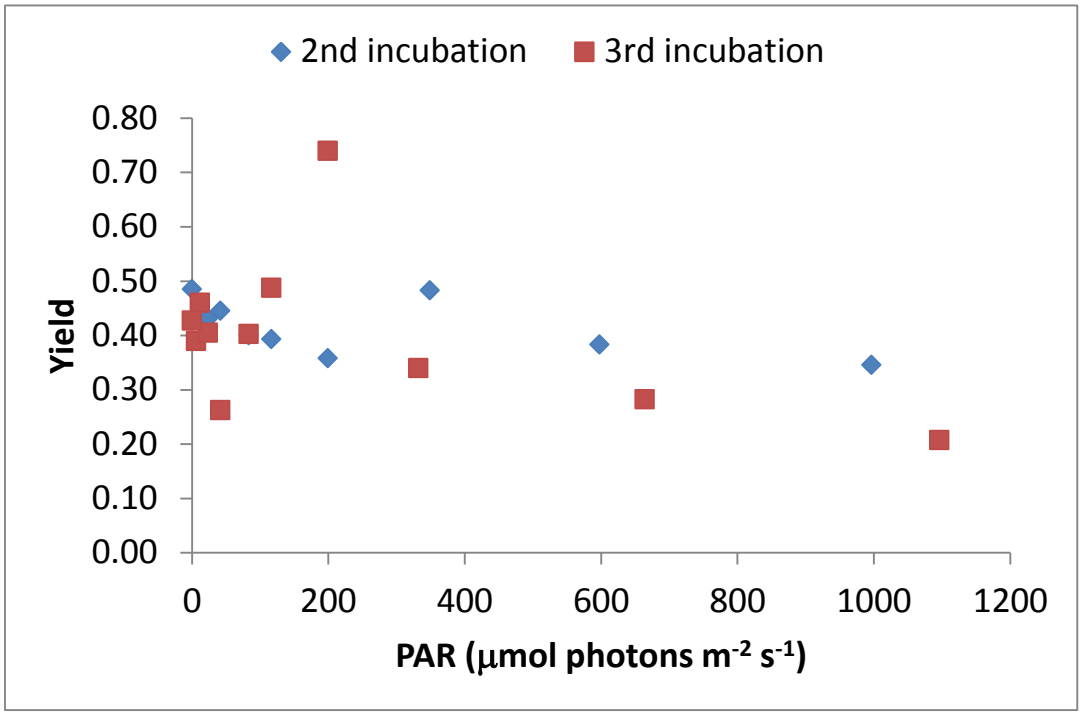


Figure 21. Photosynthetic quantum yield as a function PAR light intensity for water samples incubated in the photosynthetron (2nd and 3rd incubations) (cf. - The influence of incubation time and water masses on P-I curves).

Impact of irradiance and nutrient under oscillating temperature

Micheal Roleda (Bioforsk, Bodø)

The competitive success of key high-latitude phytoplankton species can be driven by temperature, light and nutrient availability. The interactive effect of light and nutrient availability, to simulate reduced ice cover and increased stratification, was investigated under dynamic oscillating temperature. Natural plankton community in seawater obtained at 15m depth at station V12 was incubated for 6 days under two different irradiance and three different nutrient conditions. The 18× 2-L bottles were incubated inside two stainless steel chambers equipped with continuous water flow at temperature near the ambient seawater (Figure 22). Light was manipulated by covering the eight fluorescent lamps with one and two layers of neutral density screen, representing high and low light, respectively. Nutrient condition was (1) ambient, (2) ambient+N+P, and (3) ambient+N+P+Si; each treatment combination was in triplicate.

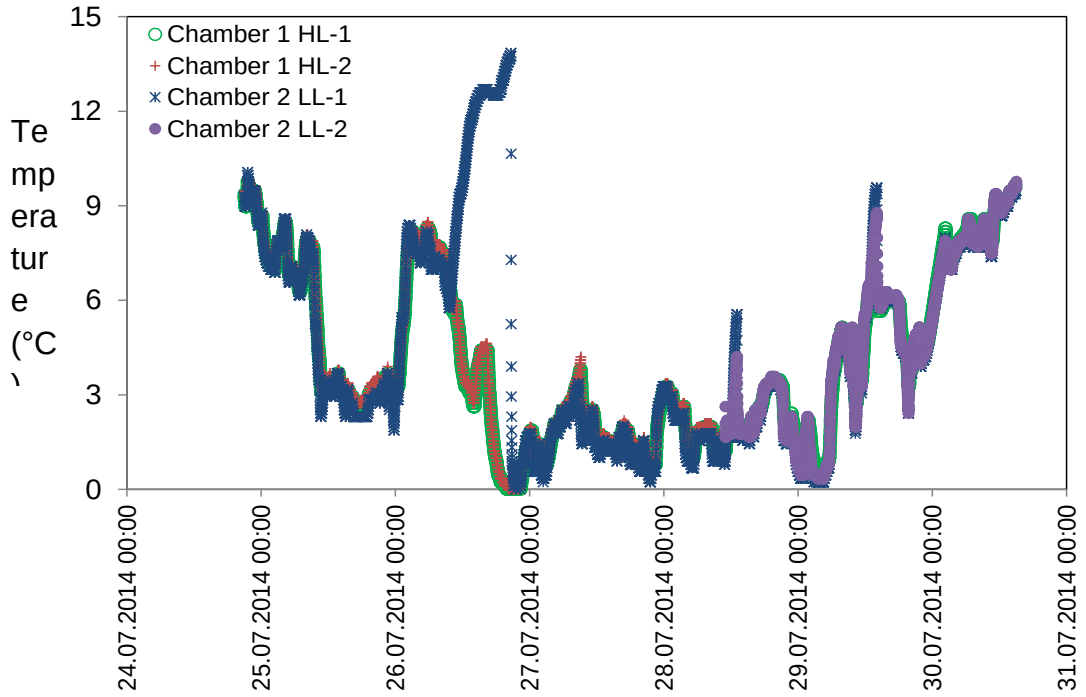


Figure 22. Temperature profiles inside the culture chambers (1 and 2) during the entire experimental period measured using pendant HOBO data loggers (2 data loggers in each chamber). The increase in temperature inside chamber 2 (LL, up to 13.8°C) was due to accidental uncoupling of the continuous water flow.

Chl *a* was measured every day; snapshot day 4 chl *a* profile showed treatment effect (Figure 23). Initial and final samples for species ID, CNP, BSi, HPLC, DMSP and seawater nutrient analysis were collected. Seawater nutrient analysis will be measured at University of Tromsø (Svein Kristiansen). Frozen samples (-80°C) for HPLC pigment analysis will be sent to University of Gothenburg (Angela Wulff). For the rest of the analyses, i.e. species ID, CNP, BSi and DMSP, samples will be sent to University of Southern California (Dave Hutchins, Feixue Fu, Avery Tatters, Naomi Levine).

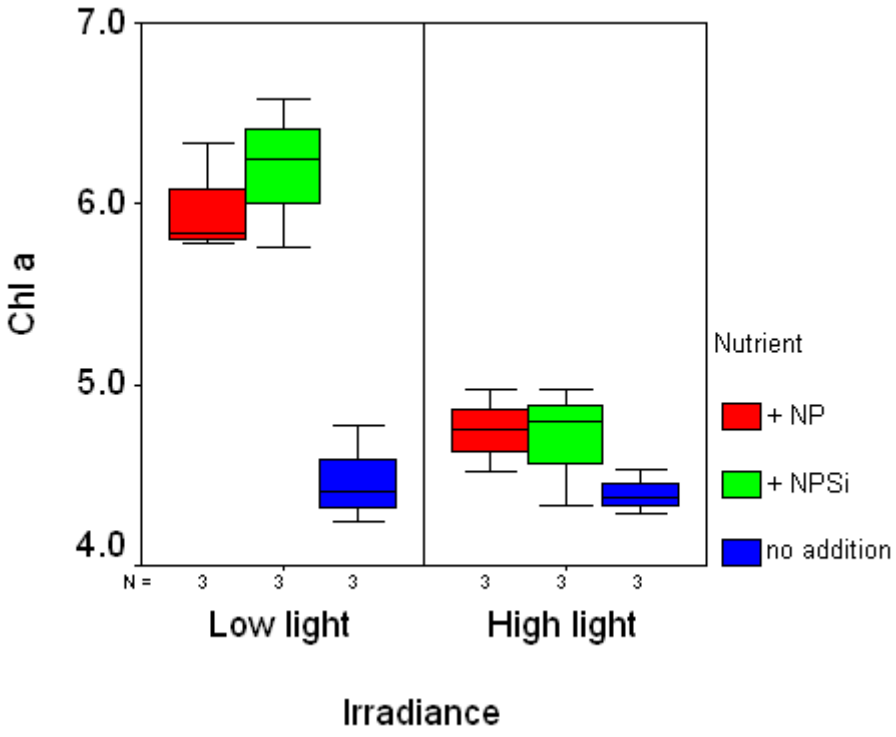


Figure 23. Snapshot day 4 Chl *a* (mg L^{-1}) concentration of natural plankton community exposed to different irradiance and nutrient conditions under dynamic oscillating temperature regime.

Zooplankton fecal pellet production

Anette Wold, Joseph Wictor Jr., Kasia Dmoch, Pernilla Carlsson

The aim was to estimate the production of faecal pellets *in situ* by larger stages of *Calanus* spp.. Zooplankton was sampled with a WP3 with non-filtering, large cod end and stored in 50L containers diluted with sea water at ambient temperature. Undamaged and active specimen were sorted under stereomicroscope AS SOON AS POSSIBLE and added directly to incubation chambers with false bottom (300µm mesh) filled with filtered sea water. Incubation lasted for 24 h. After the incubation the animals were removed, inspected and frozen separately and the fecal pellets were counted. Fecal pellet rate is calculated as: Number of fecal pellets/incubation time*number of animals per incubation. Fecal pellets were filtered into pre-weighted and pre-combusted Whatman GF/F filters.

Table 4: Rate of fecal pellet production for *Calanus finmarchicus*, *Calanus glacialis* and *Calanus hyperboreus*, based on experiments from outer part of Kongsfjorden and Rjipfjorden

Location	**Species**	**Rate (fecal pellets*hrs^{-1}*ind^{-1})**	
		avrg	stdv
Kongsfjorden	*C. glacialis* CV	1.542	0.480
	C. finmarchicus AF	2.042	0.641
Rjipfjorden	*C. glacialis* CV	2.340	0.673
	C. hyperboreus CIV	2.000	1.142
	C. glacialis AF	0.993	1.210

Zooplankton respiration

Anette Wold, Joseph Wictor Jr., Kasia Dmoch, Pernilla Carlsson

Oxygen consumption was measured by optode respirometry (Oxy-10 Mini, PreSens Precision Sensing GmbH, Regensburg, Germany). 1-2 hours after sampling, the animals are gently introduced in the 100 ml incubation bottles filled with cold filtered sea water. The numbers of individuals per incubation bottle depended on taxon and body size. The bottles were sealed and kept in the portable fridge at ambient temperature (2-5^{o}C). In Rjipfjorden the water temperature was -1°C, therefore incubation temperature were 3°C above ambient temperature. At least 3 animal-free bottles were incubated as controls to correct for potential microbial oxygen consumption during the experiment. Readings of oxygen concentration were made at approx. 2 hrs intervals during the 6-12 hours of the experiment. Each of the animals was preserved in a cryovial at -20^{o}C for length measurements, dry mass and carbon determination. Rates of O_2 (mlO_2 L^{-1} or mlO_2 L^{-1}) consumption in the chambers were derived from a linear regression of O_2 concentration over time.

Table 5. Respiration rate of abundant zooplankton in Kongsfjorden and Rjipfjorden.

Exp.	**Location**	**Species**	**ind./incub.**	**Replicates (n)**	**Respiration rate (mlO_2*hrs^{-1})**
Exp 1	Kongsfjorden	*C. glacialis* CV	5	5	
Exp 2	Kongsfjorden	*C. glacialis* CV	5	5	
Exp 2	Kongsfjorden	*T. libelulla*	3	5	
Exp 2	Kongsfjorden	*T. abyssorum*	3	5	
Exp 3	Rjipfjorden	Oikopleura	5-7	11	
Exp 3	Rjipfjorden	*Th. inermis* juv	11	1	
Exp 3	Rjipfjorden	*Th. inermis*	1	5	
Exp 3	Rjipfjorden	*C. limacina*	1	5	
Exp 4	Rjipfjorden	Oikopleura	5	10	

Nitrogen transformations in phytoplankton and bacteria

Svein Kristiansen (UIT)

Phytoplankton and bacteria assimilate nitrogen (and other nutrients) from sea water. Assimilation of nitrogen nutrients are of special interest because these rates can also be used to estimate the fraction new production; or the amount of the primary production available for higher trophic levels (Dugdale and Goering (1967). Phytoplankton and bacteria were separated by size fractionation using 147mm polycarbonate filters with pore size 1.0 µm.

Water samples were collected from the chlorophyll maximum using a trace-metal-clean 30-liter GO-FLO bottle at the two stations R3 And NTr1. Water from the GO-FLO bottle was transferred to 2-liter acid washed polycarbonate Nalgene bottles. Three polycarbonate bottles were each added 0.2 µmol l-1 ammonium or 0.2 µmoll-1 nitrate or1.0 µmoll-1 nitrate, all 99% 15N enriched. The bottles were incubated for 24 hours on deck in incubators giving simulated light and temperature conditions. The samples will be analyzed later. Details as in (Kristiansen, Farbrot et al. 2001)

Dugdale, R. C. and J. J. Goering. (1967). Uptake of new and regenerated forms of nitrogen in primary productivity. Limnol. Oceanogr. 12: 196-206.

Kristiansen, S., T. Farbrot & LJ. Naustvoll. (2001). Spring bloom nutrient dynamics in the Oslofjord. Mar. Ecol. Prog. Ser. 219: 41-49.

Marin geology

The main objective of the marine geology group is to monitor and quantify past and recent ecosystem effects of environment and climate changes. Such information is vital in order to evaluate the full range of the eco- and ocean-climate systems. During the cruise the monitoring of living benthic foraminifera in Kongsfjorden 2005- 2010 was continued. Benthic foraminifera are good monitors of environmental changes because they are very abundant in the surface sediments and very diverse even in Arctic coastal and fjord settings. Furthermore, they have a short life cycle enabling a quick response to changes. After death, the shells of the benthic foraminifera are preserved in the sediment enabling baseline studies of pre-impacted conditions back in time. Five key sites were selected and sampled for surface sediments in Kongsfjorden: Kb3, Kb2, Kb1, and Kb0 in addition to a site in the fjord mouth ("Fjord mouth station"/FM). Surface sediment samples were also collected at two sites in Rijpfjord: R1b and R2 (Figure 24). It was not possible to reach R1 due to sea ice and a site was sampled close to the ice edge. It was planned to sample a third site in further out in Rijpfjord, R5, as well, but it was not possible to reach that site neither due to heavy sea ice.

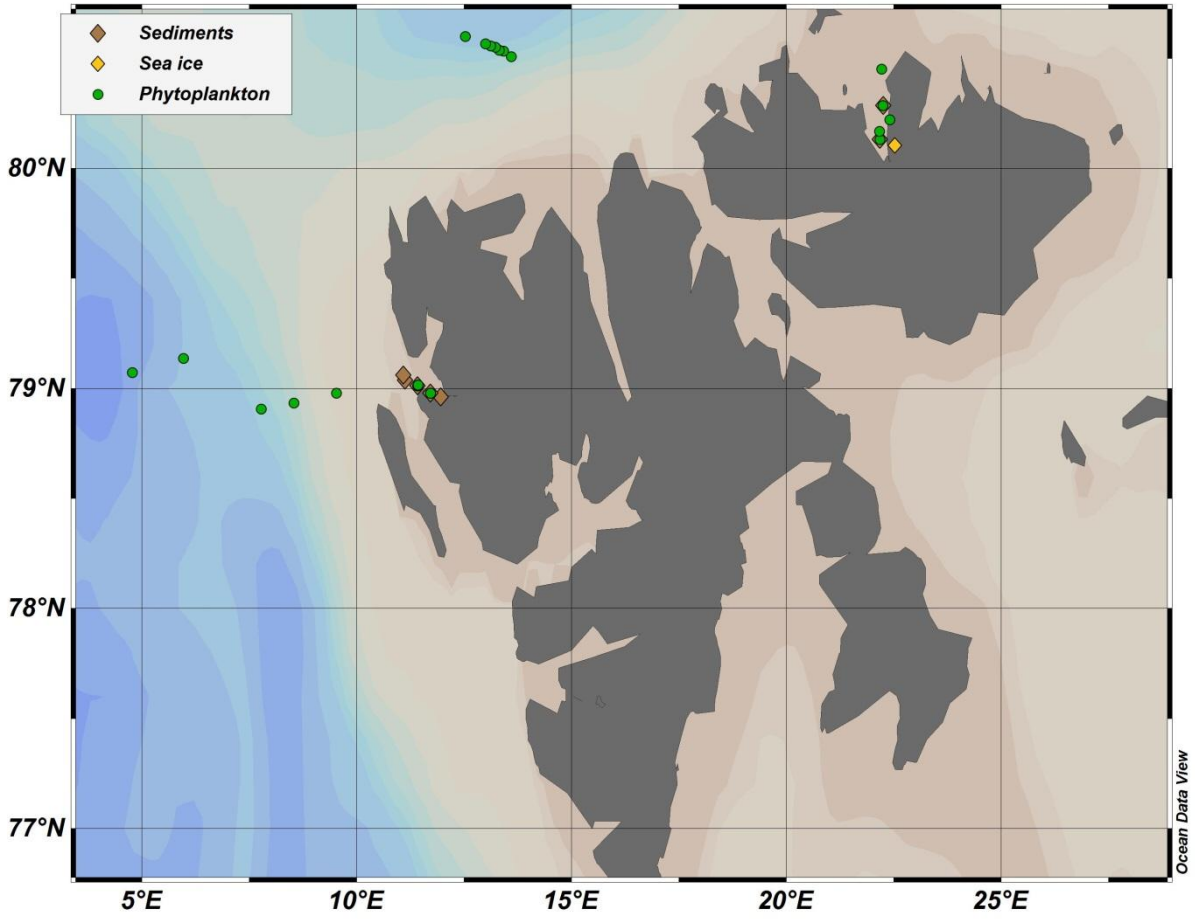


Figure 24. Location of all surface sediment samples collected for analysis of benthic foraminifera, diatoms and HBI (brown diamonds). The sites, where additional sampling for HBI was performed, are also indicated. Yellow diamond corresponds to sea ice location, and green circles correspond to locations of phytoplankton samples collected. Green diamonds indicate stations where samples of both sediment and phytoplankton were collected.

In order to obtain data on temperature, salinity etc. in the water masses from the past when it was not possible to get instrumental measurements of these factors; we study fossil micro-fauna (foraminifera) and micro-flora (diatoms) in the sediments. We also study the chemical composition of the micro-fauna/flora in addition the chemical composition of the sediments (sea ice biomarker IP25 and other structurally similar compounds, collectively called Highly Branched Isoprenoids/HBIs). Their composition and abundance depend on many environmental factors like temperature and salinity of the sea water, thus showing how the marine environment and water masses were back in time (paleo-oceanographic proxy data). The second aim of the project is to improve the proxies of ocean temperature and sea-ice and apply them to down core sediment samples from the multicores (fossil data). Hence, the monitoring data will also serve as modern analogue data for interpretation of fossil data of benthic foraminifera, diatoms and HBIs. Additional sampling for this purpose was done by collecting phytoplankton and sea ice samples for analysis of HBIs (Figure 15). The modern analogue data will also be utilized when developing statistical models making quantitative reconstructions (transfer functions). Two sites in Kongsfjorden (Kb3 and "fjord mouth station") and two sites in Rijpfjord (R1b, R2) were sampled down core for analysis of benthic foraminifera, diatoms and HBIs.

Sampling procedures

Surface sediment samples

The multi corer automatically gives six cores. The upper 0-1 and 1-2 cm were sampled immediately or within a couple of hours in order to avoid compaction of the unconsolidated surface sediments. The foraminiferal samples was preserved with ethanol and Rosa Bengal stain and kept in small plastic sediment containers. The upper 0-1 cm was sampled in a fourth multicore (MC D) for diatoms and biomarker analysis (half a sample for each proxy). These samples were stored cold onboard (maximum 5-10° C) in small Ziploc plastic bags. All samples for benthic foraminifera and diatoms analysis were transported to Norwegian Polar Institute (NPI) with RV "Lance" for further processing and analysis. All samples for HBIs analysis were taken to University of Plymouth after the cruise for analysis (NB the samples were stored cold as long as they were onboard the ship).

Down core sediment samples for paleo-reconstructions

The multi corer automatically gives six cores. Down core sampling of the multicores must be carried out immediately or within a couple of hours so compaction of the unconsolidated surface sediments is avoided. Three multicores were subsampled for every cm; one multicore (MC A) from 2 cm to the bottom of the core (foraminifera), one multicore (MC D) from 1 cm to the bottom (diatoms/ biomarkers), and one multicore (MC E) will be sampled for dating (^{210}Pb) and as a reference from top of the core, 0 cm, to the bottom. These samples for benthic foraminifera and diatoms were stored cold (maximum 5-10° C) onboard RV "Lance" and taken to NPI. All foraminiferal analysis will be carried out at NPI. Down core sediment samples for diatom analysis from Kongsfjorden (Kb3, Kb2, Kb1, Kb0, FM) will be carried out at National Centre for Antarctic & Ocean Research (NCAOR), India, but the remaining analysis of diatoms from Rijpfjord will be carried out at NPI. The samples for HBIs were taken to University of Plymouth, UK with the surface sediment samples.

Additional phytoplankton and sea ice sampling

Phytoplankton sampling was also carried out by filtering water samples from selected stations in the fjords and on the shelf west and north of Svalbard (Figure 23). Water was obtained from the ships water intake or CTD. Similarly, to sediment samples, all of the phytoplankton samples will be subjected to chemical analysis for HBIs at University of Plymouth. Samples from a single sea ice station in Rijpfjord was also obtained. These samples will be analyzed (microscopically) for the presence of IP_{25} but also other HBI producing species, followed by chemical analysis for the HBIs.

Preliminary results

Surface sediments collected during the cruise have already been subjected to onshore analysis of HBIs. The sea ice biomarker, IP_{25}, is present in all samples (Figure 25). This shows that both Kongsfjorden and Rijpfjord have been influenced by seasonal sea ice in recent years, which is also well documented by satellite images of the maximum sea ice extent.

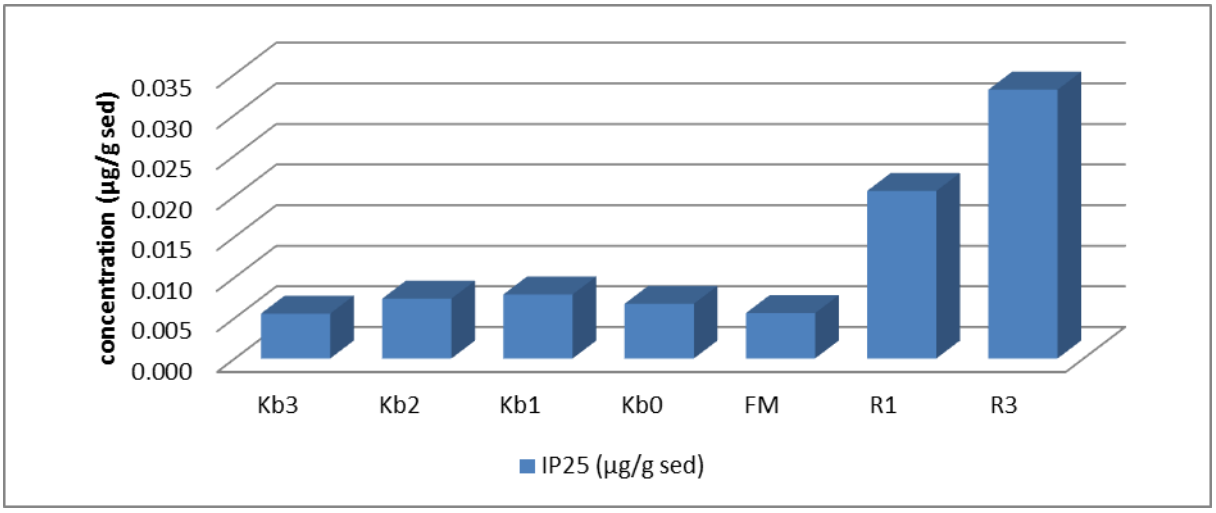


Figure 25. Concentrations of IP_{25} determined in surface sediments (0-1 cm) from Kongsfjorden and Rijpfjord.