IARC Technical Report # 6

Report of the NABOS/CABOS 2008 Expedition Activities in the Arctic Ocean

With support from:

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GLOSSARY:
AARI: Arctic and Antarctic Research Institute, St.Petersburg, Russia
ASBO: The UK Arctic Synoptic Basin-wide Oceanography programme
BAS: British Antarctic Survey, UK
BU: Bangor University, UK
IAF: Institute of Atmospheric Physics, Russian Academy of Science, Moscow, Russia
IARC: International Arctic Research Center, University of Alaska Fairbanks, Alaska, USA
IOS: Institute of Ocean Sciences, BC, Canada
IFM-GEOMAR: Leibniz Institute of Marine Sciences, University of Kiel, Germany
LU: Laval University, Quebec City, Quebec, Canada
NOCS: National Oceanographic Center, Southampton, UK
OM: Oceanetic Measurement Ltd., Sidney, BC, Canada
POI: V.I.Il'ichov Oceanographic Institute, Far Eastern Branch of the Russian Academy of Sciences
SAMS: Scottish Associationn of Marine Science, UK
UAF: University of Alaska Fairbanks, Alaska, USA
UCL: University College London, UK

ADCP: Acoustic Doppler Current Profiler, an instrument that measures these parameters.
BPR: Bottom Pressure Recorder, an instrument that measure these parameters.
CTD: Conductivity, Temperature and Depth an instrument that measures these parameters.
MMP: McLane Moored Profiler
MT: Moscow time (IB "*Kapitan Dranitsyn*" used MT as local time)
SBE: Seabird, a Seattle based company that produces a number of oceanographic instruments

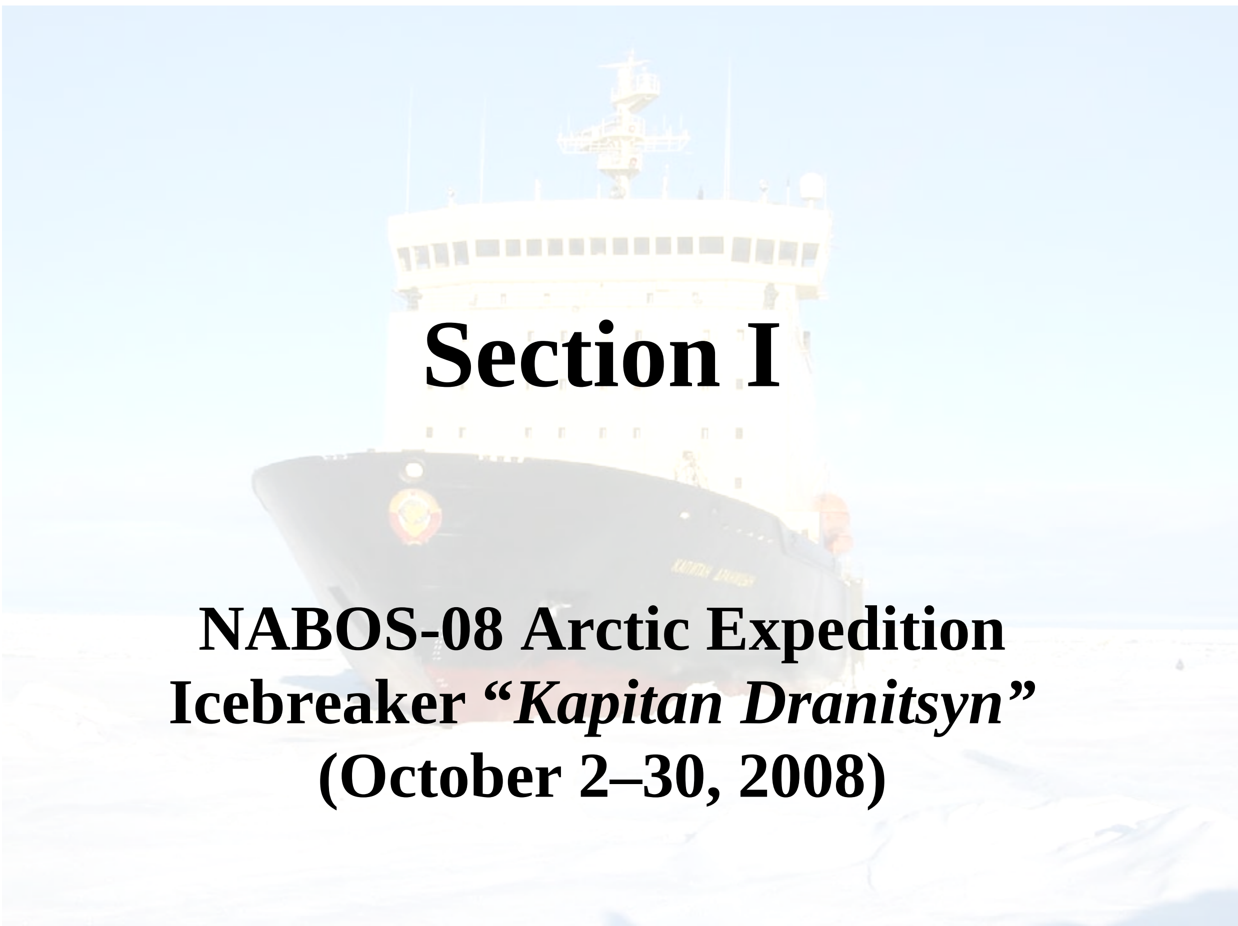
PREFACE

2008 was the most successful year and at the same time among the most difficult of the eight years of NABOS history. Our publication record grows steadily – a good sign of program maturity. Some progress was achieved toward establishing and maintaining our mooring-based observational system. We successfully recovered five and deployed two moorings in the Eurasian Basin of the Arctic Ocean. Two deployed moorings have a new design, which provides a better chance of collecting multi-year records without gaps. These moorings complement our “standard” observations by measurements of temperature and salinity in the uppermost layer of the Arctic Ocean and by sea-level measurements. We also deployed our CABOS mooring, thus continuing our multi-year record of observations in the Canada Basin. NABOS observations from the early 2000s captured the exceptional warming of the Atlantic layer. Observations carried out in 2008 suggest that this pulse of warm Atlantic Water passed its tipping point. For example, NABOS mooring-based and CTD snapshot observations documented strong, up to 1°C, cooling near Svalbard. Thus, our program provided key information about unprecedented transitions occurring in the Arctic Ocean, becoming an important component of the Arctic Observational Network. The program’s strong international reputation materialized when it was included as a part of the NOAA (USA) and RosHydroMet (Russia) Cooperative Agreement. Despite the solid steady progress our program has enjoyed over the years, we are not isolated from rapid global and regional political changes and financial crisis. These changes resulted in an unprecedented increase of icebreaker charter costs and were reflected in our exceptionally tight funding situation. Mother Nature contributed to our problems when two moorings deployed by our good partner, Laval University, disappeared off Novosibirskiye Islands. Despite these problems, NABOS has been an unqualified success. In this time of rapid environmental and political change, it presents a critically important scientific and political in-road to developing an understanding of the Arctic that is important to the global community.

Igor Polyakov
US Principal Investigator

Leo Timokhov
Russian Principal Investigator

NABOS
Nansen and Amundsen Basins Observational System



Section I

NABOS-08 Arctic Expedition
Icebreaker *“Kapitan Dranitsyn”*
(October 2–30, 2008)

I.1. INTRODUCTION *(V.Ivanov, SAMS)*

The 2008 arctic research cruise aboard the icebreaker *"Kapitan Dranitsyn"* was the seventh expedition under the aegis of NABOS (Nansen Amundsen Basin Observations System) conducted by the International Arctic Research Center (IARC) at the University of Alaska Fairbanks (UAF) in partnership with the Arctic and Antarctic Research Institute (AARI, St. Petersburg, Russia), ArcticNet at Laval University (Quebec, Canada), and the ASBO consortium of universities from the United Kingdom. The main goal of the NABOS project is to provide a quantitative assessment of circulation and water mass transformation along the principal pathways transporting water from the Nordic Seas to the Arctic Basin. A specific feature of the 2008 NABOS cruise was that it was carried out in the beginning of the arctic winter, when daylight was limited to 4–6 hours, the temperature was always below 0°C, and the ice was growing rapidly. Because of these difficulties, the complexity of field activities increased tremendously, yetthe cruise program was successfully fulfilled. New unique scientific data collected along the Eurasian continental marginunder these extreme conditions will be vital for understanding arctic climate change. Five moorings were recovered and two new ones were deployed. Strong seasonal oscillations of the temperature and salinity in the Atlantic Water layer found in 2004–2007 NABOS data were confirmed by newly obtained time series north of Svalbard and from the Severnaya Zemlya area.

I.2. RESEARCH VESSEL *(I. Polyakov, IARC)*

The Russian I/B *Kapitan Dranitsyn* (**Figure I.2.1**) has been chartered by the University of Alaska Fairbanks to carry out oceanographic research over the continental slope of the Siberian Arctic shelf. The ship is operated by the Murmansk Shipping Company located in Murmansk, Russia. I/B *Kapitan Dranitsyn* is a powerful conventionally propelled icebreaker, constructed in 1982. It was intended for working in the conditions of the Northern Sea Route and the Baltic Sea. The vessel was built at Wartsila Shipyard, Helsinki, Finland; on December 2, 1980, she was accepted by the crew and registered under Russia's flag. In 1994 the icebreaker was remodeled in Finland; later she was re-equipped for passenger operations. In 1999 she was updated in Norway and got a passenger vessel certificate. The icebreaker's main technical characteristics are presented in Table I.2.1.

The ship may be navigated from two positions on the bridge and from an aft auxiliary bridge (ice can also be broken when travelling stern-first). An air curtain system is applied to assist ice-breaking (air at 0.8 kg cm^{-2} is discharged through vents from forward to amidships 2m above the keel). Ice friction is reduced by polymeric coatings on the ice skirt. A cushioned stern allows close towing when vessels are being assisted through ice. Pumps can move 74 tons of water a minute between ballast and heeling tanks. Fresh water is provided from a vacuum distillation apparatus heated by exhaust gasses, which is supplemented by a reverse osmosis apparatus. A maximum of 80 tons a day can be produced. Two helicopters can be carried to assist ice navigation. Safety equipment includes 4 fully enclosed lifeboats and 4 inflatable life rafts (total capacity 264 persons). The fuel consumption rate is shown in Table I.2.2. The icebreaker is equipped with 3 deck cranes. Two forward cranes can lift 3 tons each, and one at the helicopter deck lifts up to 10 tons.

Figure I.2.1: Icebreaker *Kapitan Dranitsyn* on NABOS-02 cruise in the northern Laptev Sea.

Table I.2.1: The main technical characteristics of I/B *Kapitan Dranitsyn*

Displacement	15000 t (full load)
Draft	8.5 m
Breadth	26.75 m
Length	121 m (waterline), 132.4 m (overall)
Height	48.7 m
Main engines	6 Wärtsilä-Sulzer 9 ZL40/48 Diesel sets developing 18.5MW (24 200 horse power) which drive 6 AC generators
Propulsion	3 twin DC electric motors, each producing 5400 kW in either direction turn the 22m long propeller shafts (one spare shaft is carried)
Propellers	3, fixed pitch, 4.3 m diameter with 4 hardened steel blades turn at about 110 to 200 rpm. Spare blades are carried which can be deployed at sea
Auxiliary power	5 alternating current generator sets developing 730kW (2200 horse power)
Fuel	IFO-30 for main diesel sets, MGO for auxiliary generator sets
Fuel storage	2800 ton IFO-30 and 600 ton MGO
Hull thickness	45 mm where hull meets ice (the ice skirt) and 22-35 mm elsewhere
Speed	Full: 19 knot (35.2 km/h) with 6 engines; cruising speed: 16 knot (30 km/h) in calm open water; ice 1.5 m thick may be broken at 1 knot (1.8 km/h), 3 m has been broken by repeated ramming.
Ice class	KM*LL3 A2
Operating range	10 500 nautical miles (19 500 km) at 16 knot (30 km/h)
Anchors	2 weighing 6 tons each, with 300 m chains, and one spare
Crew and passengers	60 and 102

Table I.2.2: Fuel consumption of I/B *Kapitan Dranitsyn*.
(Data provided by Murmansk Shipping Company)

Consumption for main diesel sets (IFO-30)		Additional consumption (IFO-30)	
Number of Diesels	Fuel Consumption (tons/day)	Air Temperature (grad. C)	Fuel Consumption (tons/day)
1	15.6	+15	2.5
2	31.2	+5	3.5
3	46.8	-10	5.0
4	62.4	-30	6.0
5	78.0	Site Consumption	Consumption Rate MGO/IFO
6	93.6	4 ton/day	1/25

A LEBUS double-drum electric oceanographic winch (**Figure I.2.2**) manufactured by LEBUS Engineering International Ltd., England, was additionally deployed on the helicopter deck of the icebreaker in September 2003 in order to operate the conductivity/temperature/depth (CTD) profiler, biological nets and trawl and to deploy/recover the moorings. Winch electric motor power is 7.3 KW. Each drum capacity is 3500 m of 0.3-inch cable. The left drum is used only for mooring recovery. The right drum with spooling mechanism contains the mechanical cable of 3000 m length to carry the CTD probe, nets and trawl. A HAWBOLDT C15-40 horizontal capstan manufactured by HAWBOLDT Industries (1989) Ltd., Canada, was placed near the LEBUS winch in September 2004 (**Figures I.2.3** and **I.2.4**). The capstan is equipped with 11.2 KW two-speed Toshiba electric motor and is used for mooring deployment/recovery. The horizontal drum diameter is 40”.

Figure I.2.2: LEBUS double-drum oceanographic winch on the helicopter deck.

Figure I.2.3: HAWBOLDT C15-40 horizontal capstan on the helicopter deck.

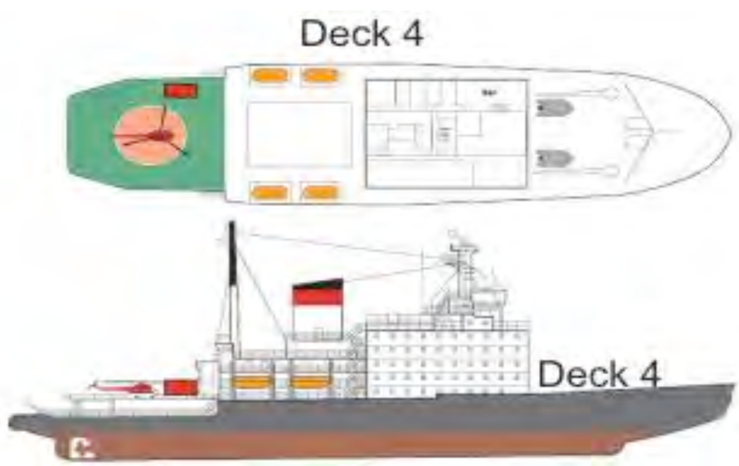


Figure I.2.4: CTD/Rosette winch and mooring capstan site position on Deck 4 are shown by red rectangles.

I.3. CRUISE TRACK (*V.Ivanov, SAMS*)

The icebreaker *Kapitan Dranitsyn* left Kirkenes, Norway, at 6 p.m. local time on October 2, 2008, after loading/mounting the equipment and embarkation of the expedition team. The research area included the Eurasian continental margin from Spitsbergen to the East Siberian Sea (**Figure I.3.1**).

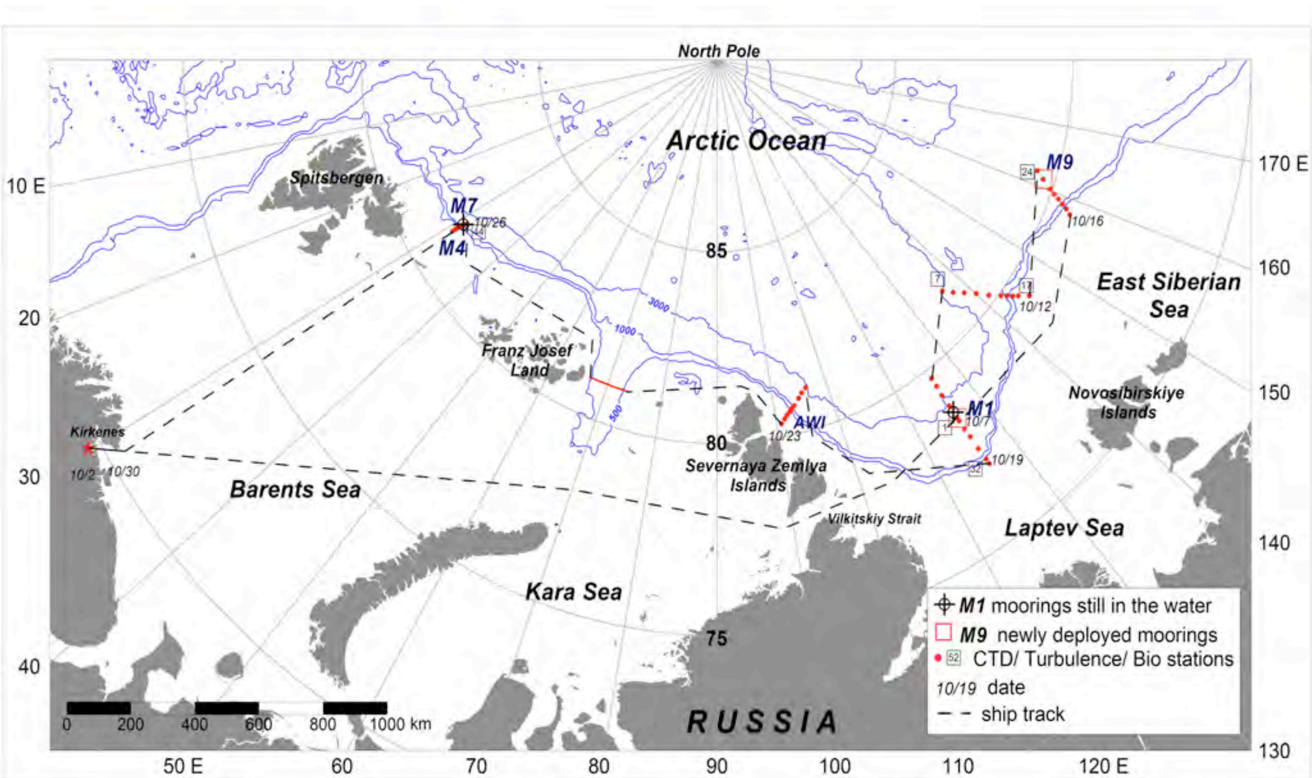


Figure I.3.1: NABOS 2008 cruise map

The operation area partly overlapped the Russian Exclusive Economic Zone (EEZ). By the beginning of the cruise, permission for work within the EEZ had not been granted. Hence, the work started at the mooring site M1 outside the Russian EEZ (**Figure I.3.2**). On October 7, the vessel arrived at the M1 location. An attempt to recover the mooring failed due to malfunctioning of the release. An additional attempt with the other release was not taken because of coming dusk and heavy ice conditions. During October 7 and 8, the northern part of transect *A* (five stations, **Figure I.3.2**) was accomplished. Operations at the transect *B* started late at night on October 10 and continued during the next three days. On October 11, permission for operations within the Russian EEZ was received. Ten stations were carried out, including a 12-hour shelf station at the southernmost end of this transect. Two moorings at this transect (M8 and M3) did not respond to acoustic signals and were abandoned. The easternmost transect *C*, containing eight stations, was occupied within October, 13–16. Two moorings (M10 and M9) were recovered and one mooring (M9) was re-deployed. During October 18–19, the southern part of the transect *A* was accomplished and the M1 mooring was deployed. Another attempt to recover the M1 mooring was not taken because of 100% ice concentration (no leads) and coming dusk. Three days, October 21–23, were spent to recover two moorings (M5 and M6) and to carry out nine stations along the *D* transect northeast of the Severnaya Zemlya Archipelago.

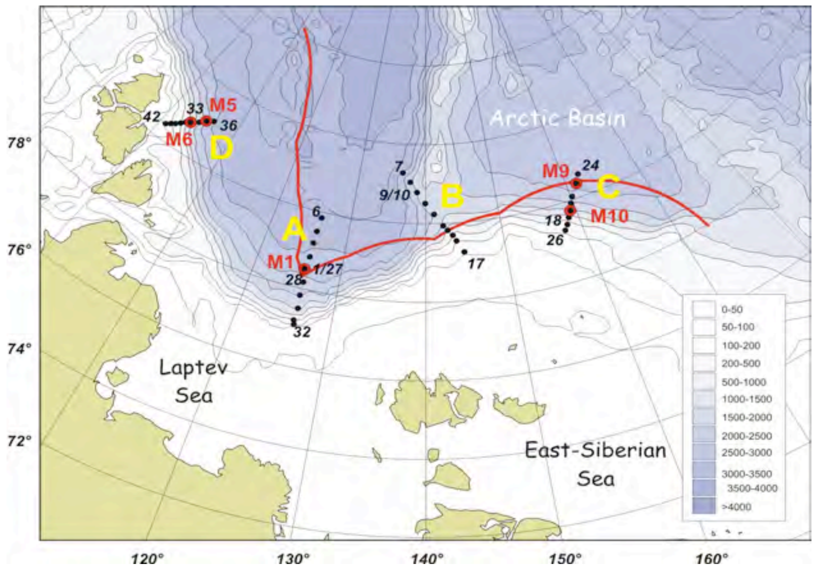


Figure I.3.2. CTD sections and mooring sites in the Laptev and East-Siberian seas during the NABOS-08 cruise. Black circles represent CTD stations; red circles denote mooring positions. The red solid line represents the position of the Russian Exclusive Economic Zone. Yellow letters indicate the oceanographic cross-slope sections.

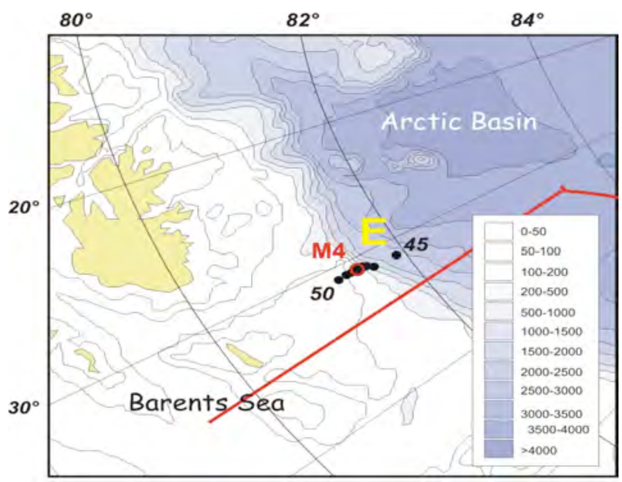


Figure I.3.3. CTD section and mooring site north of the Barents Sea during the NABOS-08 cruise. Black circles represent CTD stations; red circles denote mooring positions. The red solid line represents the position of the Russian Exclusive Economic Zone.

An attempt to retrieve AWI's shelf mooring deployed in 2005 at 180m depth on Severnaya Zemlya shelf was not successful, although this mooring responded after three years in the water. On the way to the westernmost transect *E*, a high resolution (20 XCTD/XBT casts) transect was taken across St. Anna Trough. Ten stations were accomplished at transect *E* (**Figure I.3.3**). Triangulation of moorings M7 and M4 showed a large discrepancy (several hundred meters) in positions of bottom releases and top transponders. This discrepancy may be caused by strong currents, which incline the wire in the upper part, as was documented at M4 during the 2004–2006 deployment. The location of both moorings was covered by heavy 100% ice cover. Three hours of twilight between dawn and dusk was a serious obstacle for work as well. Under these conditions it was decided to cancel recovery/deployment of these moorings. However, while carrying out CTD stations in the vicinity of M4 mooring, the ice situation improved dramatically and the M4 mooring was successfully recovered by 4 p.m. on October 28. After this recovery, IB *Kapitan Dranitsyn* started sailing to Kirkenes to stay within the cruise schedule.

I.4. SCIENTIFIC PARTY (*V.Ivanov, SAMS*)

#	Name	Position	Affiliation	Team	Country
1	Abrahamsen, Povl	Scientist	BAS	Che	UK
2	Alekseeva Tatyana	Team Leader	AARI	Ice	Russia
3	Alexeev, Vladimir	Scientist	IARC	Met	USA
4	Beliveau, Ian	Moor.Tech	Oceanetic	Tec	Canada
5	Blondeau, Sylvain	Moor.Tech	LU	Tec	Canada
6	Bodrova, Elizaveta	PhD student	SPbSU	Hyd	Russia
8	Chechin, Dmitriy	PhD student	IAP RAS	Met	Russia
9	Chernyavskaya, Ekaterina	PhD student	AARI.	Hyd	Russia
10	Childinova, Irina	PhD student	AARI	Ice	Russia
11	Dmitrenko, Igor	Co-Chief Scientist	LIMS	Hyd	Germany
12	Geoffroy, Maxime	PhD student	LU	Bio	Canada
13	Goryunova, Natalia	Scientist	IO RAS	Geo	Russia
14	Greenbeeg, Jacob	Moor.Tech	IARC	Tec	USA
15	Hastings, Larry	Moor.Tech	IARC	Tec	USA
16	Ivanov, Vladimir	Chief-Scientist	IARC	Adm	USA
17	Kaiser, Karl	PhD student	USC	Che	USA
18	Keen, Peter	Chief Moor.Tech	Oceanetic	Tec	New Zealand
19	Kirillov, Sergey	Co-Chief Scientist	AARI	Adm	Russia
20	Kosmach, Denis	PhD student	POI RAS	Che	Russia
21	Lalande, Catherine	Team Leader	LU	Bio	Canada
22	Lenn, Yueng-Djern	Team Leader	BU	Tur	UK
23	Lincoln, Ben	PhD student	BU	Tur	UK
24	Litvinov, Egor	PhD student	AARI	Hyd	Russia
25	Makhotin, Mihail	Scientist	AARI	Hyd	Russia
26	Mugford, Ruth	Scientist	UR	Che	UK
27	Powell, Benjamin Ian	Technician	BU	Tur	UK
28	Repina, Irina	Team Leader	IAP RAS	Met	Russia
29	Rozman, Polona	MS student	AARI	Che	Slovenia
30	Saluk Anatoliy	Scientist	POI RAS	Che	Russia
31	Smirnov, Alexander	Scientist	IAP RAS	Met	Russia
32	Syromyatina, Margarita	Adm.assist.	SPbSU	Adm	Russia
33	Timofeeva, Anna	Scientist	AARI	Ice	Russia
34	Torres-Valdes, Sinhue	Team Leader	NOCS	Che	UK
35	Walsh, David	Scientist	PTWC	Hyd	USA
36	Wieczonek, Piotr	Technician	IO PAS	Tec	Poland

I.5. METEOROLOGICAL/ICE CONDITIONS *(V.Ivanov, SAMS; I.Repina, IFA; T. Alexeeva, AARI)*

October in the high-latitude Arctic is the beginning of winter. After the autumn equinox, the duration of daylight rapidly decreases, and by mid-October the areas to the north of 80°N are where the polar night reigns (**Figure I.5.1**).

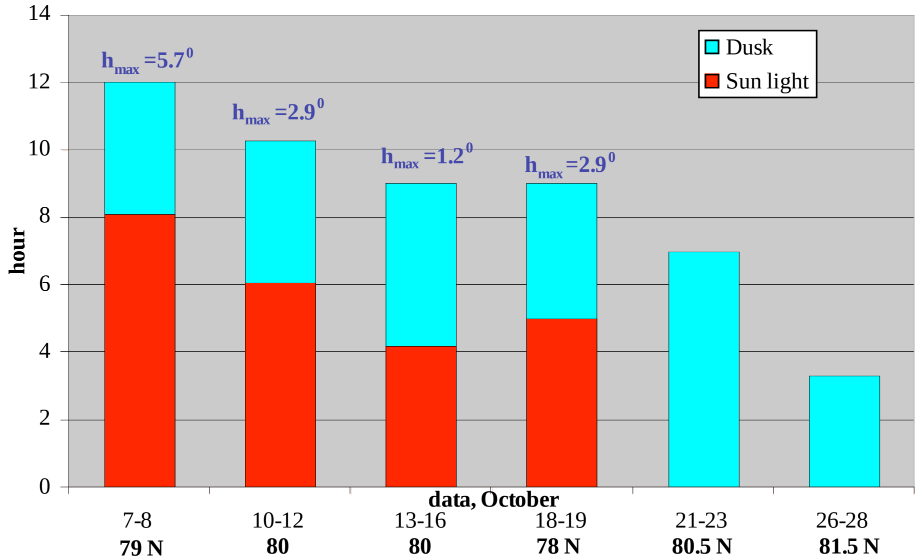


Figure I.5.1: Duration of light day during the cruise

In October, the surface air temperature (SAT) is normally below 0°C, and the sea surface temperature (SST) is typically at the freezing point. Together with strong winds, these factors cause intensive ocean-air heat flux, resulting in rapid ice growth. During the 2008 NABOS cruise weather conditions were close to normal for this season of the year (**Figure I.5.2**).

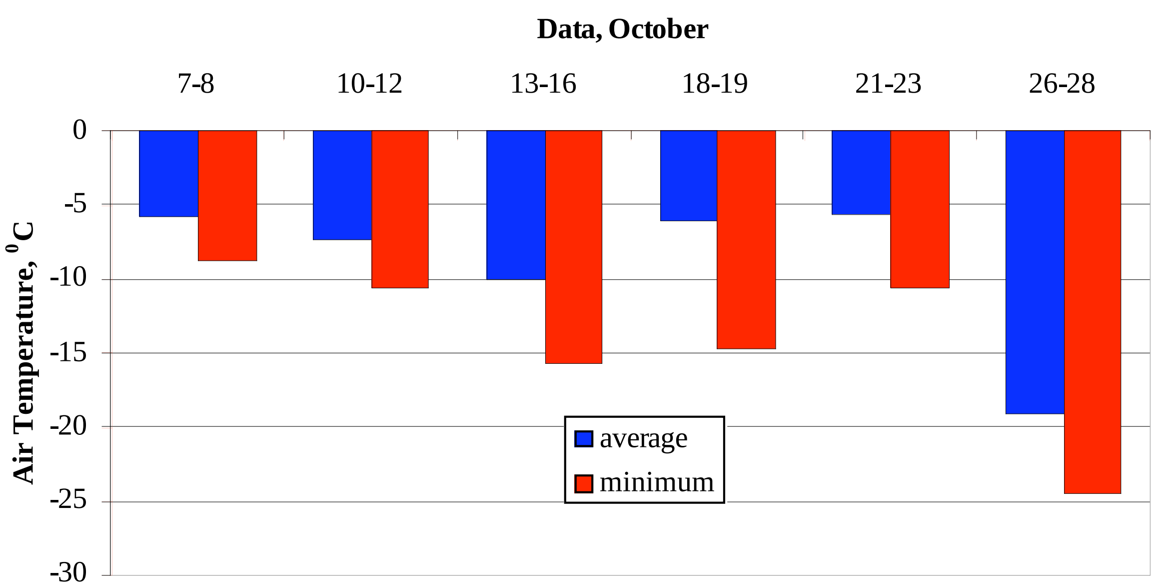


Figure I.5.2: Surface air temperature during the cruise.

During the 2008 NABOS cruise, average SAT was about -5–7°C, while the extreme temperature minima were at -25°C. Low temperatures complicated water sampling from the rosette (the water in the bottles was often frozen when onboard). High humidity over polynyas and leads caused fast icing of meteorological instruments, thus biasing the measurements of sea-air interaction.

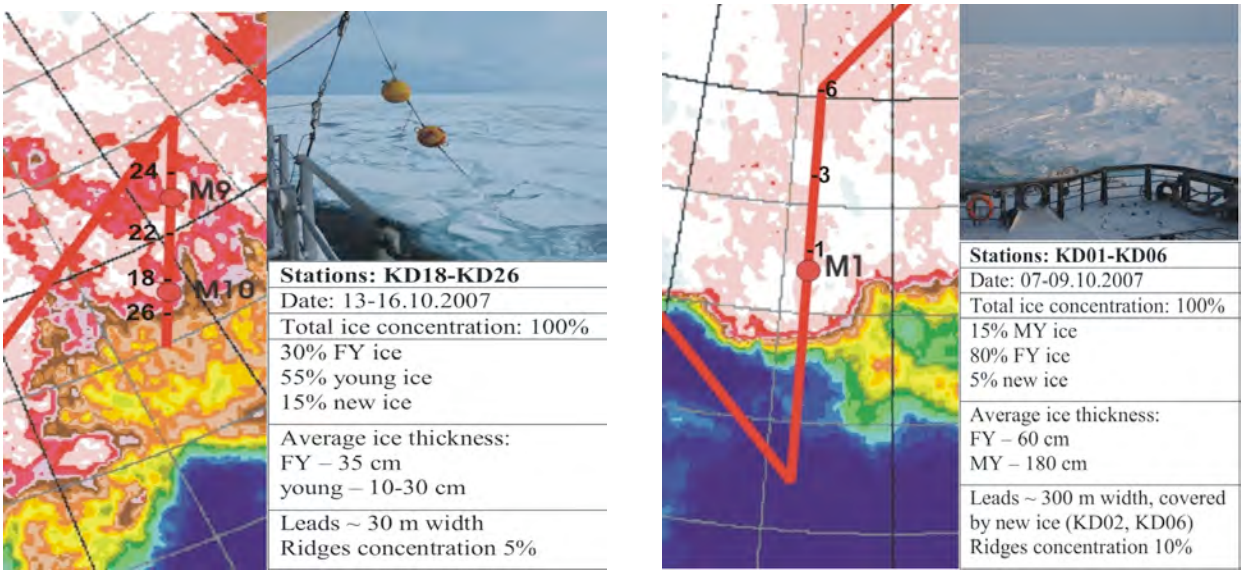


Figure I.5.3: Typical examples of ice conditions during the cruise.

Ice conditions during the cruise were severe (**Figure I.5.3**). Generally, all transects were taken under 100% ice concentration. Although the ice encountered during the cruise was either first-year ice (~40–60cm), or newly formed nilas/gray/white ice (<30 cm), it often caused a serious obstacle for field operations and even for navigation. Under the conditions of compression/ridging, complexity of mooring recovery operations increased tremendously. It was virtually impossible to clean enough space (~200m in diameter) to secure mooring recovery. Therefore, all recoveries, accomplished during this cruise were risky, with limited chances to get the mooring out of the water after firing the release.

I.6. OBSERVATIONS *(V.Ivanov, SAMS; S. Kirillov, AARI)*

The NABOS-08 program included routine CTD and XCTD observations, water sampling, recovery and deployment of oceanographic moorings, and turbulence, hydrochemical, geochemical, ice, and meteorological observations. The operational map of the NABOS-08 I/B *Kapitan Dranitsyn* cruise is shown in **Figure I.3.1**; measurements made during the cruise are listed in **Table I.6.1.**

Table I.6.1: Observations during the NABOS-08 cruise of the I/B Kapitan Dranitsyn

Station #	Date Dd/mm	Time UTC	Lat	Lon	Depth (m)	CTD	Rosette	XCTD	XBT	Moor. Dep.	Moor Rec.	Turbu-lence	Net	Ice sampl
KD0108	7.10	6:56	78° 30,67’	125° 49,41’	>1 km	X	X					X	X	
KD0208	7.10	18:00	78° 49,9’	125° 59,6’	>1 km	X	X					X		
KD0308	7.10	23:45	78° 29,6’	125° 49,1’	>1 km						F			
KD0408	8.10	16:06	79° 10,88’	125° 56,53’	>1 km	X	X					X		
KD0508	8.10	22:09	79° 30,09’	126° 01,60’	>1 km	F	F	X				X	X	
KD0608	9.10	1:56	79° 49,9’	126° 04,1’	>1 km	X	X	X				X	X	
KD0708	10.10	5:09	81° 16,3’	136° 29,7’	>1 km	X	X						X	
KD0808	10.10	12:20	81° 03,12’	137° 50,68’	>1 km	F	F	X				X	X	X
KD0908	10.10	19:00	80° 47,91’	136° 51,18’	>1 km	X	F					X	X	
KD1008	10.10	23:55	80° 47,16’	138° 48,53’	>1 km	X	X							
KD1108	11.10	4:15	80° 31,03’	140° 02,88’	>1 km	X	X					X	X	M8
KD1208	11.10	9:28	80° 13,82’	141° 12,52’	>1 km	X	X					X		
KD1308	11.10	15:28	79° 56,62’	142° 19,96’	>1 km	X	X					X	X	
KD1408	12.10	0:12	79° 48,76’	142° 58,53’	>1 km	X	X						X	M3
KD1508	12.10	4:09	79° 41,11’	143° 32,18’	500	X	X					X	X	
KD1608	12.10	8:07	79° 32,97’	144° 00,09’	300	X	X						X	
KD1708a	12.10	11:21	79° 17,51’	144° 57,37’	100	X	F						X	
KD1708b	12.10	14:55	79° 12,24’	144° 50,4’	100	X	X					X	X	
KD1708c	12.10	18:25	79° 13,78’	144° 55,5’	100	X	X							
KD1708d	12.10	20:35	79° 14,47’	144° 57,29’	100	X	X							
KD1708e	12.10	22:09	79° 15,21’	144° 58,37’	100	X	X							
KD1808	13.10	10:14	79° 27,0’	158° 21,64’	300	X	X						X	
KD1908	13.10	12:20	79° 35,36’	158° 46,73’	800	X	X					X	X	
KD2008	13.10	15:17	79° 45,71’	159° 20,09’	>1 km	X	X							
KD2108	13.10	17:55	79° 54,94’	159° 40,32’	>1 km	X	X				X			
KD2208	14.10	8:50	80° 02,93’	160° 13,94’	>1 km	X	X						X	
KD2308	14.10	13:18	80° 20,84’	161° 15,81’	>1 km	X	X				X	X	X	
KD2408	14.10	17:18	80° 33,78’	162° 11,96’	>1 km	X	X							
KD2508	16.10	8:10	79° 44,64’	159° 02,81’	>1 km					F				
KD2608	16.10	18:48	79° 19,43’	157° 58,03’	220	X	F							
KD2708	18.10	2:10	78° 25,83’	125° 29,29’	>1 km	X	X			X			X	

KD2808	18.10	14:48	78° 09,92’	126° 00,76’	>1 km	X	X					X	X	
KD2908	18.10	18:54	77° 50,14’	126° 00,68’	>1 km	X	X					X	X	
KD3008	18.10	0:00	77° 29,83’	126° 05,16’	>1 km	X	X					X	X	
KD3108	19.10	4:40	77° 09,89’	126° 07,11’	900	X	X						X	
KD3208	19.10	7:53	77° 04,27’	126° 04,8’	>1 km	X	X						X	
KD3308	21.10	0:05	80° 44,93’	103° 29,98’	>1 km	X	X				X	X	X	
KD3408	21.10	11:02	80° 53,28’	104° 33,84’	>1 km	X	X					X	X	
KD3508	21.10	16:23	81° 00,78’	105° 20,42’	>1 km	X	X				X	X	X	
KD3608	21.10	20:11	81° 05,63’	106° 16,09’	>1 km	X	X					X	X	
KD3808	22.10	9:40	80° 40,68’	103° 00,95’	620	X	X					X	X	
KD3908	22.10	13:50	80° 36,52’	102° 31,44’	340	X	X					X	X	
KD4008	22.10	16:36	80° 31,71’	102° 01,86’	284	X	X					X	X	
KD4108	22.10	18:39	80° 27,51’	101° 23,23’	234	X	X					X	X	
KD4208	22.10	20:52	80° 23,07’	100° 57,62’	181	X	X					X	X	
KD4308_01-KD4308_20	24.10	5:17-05:2			150-600			X	X					
KD4408	25.10	21:00	81° 39,75’	31° 05,63’	> 1 km									
KD4508	26.10	4:06	81° 54,48’	31° 18,98’	>1 km	X	X					X	X	
KD4608	26.10	8:49	81° 39,81’	31° 08,18’	>1 km	X	X				X	X	X	
KD4708	26.10	16:00	81° 36,58’	31° 00,60’	>1 km	X	X					X	X	
KD4808	26.10	21:32	81° 27,38’	30° 57,52’	520	X	X						X	
KD4908	27.10	1:05	81° 24,55’	30° 58,25’	330	X	X						X	
KD5008	27.10	3:33	81° 19,08’	31° 01,93’	190	X	X						X	
KD5108	27.10	11:08	81° 33,52’	30° 50,18’	>1 km	X	X						X	
KD5208	27.10	15:54	81° 29,73’	30° 54,61’	>1 km	X	X						X	
KD5308	27.10	20:09	81° 34,99’	30° 55,49’	>1 km	X	X							
KD5408	27.10	22:29	81° 31,74’	30° 51,39’	900	X	X							

I.6.1. SEA-ICE OBSERVATION (*T. Alexeeva, AARI*)

Regular sea ice observations started on October 5, when I/B *Kapitan Dranitsyn* met the first ice floes in the Kara Sea, and were finished on October 28 east of Svalbard. Ice zones with homogeneous characteristics were observed daily. Regionally, observations were divided into two subareas. One is called “in the region” (within the range of horizontal visibility and screen area of radar) and the second one is called “on the route” (within the zone of three widths of the vessel from each side). The sea-ice pattern in these two areas is characterized by the following ice-cover parameters: ice concentration (total and partial for all stages of development); stages of development and forms (according to stages or predominance); hummock and ridge concentrations, average and maximal height of hummocks; predominant ice thickness (en route only); predominant snow height (en route only); surface contamination concentration; ice pressure; percentage of rafted ice (for new and young ice); existence and orientation of openings (leads, cracks) in the ice cover, their average width; meteorological parameters like visibility, snow and fog and icebergs (height, width, coordinates), polar bears and their footsteps, seals.

For visual definition of en-route ice thickness, a 2-meter stick attached to the board was used (**Figure I.6.1.1**). Regular shipborne radar was used to estimate configuration of ice zones within the area of navigation.

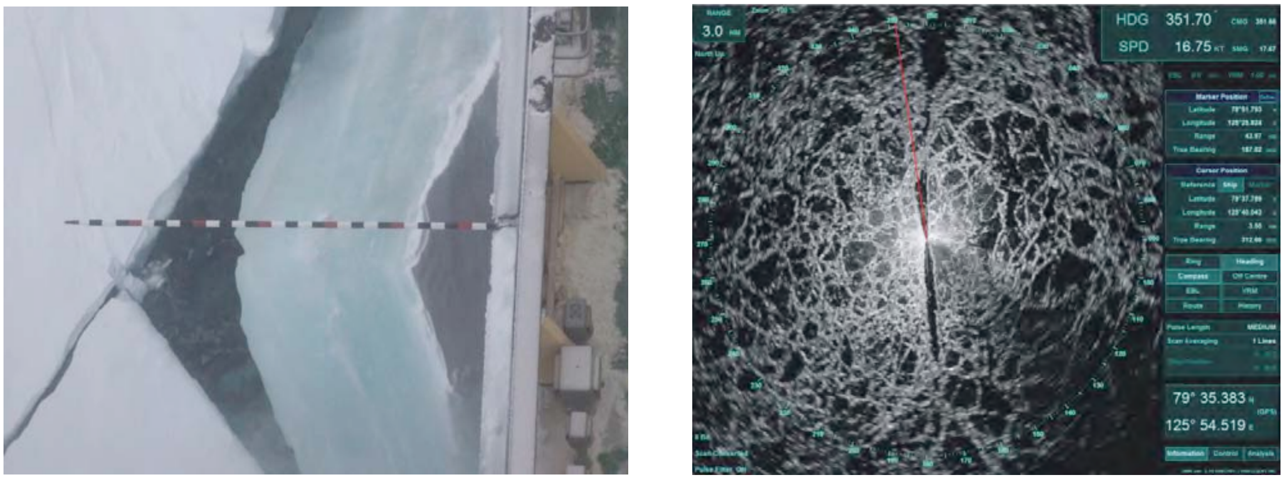


Figure I.6.1.1: Photos of the ice stick and regular ship radar.

Fourteen satellite-based ice charts were obtained during October 4–28, 2008, from http://www.seaice.dk (**Figure I.6.1.2**). These ice charts were compiled using 6km resolution ice concentration imagery from AQUA AMSR, based on the hybrid DTU algorithm to retrieve the total ice concentration. Coloring and geographical transformation of initial imagery downloaded from the DTU server were carried out using the author's software (V.M. Smolyanitsky, AARI), while visualization and additional geographic location were accomplished using DTU-developed Java software available at the URLs http://www.seaice.dk and http://www.dcrs.dtu.dk.

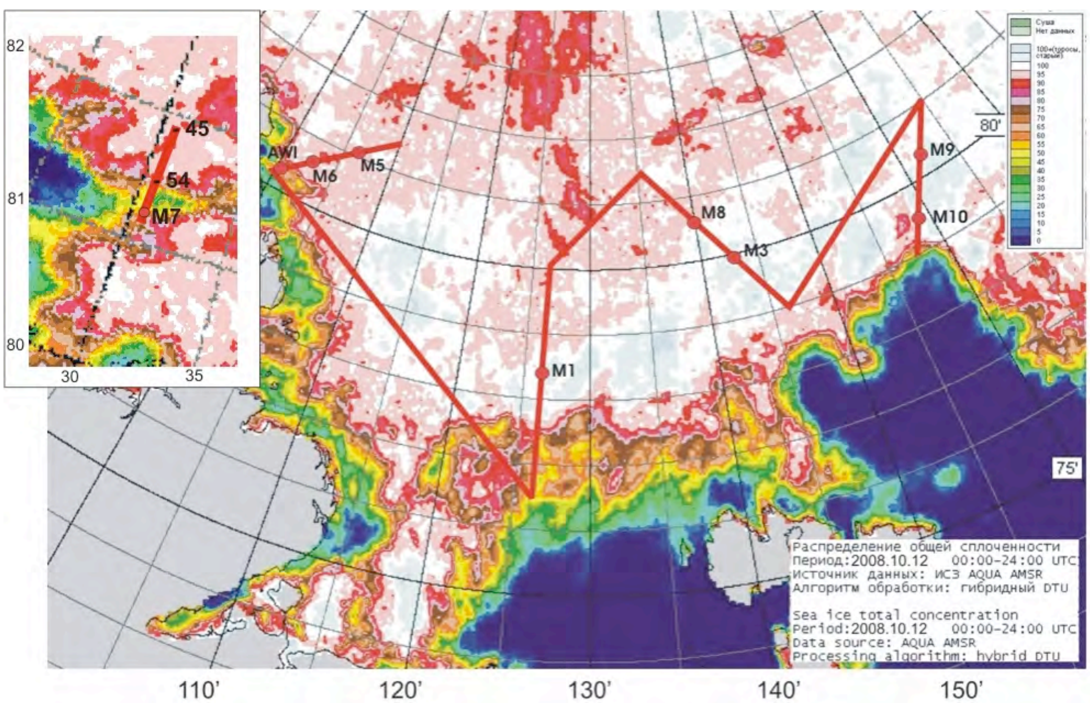


Figure I.6.1.2: Satellite image of ice cover (October 12, 2008) from http://www.seaice.dk together with oceanographic stations and moorings in the Laptev Sea and near Svalbard (the latter shown as insert in the left top corner).

In the beginning of October, the Kara Sea was almost ice-free, except the near-shore area to the west of Severnaya Zemlya where a part of the Northern Kara ice mass remained. Intensive new ice formation was observed on October 6 when passing Vilkitsky Strait. Ice conditions in the Laptev Sea in October 2008 were difficult for navigation even for the I/B *Kapitan Dranitsyn* in the area of research. In the southwestern Laptev Sea, a small area of the Taimyr ice mass remained after the summer melting season. The northern part of the Laptev Sea was fully covered by compact ice. Both strong snow and formation of the new ice in openings between one- and multi-year ice floes hampered navigation. Difficulties were also caused by poor visibility. These conditions made ship navigation very difficult.

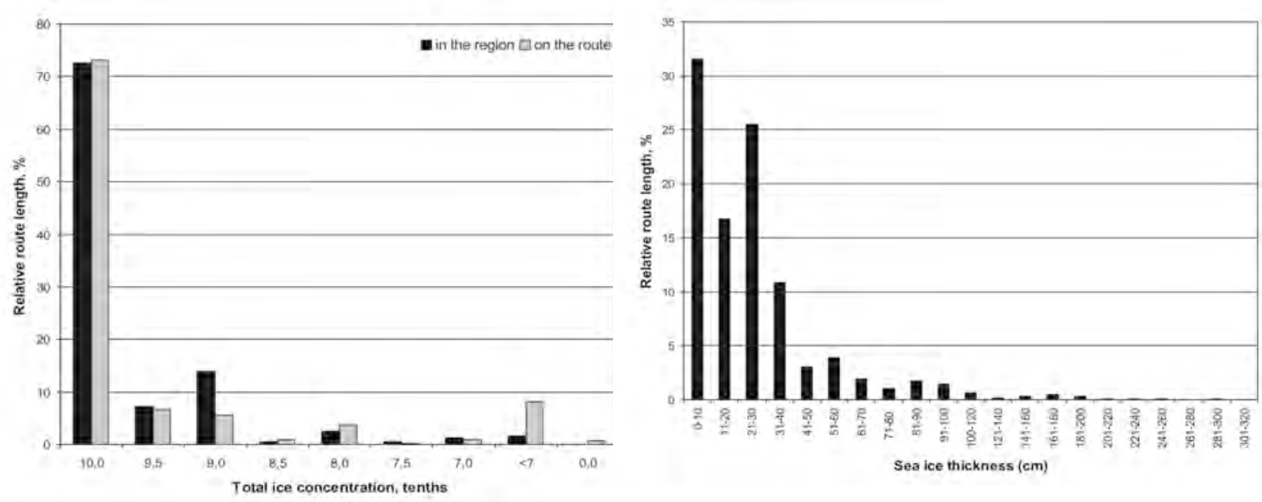


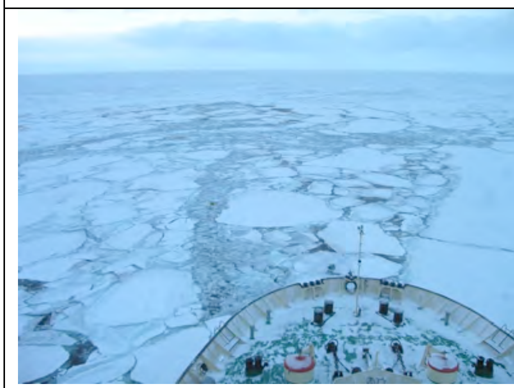
Figure I.6.1.3: (Left) Part (%) of the ship trajectory in the ice of various concentrations (left) in ice of various thicknesses (right).

Table I.6.1.1: Observed sea-ice conditions along NABOS-08 transects

Date	Stations	Total ice concentration	Average ice thickness	Leads, Ridges
07-09.10.2008	Transect A1, KD01-KD06 Mooring M1	100% (15% of MY ice, 80% of FY ice, and 5% of new ice)	MY – 180 cm FY – 60 cm	Leads ~ 300 m width, covered by new ice (KD02, KD06) Ridges concentration 10%
10-12.10.2008	Transect B, KD07-KD17 Mooring M3 and M8	100% (40% of FY ice, 50% of young ice and 10% of new ice)	FY – 40 cm young – 20-30 cm	Leads ~ 50 m width, covered by young ice (KD11-KD17) Ridges conc. 20%
13-16.10.2008	Transect C, KD18-KD26 Mooring M9 and M10	100% (30% FY ice 55% young ice 15% new ice)	FY – 35 cm young – 10-30 cm	Leads ~ 30 m width Ridges concentration 5%
18-19.10.2008	Transect A2, KD27-KD32, Mooring M1	100% (5% of FY ice, 90% of young ice and 5% of new ice)	FY – 35 cm young – 20-30 cm	
21-22.10.2008	Transect D, KD33-KD42, Mooring M5, M6 and AWI	100% (5% of MY ice, 70% of FY ice and 25% of young ice)	MY – 220 cm FY – 50 cm young – 20-30 cm	Leads ~ 100 m width Ridges concentration 40%
26-27.10.2008	Transect E, KD45-KD54, Mooring M7	100% (85% of FY ice and 15% of young ice)	FY – 50 cm young – 20-30 cm	Leads ~ 20 m width Ridges concentration 20%

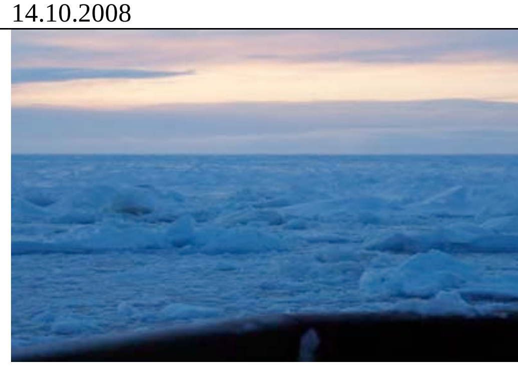

Transect A1. Photo by I.Childinova 08.10.2008


Transect B. Photo by I. Childinova 11.10.2008


Transect C. Photo by I. Childinova 14.10.2008


Transect C. Mooring recovery. Photo by I. Childinova 14.10.2008


Transect A2. Photo by R. Mugford 19.10.2008


Transect D. Photo by E. Litvinov 21.10.2008


Transect D. Photo by R. Mugford 22.10.2008


Transect E. Photo by R. Mugford 26.10.2008

Figure I.6.1.4: Ice conditions along the NABOS-08 cruise track.

Total ice concentration (percentage of the sea surface covered by ice) along the ship route was estimated visually. The icebreaker's pathway in the Laptev Sea was through very heavy ice with predominant ice concentrations 80–100%. Less than 3% of the ship route was through ice with concentration ~70% (**Figure I.6.1.3**).

Newly formed young ice with thickness of 0–30cm occupied vast (up to 75%) areas along the ship route (**Figure I.6.1.3**). Multiyear ice in the area of research was very rare – about 1% of the total ice concentration. Because the expedition was carried out in October, the time of intensive ice formation, most of the observed first-year ice had a thickness of 30–50cm; thus it was newly formed autumnal ice. The ship route is shown schematically in **Figure I.6.1.2** which also shows a satellite-derived ice map for October 12, 2008. This map shows ice conditions for all locations of moorings and cross-sections with ice concentration close to 100%. However, ice thickness was very different at each position, and that had a large impact on the time required to accomplish work and on the success of the mission in general (see **Table I.6.1.1 and Figure I.6.1.4**).

I.6.2. OBSERVATIONS OF AIR-ICE INTERACTIONS *(I.Repina, IAF)*

I.6.2.1. Introduction

The following objectives defined the design of our experiments and the choice of instrumentation.

1. To analyze energy exchange between atmosphere and surface using measurements of turbulent fluxes (latent and sensible heat fluxes, momentum fluxes, carbon dioxide fluxes) in the subsurface layer of the atmosphere.
2. To define the exchange coefficients in the aerodynamic bulk formulas, the surface roughness parameter in respect to the type of the surface and meteorological conditions.

A suite of observations was carried out during the cruise:

- Direct measurements of temperature, horizontal and vertical components of wind speed and humidity, carbon dioxide and water vapor concentration above ice surfaces of various conditions. The data are used for calculation of turbulent fluxes, as well as roughness parameter of a surface and atmospheric stability. The measurements were carried out when the ship was moving.
- Measurement of sea surface temperature in the infrared (IR) range.
- Standard meteorological measurements.

I.6.2.2. Instruments

To carry out the measurements described above, the following equipment was used:

- A USA-1 Sonic thermo-anemometer (METEK Co.) that measures fluctuations of three components of wind speed and temperature fluctuations at frequency of 10-50 Hz.
- A WINDSONIC I Sonic anemometer (GILL Co.) that measures fluctuations of two components of wind speed at frequency of 5 Hz.
- An Eppley pyranometer for downwelling solar radiation.
- A YSI MODEL 30M unit for CTD measurements in the surface sea layer.
- An InfraRed radiometer HEITRONICS KT19 II-Series to measure skin temperatures of the sea surface.
- A VANTAGE PRO2 Weather Station. This is a self-contained system that measures air temperature and humidity, wind speed and direction, surface air pressure, and shortwave (λ ~ 0.3-3μm) incident radiation.
- An inclinometer and three axis accelerometers and rate gyros to measure ship motions in three dimensions.
- A GARMIN GPS 17-HVS navigator to measure the ship's position.

- An open path infrared gas analyzer LI-7500 (LICOR Co.), measuring H_2O and CO_2 with frequency of 10-20 Hz.
- A video camera (web cam) to the sea surface conditions visual control. The images were recorded by a laptop computer for subsequent analysis.

The locations of sensors are shown in **Figure I.6.2.1** and are listed in **Table I.6.2.1**. When the ship was moving, the turbulence equipment was installed on the bow using a meter boom (height of measurements was 8m) to optimally reduce the dynamical and thermal ship body effects. Signals from the turbulence sensors and motion sensors were sent to a PC-based data acquisition system including Labview (National Instruments). The system samples all of the data at 10 Hz and, after filtering out high-frequency noises and low-frequency trends, ship motion correction is applied to the wind velocity data. For the temperature signal, it is well calibrated and sound virtual temperature effects can be reduced later. After these correction procedures, 10-minute eddy fluxes and statistics are obtained in real-time and filed as well as row turbulence data.

Figure I.6.2.1: Turbulent devices installed on the ship.

Table I.6.2.1: Instruments installed on the *Kapitan Dranitsyn* for the NABOS 2005 cruise.

Instrument	*Location*
Weather station	At the top of the 5-m foremast
IR radiometer	On the bow under a angle 30° to a surface
Sonic anemometer USA-1	On the bow
LI-7500	On the bow
Web-camera	On the bow
Piranometer	On the bow
GPS	Antenna on front face of deck above bridge

For calculation of turbulent fluxes an eddy-covariance (or eddy-correlation) technique was used [*Edson et al*, 1998]. The technique of skin temperature calibration and calculation from microwave measurements is stated in *Cherny and Raizer* (1998).

I.6.2.3. Results

The meteorological measurements were carried out on all routes of the icebreaker from October 4 to 28. **Figure I.6.2.2** presents the time series of the meteorological parameters during the experiment. **Table I.6.2.2** contains the maximum, minimum, and the mean observations. **Figure I.6.2.3** presents the distribution of the wind direction during the experiment. All observations reduce to 10 meters in height. The real wind speed and direction were calculated by using the ship's navigation system.

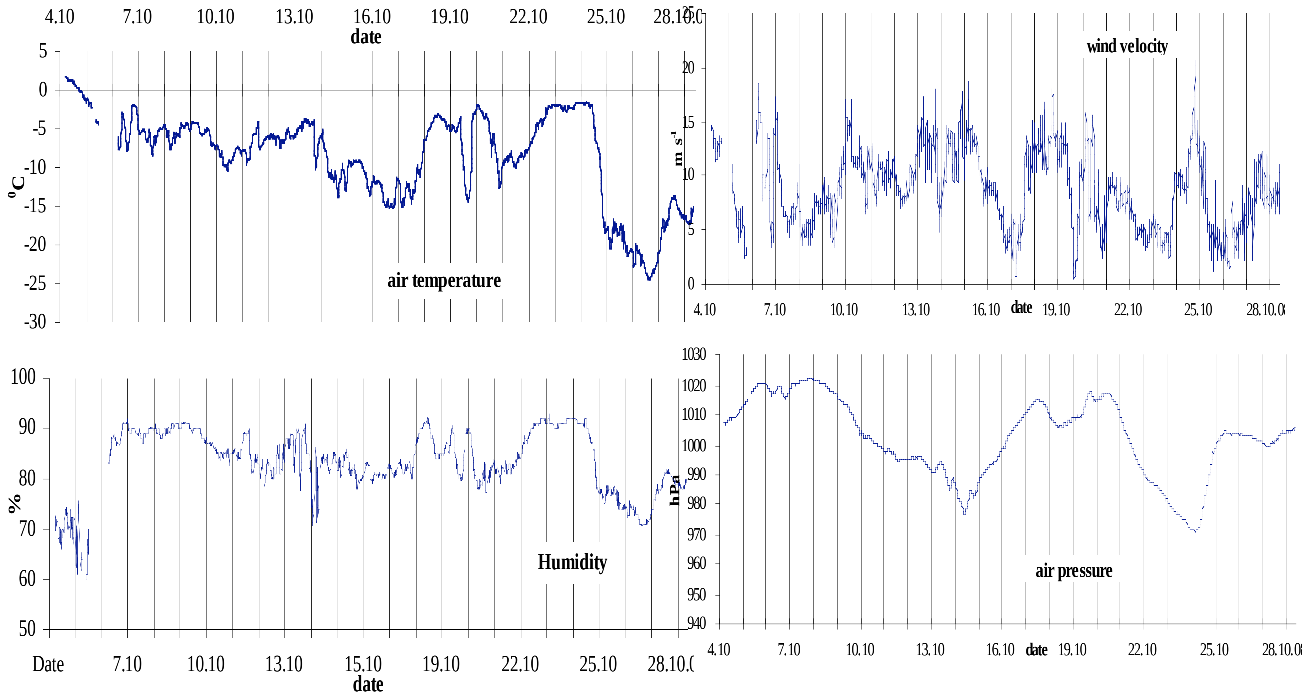


Figure I.6.2.2: Time series of the meteorological parameters during the experiment.

Table I.6.2.2: Maximum, minimum and mean values for the observed parameters

	Air temperature, ^0C	Relative humidity,	Air pressure, hPa	Download shortwave so radiation, W m^{-2}	Wind veloci m s^{-1}
Средн.	-8.6	83	1002.5	3	8.8
Мин.	-24.4	60	971.2		0.2
Макс.	1.6	93	1022,5	108	20.6

Figure I.6.2.3: The distribution of the wind direction during the experiment.

The onboard measurements were carried out along all segments of the icebreaker's track. Based on the measurements, the fluxes of sensible and latent heat, CO_2, momentum and surface roughness parameter were calculated. During the measurements, stable and unstable stratification was observed. Results of observations of energy budget components above different types of ice are presented in **Figure I.6.2.4**. The longwave radiation budget was calculated from meteorological and radiosonde data [*Ming-dan Chou, 1983*]. When the icebreaker was moving through ice, the air temperature was close to the ice surface temperature; where the ice cover was open, exposing sea water, an intensive energy exchange was observed. At the ice edge, with temperature of air -10-15°C, the icebreaker crossed a region with open water that also has resulted in a variety of turbulent fluxes. The positive heat fluxes (from the ocean to the atmosphere direction) were observed above leads and small ice-free zones, but negative fluxes were measured above the perennial ice. In **Figure I.6.2.5**, the distribution of sensible heat fluxes in the Laptev Sea is shown. The measurements carried out in 2004–2007 at the same time are added for comparison of energy exchange conditions. As compared with the past year's observations, we observed more variability and lower heat output in the Laptev Sea. This is due to the fact that observations in 2008 were done later, in October, in the presence of large ice volumes in the investigation area.

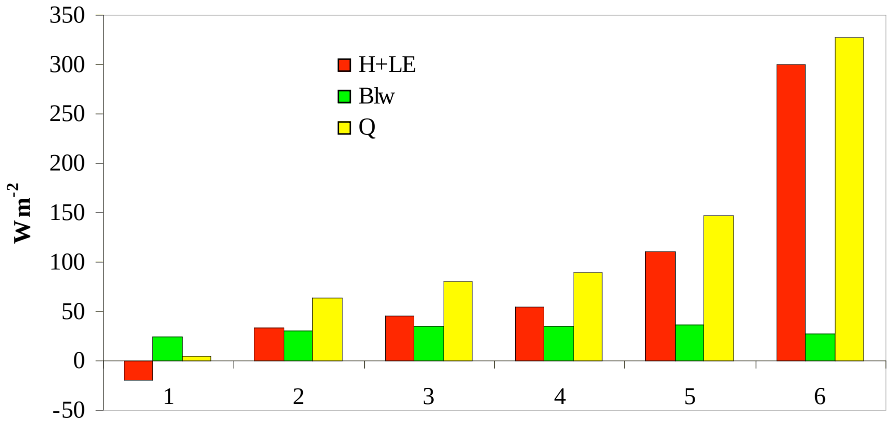


Figure I.6.2.4: The heat budget above different types of surface in winter period. 1) Perennial ice; 2) Edge zone (85% is old ice, 15% is young ice; 3) Young ice; 4) Edge zone (50% is old ice, 25% is young ice, 25% is open water); 5) Open water; 6) Open water with strong wind. Blw – long wave radiation budget calculated from atmospheric boundary layer profile. H and LE – sensible and latent heat fluxes from measurements; Q – heat balance.

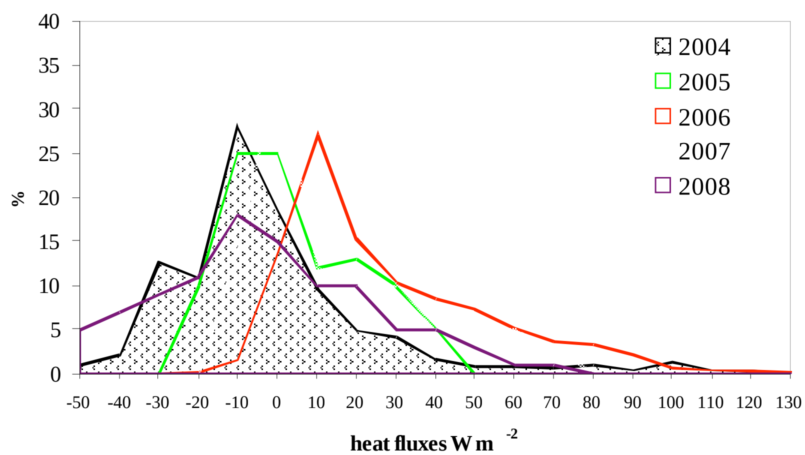
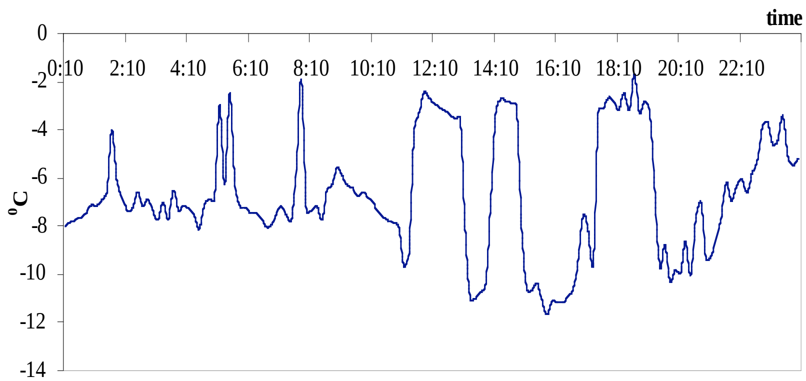


Figure I.6.2.5: Relative occurrence of the sensible heat fluxes (H) from the measurements taken over the Laptev Sea in different years.

Direct measurement of sea surface temperature in ice-covered areas is labor-consuming. The application of contact methods is not always possible, and in the case of inhomogeneous surfaces (e.g. a combination of ice floes and openings) leads to large errors. We attempted to restore the surface temperature using remote infrared radiometric measurements. In **Figure I.6.2.6,** temperature of ice surface measured over the different types of ice is shown. This figure shows that breaks in ice cover cause visible surface temperature variations.



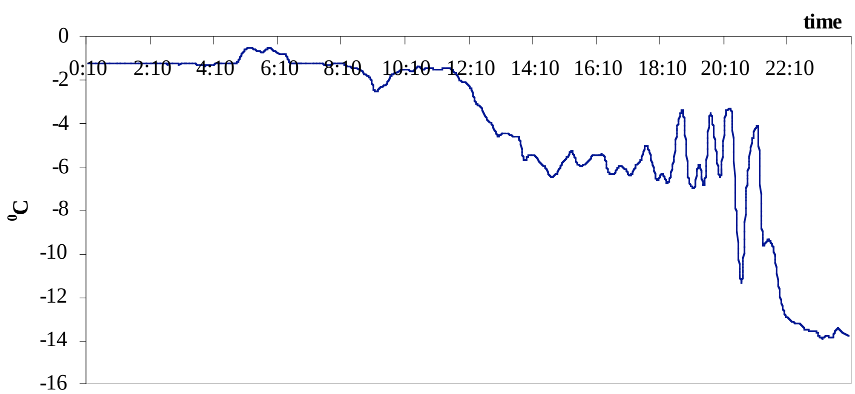


Figure I.6.2.6: The variations of the sea ice temperature. (Top) A combination of ice of different age and open water. (Bottom) Transition from open water to ice cover.

Measurements of CO_2 fluxes were carried out both along the route of the icebreaker and at oceanographic stations. In most parts of the Arctic Ocean, the ocean absorbed CO_2 from the atmosphere. The flux above ice is negative (from atmosphere to ice) and is close to 0.

I.6.3. OCEANOGRAPHIC OBSERVATIONS

(V.Ivanov, SAMS; S.Kirillov, AARI; I. Dmitrenko,IFM, I.Polyakov, IARC)

I.6.3.1. CTD measurements *(V.Ivanov)*

I.6.3.1.1. Methods *(S.Kirillov, AARI; V.Ivanov, SAMS*)

The locations of CTD/XCTD stations forming several cross-sections are shown in the **Figures I.3.2** and **I.3.3**. Total number of CTD and XCTD cast made during the NABOS 2008 cruise was 55 and 3, correspondingly. Location and time of sampling for the CTD and XCTD casts are listed in **Table I.6.1** and in the Appendix. All oceanographic stations were carried out at five cross-slope sections sequentially distributed along the Eurasian continental slope from the north-east of Svalbard to the East-Siberian shelf (**Figures I.3.2** and **I.3.3**).

Cross-section A crosses the Russian EEZ from the Laptev Sea continental slope margin to the Arctic Ocean interior. The northern part of this section (stations KD0108-KD0608) was carried out in the begining of the cruise, October 7–9. The southern stations (KD2708-KD3208) were sampled later, on October 18–19. The M1f mooring, deployed in 2007 near the position of VB0807 station, was not recovered this year because of heavy ice conditions. A new M1g mooring was deployed at almost the same position (station KD2708) to continue monitoring of the water column properties and dynamics at this site. Cross-section B (October 10–12, stations KD0708-KD1708) crosses the eastern Laptev Sea continental slope north of Novosibirskiye Islands. Unfortunately, the M8a and M3d moorings deployed at this section in 2007 (co-located with CTD stations VB1607 and VB2107) were not found at their locations and, we think, are lost. Section C (October 13-16, stations KD1808-KD2608) goes across the continental slope northeast of the Novosibirskiye Islands. Two moorings, M9a and M10a (co-located with the positions of CTD stations KD2108 and KD1808), were deployed at this section in 2007 and were successfully recovered in October 2008. Mooring M9b was reequipped and deployed at the same position. Cross-section D (October 21-22, stations KD3308-KD4208) crosses the northwestern Laptev Sea continental slope at traverse on Severnaya Zemlya Islands. Two moorings, M5b and M6a, were deployed there two years earlier in September 2006 and were successfully recovered in October 2008. OSL1a mooring (AWI) was deployed at the southernmost end of this transect in September 2005 and was found “alive” (i.e. “talking with our acoustic devices) in 2008. Unfortunately, the problem with acoustic releases did not allow us to recover this mooring before, in 2007. The attempt to drag this mooring using the cable-loop in October 2008 also failed. Cross-section E (October 26-27, stations KD4408-KD5408) crosses the continental slope northeast of Svalbard. One more section was carried out across the eastern slope of St. Anna (northern Kara Sea, not shown) by using XBT and XCTD probes on October 23. All NABOS-08 CTD casts were limited to the upper 1000m or bottom depth. Water sampling was carried out using five-liter Niskin bottles at most stations. Sampling depth levels are shown in Appendix.

I.6.3.1.2 Equipment *(P.Keen)*

Continuous CTD profiles were made using a SEACAT Profiler SBE19plus. This system continuously measures conductivity, temperature, and pressure at 0.20m intervals (assuming the 4Hz sample rate and the rate of deceasing ~80 cm/s) in the vertical. The Seacat is calibrated annually. The technical description of sensors, according to the specifications of Sea-Bird Electronics, Inc., is presented in **Table I.6.3.1**. The full information can be downloaded from http://www.seabird.com/products/spec_sheets/19plusdata.htm.

Table I.6.3.1: SEACAT Profiler SBE19plus technical information.

Sensors	Range	Accuracy	Typical stability (per month)	Resolution
Conductivity (S/m)	0-9	0.0005	0.0003	0.00005 (most oceanic waters) 0.00007 (high salinity waters) 0.00001 (fresh waters)
Temperature (°C)	-5 to +35	0.005	0.0002	0.0001
Pressure	3500 m	0.1% of full scale range	0.004% of full scale range	0.002% of full scale range
Oxygen	120% of Surface Saturation	2% Sat	2%	
Fluorometer				

Several vertical temperature and salinity profiles were carried out by the XCTD profiling systems manufactured by Lockheed Martin Co. The technical descriptions of XCTD sensors, according to the specifications of Lockheed Martin Co., are presented in **Tables I.6.3.2** and **I.6.3.3.**

Table I.6.3.2: Lockheed Martin Sippican XCTD technical information.

Sensors	Range	Accuracy	Response time	Resolution
Conductivity (mS/cm)	0-70	0.03	40 ms	0.017
Temperature (°C)	-2 to +35	0.02	100 ms	0.01
Pressure	1000 m	2%	-	17 cm

Table I.6.3.3: Lockheed Martin Sippican XBT technical information.

Sensors	Range	Accuracy	Resolution
Temperature (°C)	-2 to +35	0.1	0.01
Pressure	760 m	2%	65 cm

I.6.3.1.3 Preliminary results *(V.Ivanov, SAMS; S.Kirillov, AARI*)

Vertical distribution of temperature and salinity along cross-sections A-E is shown in **Figure I.6.3.1** and **Figure I.6.3.2**. The vertical thermohaline structure at every cast has common arctic features that consist of a low salinity surface mixed layer, halocline, and intermediate warm salty Atlantic waters. The properties within layers differ from station to station and between sequential sections. The mixed layer extends from the surface down to 15–25m at each station. Surface water salinity tends to decrease from west to east and from north to south. For instance, surface salinity in section D slightly increased from 32.12 to 33.40 toward the north. At the section A, B and C, surface salinity ranges respectively from 31.41, 31.10 and 26.76 up to 33.03, 32.32 and 28.51 at the northern sites. In most cases, the temperatures in the surface mixed layer are close to the freezing point at given salinity. This cooling is mainly attributed to the low air temperatures and ice-freezing due to the late cruise.

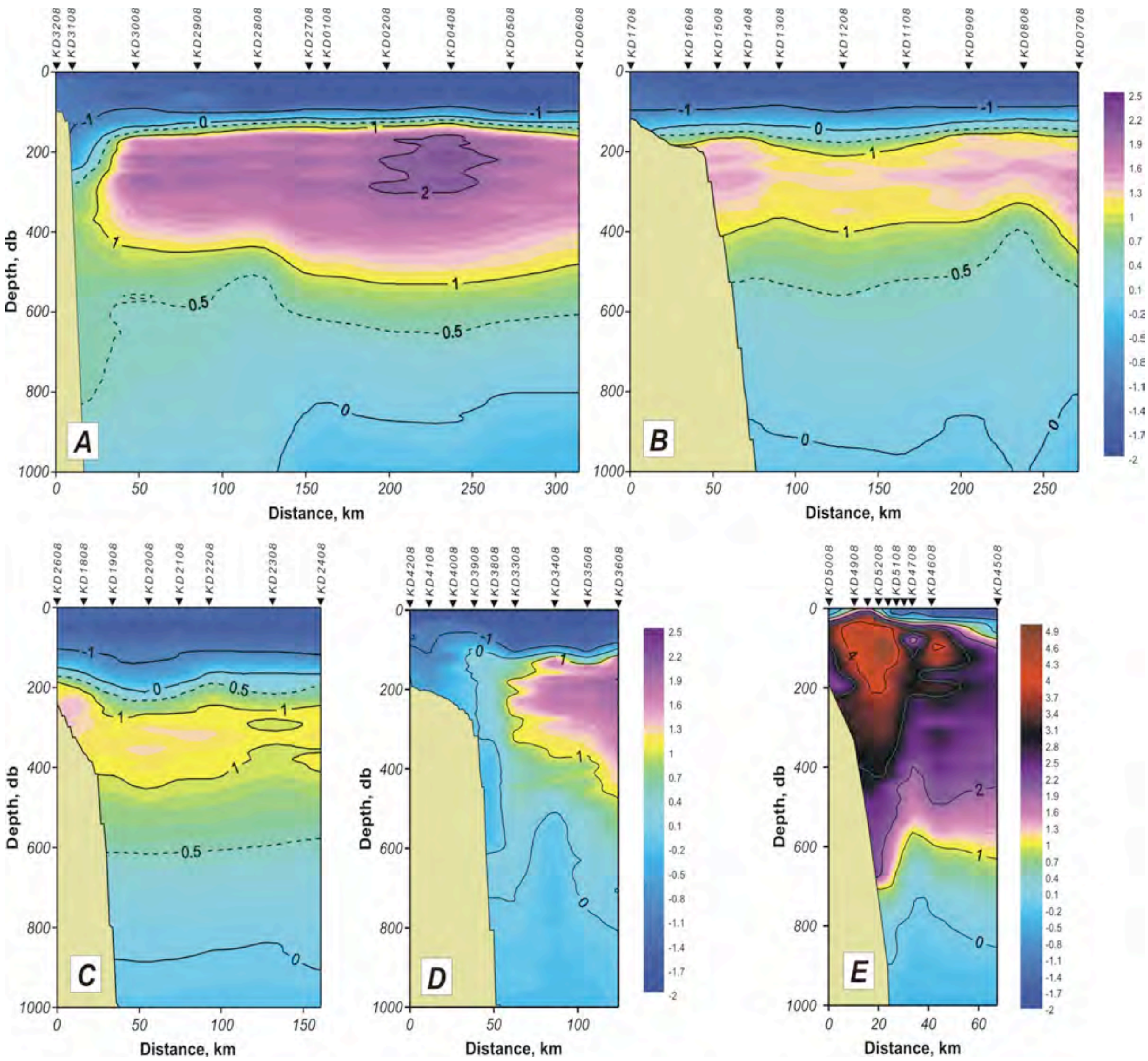


Figure I.6.3.1: Vertical distribution of water temperature (°C) at the cross-slope sections A-E.

AW spreading eastward as a boundary current loses heat and salt. It results in a continuous decrease of water temperatures and salinities within the AW intermediate layer. For example, at the E section the maximum temperatures were 4.1–4.9°C. The temperatures in AW layer decrease to 1.75-2.25°C at section A, 1.25-1.60°C at section B and 1.05-1.40°C at section C. The maximum core temperatures were found at station KD5108 (section E, 4.90°C), KD0408 (section A, 2.25°C), KD0708 and KD1408 (section B, 1.61°C) and KD3608 (section C, 1.40°C). The heavy ice conditions limited our ability to reach the AW core at the section D. The maximum temperature 2.01°C at this transect was recorded at the station KD3608. However, an earlier oceanographic expedition onboard Russian RV *Akademik Fedorov* (September 2008) bounded the AW core north of Severnaya Zemlya Islands and registered core temperature 2.41°C roughly 100km north of section D. The heat escape from AW leads to denser water formation and AW core deepening. The depths of the AW core maximum temperature decrease from ~100m at E section to ~200m north of Severnaya Zemlya (data from *Akademic Fedorov*). Almost the same depth of AW core was observed at Section A, and further eastward it continued deepening to ~260m (at B section) and ~240m (at C section). The lower AW boundary (traditionally sited at the level of 0°°C isotherm) locates at the depths 800-900m with some spatial variations.

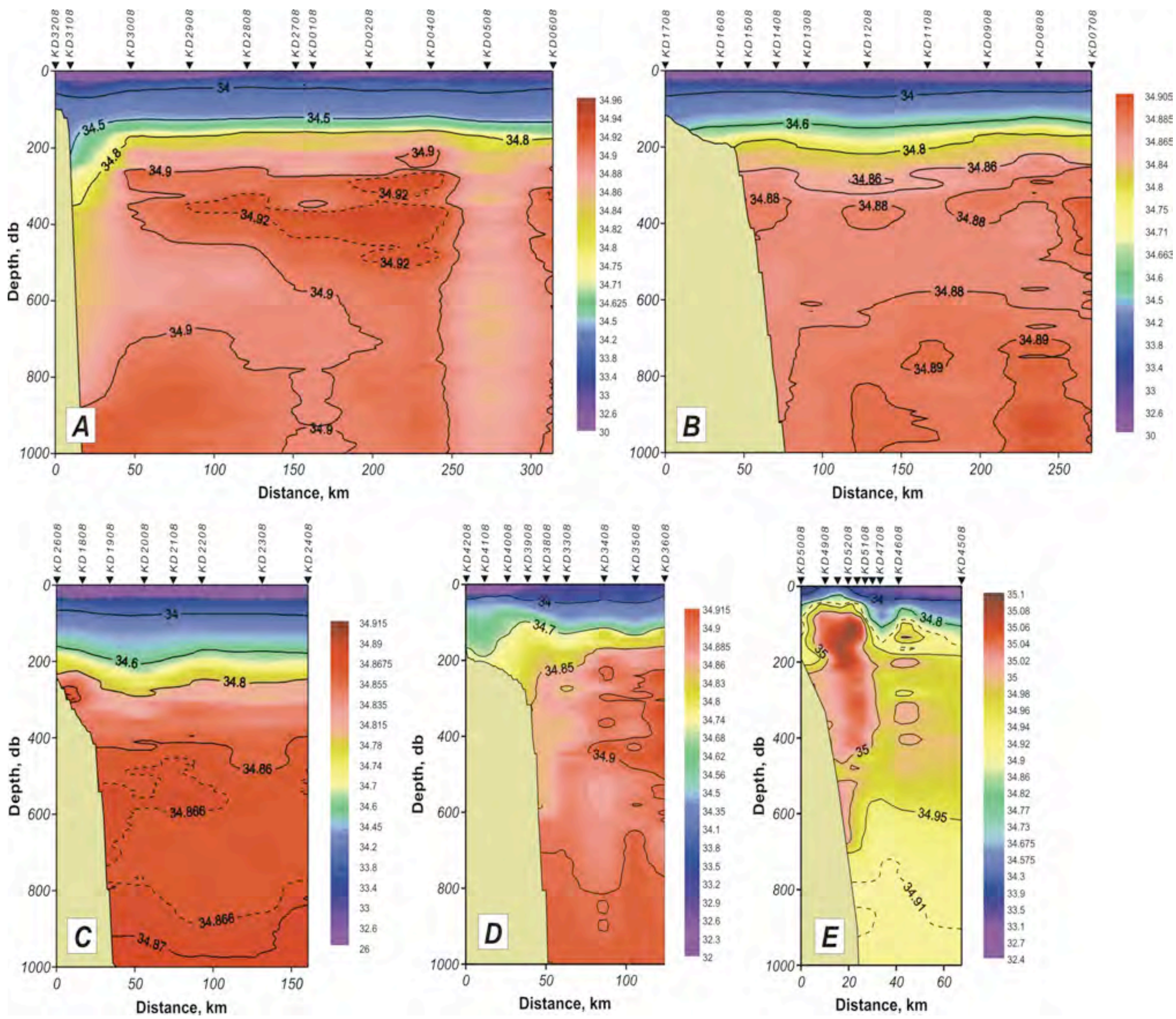


Figure I.6.3.2: Vertical distribution of water salinity at the cross-slope sections A-E (KD0508 XCTD station at section A results in artificial "chimney" structure due to the stable negative bias of XCTD conductivity sensor).

Both temperatures and salinities at Section B provide clear evidence of AW flow split after passing Section A. Two cores were observed: the first core is located at the continental slope and the second one is shifted 200–250km northward. This fact provides evidence of AW splitting and forming the circulation cell which may be attributed to the large-scale features of bottom topography. Water salinity steadily increases from the surface and AW layer. At every section, the salinity maximum is ~150-200m deeper than the temperature maximum is observed (except of E section where temperature and salinity maxima are close each to other).

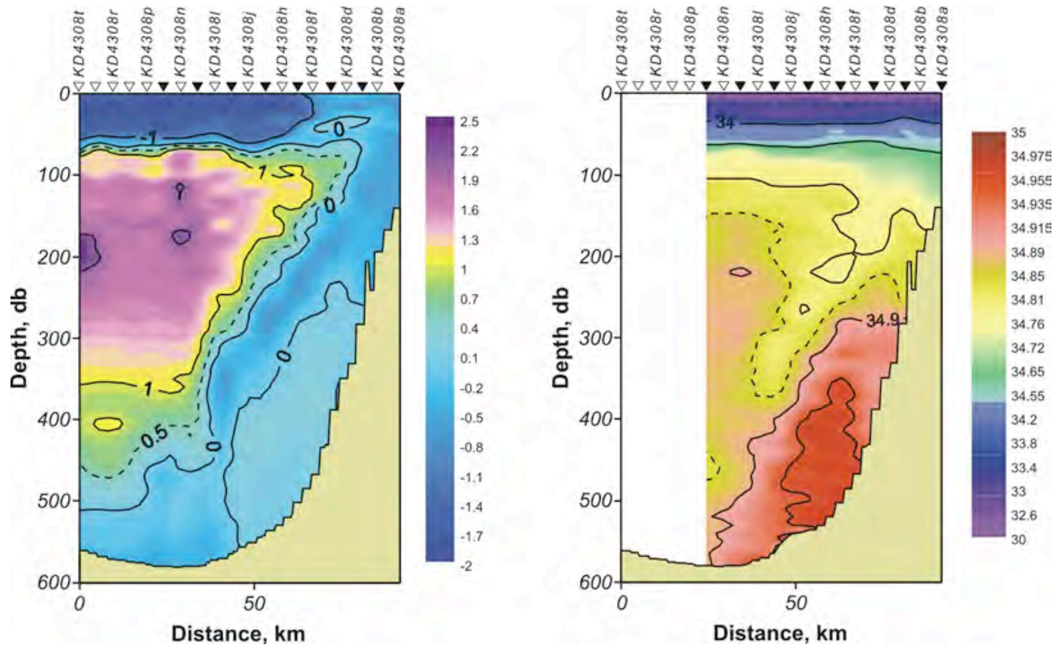


Figure I.6.3.3: Vertical distribution of water temperature (°C) and salinity at the section across St. Anna Trough in the northern Kara Sea. Black triangles indicate the position of XCTD profiles and white triangles are XBT casts.

Section made across the St. Anna Trough in the northern Kara Sea clearly demonstrates the invasion of a saltier (~34.97) and warm (0.2-0.3°°C) tongue of the Barents Sea branch of AW near the bottom at the depth of ~250-550m (**Figure I.6.3.3**). Warmer and fresher waters from the Fram Strait branch of AW enter St. Anna Trough at the intermediate depths from the deep Arctic Basin. The maximum measured temperature of 2.59°°C was found at station KD4308t at the level of 204m.

Table I.6.3.4: Changes of the AW core maximum temperature at different sections since 2002

Year	2002	2003	2004	2005	2006	2007	2008
AW core maximal temperature, °C							
Section D	-	-	-	2.04	2.52	-	2.41[*]
Section A	1.42	1.33[**]	1.78	1.79	1.96	2.10	2.25
Section B	-	1.10	1.42	1.51	1.99	1.86	1.61
Section C	-	-	-	-	-	1.44	1.40

[*] data from “Akademic Fedorov”
[**] the AW core is unresolved spatially

The long-term monitoring of AW core temperatures in September-October has revealed the abrupt changes in the AW thermal state that come from the pulse-like warm signal propagating from the North Atlantic. This signal led to a steadily increase of AW core temperatures up to 2006–2007 (**Table I.6.3.4**). The oceanographic survey in 2008 demonstrated a modest decrease at most of the sections. The section A is the only one where maximal temperature was 0.15°C higher than in 2007.

I.6.3.2. Moorings observations *(I. Polyakov, IARC*)

I.6.3.2.1. Introduction *(P. Keen)*

The overall purpose of these mooring observations was to provide observationally based information on temporal variability of water circulation and water mass transformation on the Eurasian continental slope. The major objectives were to quantify the structure and temporal variability of the main water masses over the Eurasian continental slope and to obtain detailed information about AW layer dynamics and seasonal variations. A summary of NABOS moorings is presented in **Table I.6.3.5**.

Table I.6.3.5: Summary of the status of moorings in the NABOS 2008

Mooring No.	*Deployment/ Recovery*	*Lat./ Long*	*Depth*	*Instruments*	*Status 30 October 2008*
M1 (F)	Recover	78° 29.588'N 125° 49.092'E	2730m	2 x SBE37 1 x MMP	Remains on deployment
M1 (G)	Deploy	78° 25.735'N 125° 28.527'E	2692m	7 x SBE37 3 x ADCP 1 x BPR	Deployed
M8 (A)	Recover	80° 47.030'N 138° 47.258'E	2048m	1 x SBE37 1 x MMP 1 x ADCP	Lost, no response
M3 (D)	Recover	79° 56.109'N 142° 19.317'E	1350m	1 x SBE37 2 x RCM9 6 x Sed. Trap	Lost, no response
M10 (A)	Recover	79° 45.380'N 159° 20.267'E	1464m	1 x SBE37 1 x ADCP 2 x RCM11 2 x Sed. Trap	Recovered
M10 (B)	Deploy	N/A	N/A	N/A	Not Deployed
M9 (A)	Recover	80° 20.932' N 161° 15.757' E	2690m	1 x SBE37 1 x ADCP 1 x MMP	Recovered
M9 (B)	Deploy	80° 23.215' N 161° 34.080' E	2718m	7 x SBE37 3 x ADCP 1 x RCM11 2 x Sed. Trap	Deployed
M6 (A)	Recover	80° 44.928'N 103° 29.987'E	2461m	2 x SBE37 1 x MMP	Recovered
M5	Recover	81° 00.67' N 105° 17.43' E	1545m	1 x SBE37 1 x ADCP 1 x MMP	Recovered
AWI	Recover	80° 21.890'N 101° 26.034'E	180m	1 x SBE37 1 x ADCP	Remains on Deployment
M7 (A)	Recover	81° 39.640'N 031° 11.101'E	2461m	1 x SBE37 1 x MMP	Remains on Deployment
M7 (B)	Deploy	N/A	N/A	N/A	Not Deployed
M4 (B)	Recover	81 33.669'N 030 51.327'E		5 x SBE37 3 x RCM9	Recovered
M4 (C)	Deploy	N/A	N/A	N/A	Not Deployed

I.6.3.2.2. Mooring design and equipment *(P.Keen and I. Polyakov)*
Mooring design and oceanographic equipment are presented in **Figure I.6.3.4**. The modified avalanche beacons were removed from the mooring design at the beginning of the 2005 field season because they would be needed only for a through-ice recovery, for which we are not equipped, and because this equipment sometimes became entangled during deployments and recoveries. The McLane Moored Profiler (MMP) (**Figure I.6.3.5** designed and manufactured by McLane Research Laboratories, Inc. is the main component of NABOS moorings. Technical information and a description are available at http://www.mclanelabs.com. Because of low reliability of MMPs we decided to use conventional moorings for climate research, thus avoiding gaps in records which may be caused (and were caused) by malfunctioning of the MMPs. MMP-equipped moorings are still planned to be used for process-oriented studies.

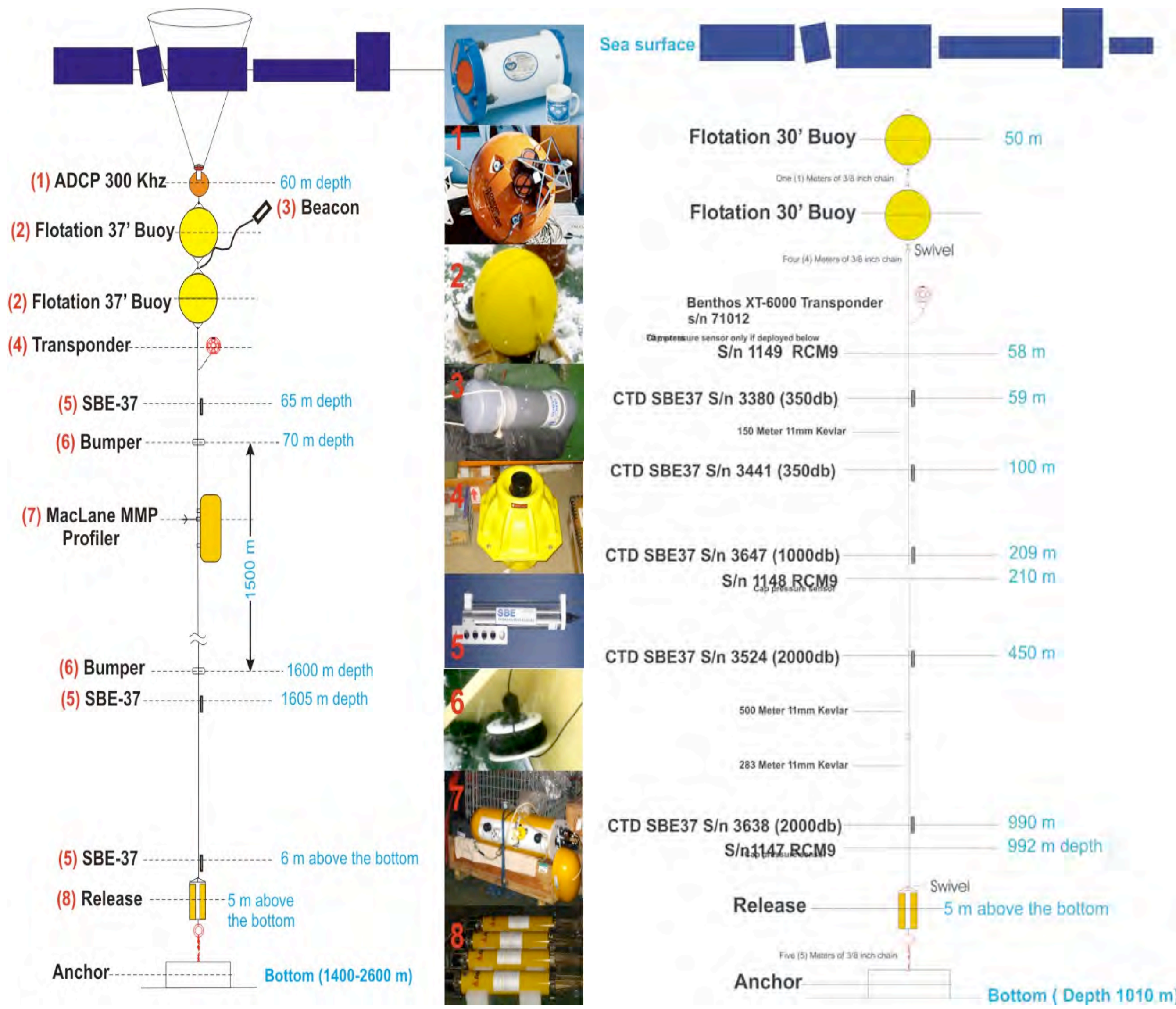


Figure I.6.3.4. Basic design and equipment of NABOS MMP-based (left) and conventional (right) moorings.

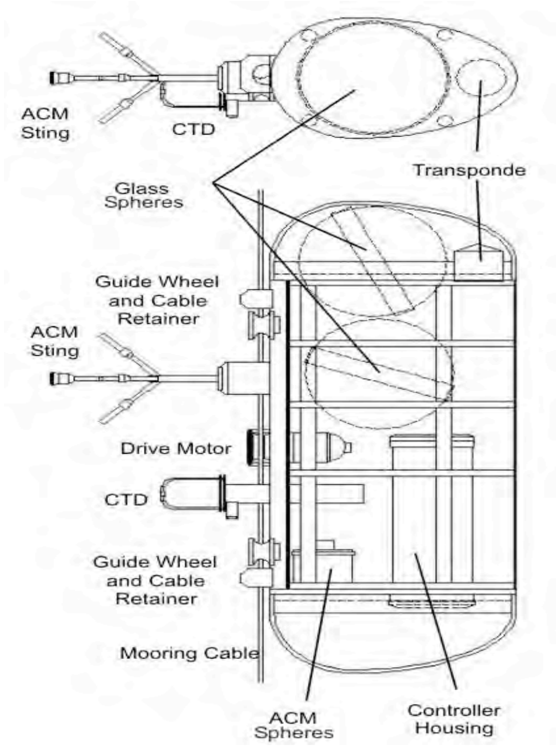


Figure I.6.3.5: Sketch of McLane Moored Profiler© of McLane Research Laboratories, Inc.

Our conventional moorings consist of ADCPs, Seabird SBE37 Microcat CTDs and a Seabird SBE53 Bottom pressure recorder (BPR). The BPR was first deployed at M1g moorings and set upon a wooden subframe or "caddy" and attached to the paired release assembly with dissolving links and stainless steel cable, tensioned with stainless steel turnbuckles (**Figure I.6.3.6**). This was designed so that the BPR would fall away from the release pack and lie on the seafloor approximately 48–72 hours after deployment. The BPR is attached above the release assembly to the remainder of the mooring by a 10mm rope sufficient in length to easily reach the seabed.

Figure I.6.3.6: Image showing SBE 53 BPR in position on dual release unit supported by a disposable wooden caddy.

I.6.3.2.3. Mooring deployments *(P.Keen)*

M1g mooring deployment, October 18, 2008. The mooring M1g consists of 3xADCP, 7xSeabird SBE37 Microcat CTDs and a Seabird SBE53 Bottom pressure recorder (BPR). With the exception of the removal of 10m 18mm KAPA floating line and a Nokalon float, the rig was deployed as originally planned. Final instrument depths and set up parameters are summarized in **Table I.6.3.6** and **Figure I.6.3.7**.

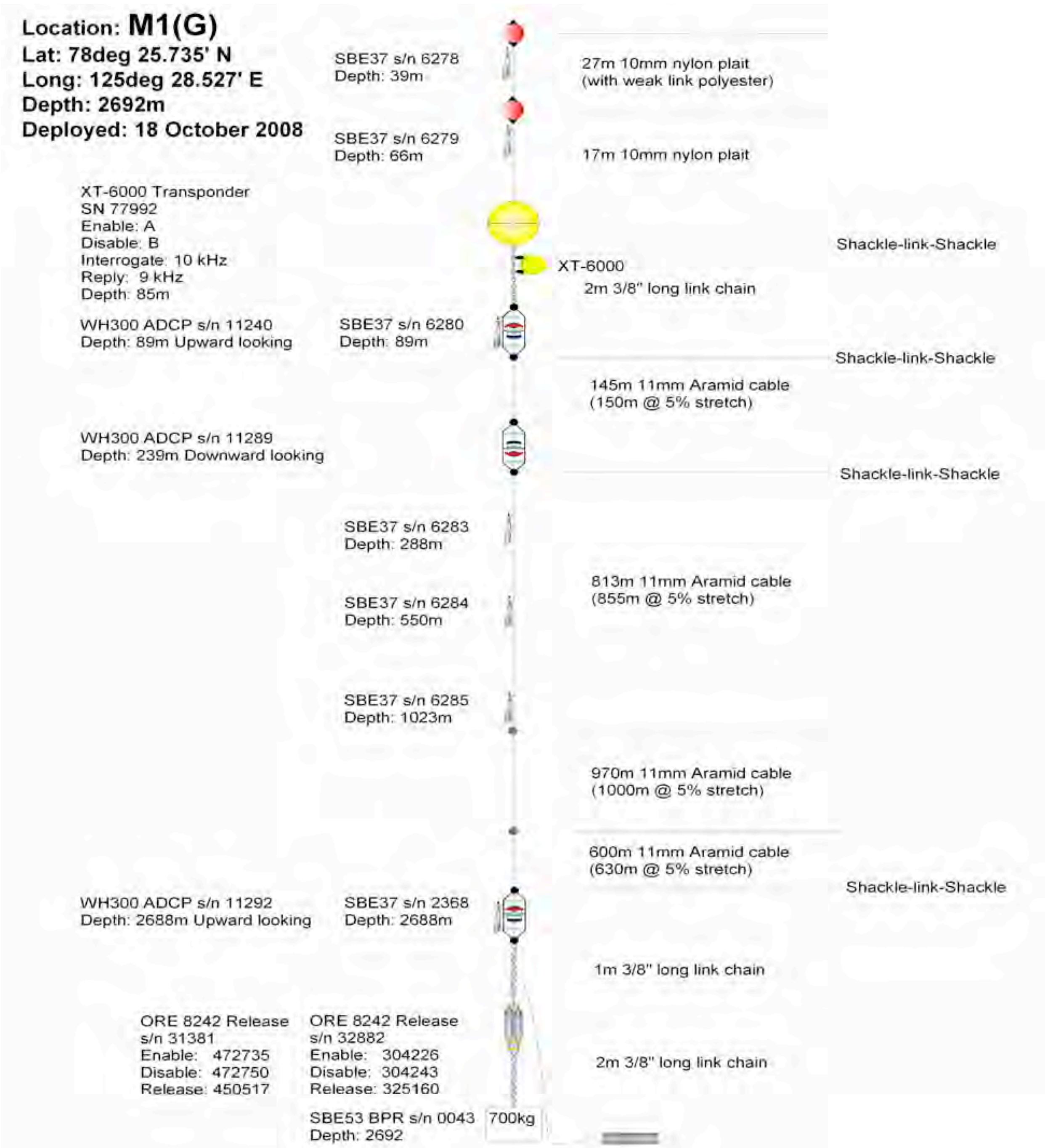


Figure I.6.3.7: NABOS-08 M1g mooring design and equipment.

Table I.6.3.6: Mooring M1g as deployed

Instrument	Serial #	Target H	Deployed H	Sampling Regime	Deployment setup file
SBE 37	6278	16	39	900 sec	SBE37_6278.cap
SBE 37	6279	43	66	900 sec	SBE37_6279.cap
XT-6000	74402	71	85	Not applicable	
SBE 37	6280	75	89	900 sec	SBE37_6280.cap
WH300 ADCP	11240	75	89	27 x 4m bins, 1 hr sampling int. 10 pings/ensemble, 5 pings/hr BT	WH11420BT.txt
WH300 ADCP	11289	220	239	27 x 4m bins, 1 hr sampling int. 50 pings/ensemble	WH11289.txt
SBE 37	6283	275	288	900 sec	SBE37_6283.cap
SBE 37	6284	550	550	900 sec	SBE37_6284.cap
SBE 37	6285	1000	1023	900 sec	SBE37_6285.cap
SBE 37	2368	2659	2688	900 sec	SBE37_2368.cap
WH300 ADCP	11292	2659	2688	27 x 4m bins, 1 hr sampling int. 50 pings/ensemble	WH11292.txt
SBE 53 BPR	0043	2663	2692	30 minutes	0043.cap
8242 RELEASE	31381	2660	2690	Rel: 450517; En: 472735; Dis: 472750	
8242 RELEASE	32882	2660	2690	Rel: 325160; En: 304226; Dis: 304243	

Table I.6.3.7: Mooring M9b as deployed

Instrument	Serial Number	Target depth	Deployed depth	Sampling Regime		Deployment setup file
SBE37	6275	13	16	900 sec		6275.cap
SBE37	6276	40	43	900 sec		6276.cap
XT-6000	71012	71	74	Int: 10 kHz, Reply: 12 kHz, Enable: A, Disable: B		
SBE37	6277	75	78	900 sec		6277.cap
WH300 ADCP	11243	75	78	Upward looking, 27 x 4m bins, 1 hr sampling int., 10 pings/ensemble; 5 pings/hr BT		WH11243BT.txt
Sediment Trap	024	275	278	Cup	Collection days	
				1	82	
				2	90	
				3	61	
				4	30	
				5	31	
				6	61	
				7	92	
				8	90	
				9	61	
				10	30	
				11	31	
				12	31	
RCM11	287	277	280			
WH300 ADCP	11290	280	283	Downward looking 27x4m bins, 1hr sampling int., 50 pings/ensemble		WH12290.txt
SBE37	4281	300	303	900 sec		4281.cap
SBE37	2308	550	553	900 sec		2308.cap
Sediment Trap	184	1000	1000	Same as above		
SBE37	4976	1000	1003	900 sec		4976.cap
WH300 ADCP	11291	2712	2715	Upward looking, 27 x 4m bins; 50 pings/ensemble		WH11291.txt
SBE37	1604	2712	2715	900 sec		1604.cap

8242 RELEASE	31368	2713	2716	Rel: 450236; En: 472165; Dis: 472207	
8242 RELEASE	31370	2713	2716	Rel: 450270; En: 472262; Dis: 472313	

M9b mooring deployment, October 15, 2008. The M9b mooring differed from the original plan. Originally it was planned to conduct two deployments close to this location, one consisting of SMB37 microcat CTDs and 300khz Workhorse ADCPs for UAF and the second composed of RCM11 and Sediment traps for ArcticNet at Laval University. Following discussion between Laval University mooring technician Sylvain Blondeau and Chief mooring technician Peter Keen, a new plan was devised to combine these into one mooring. A design analysis was run and sent to Ian Waddington for checking. These changes were subsequently approved by Igor Polyakov, NABOS Program Leader. Through the use of extra floatation available on board and substituting instruments where necessary, the new design addressed all aspects of the formerly separate moorings to achieve the scientific objectives with a single deployment. Final instrument depths and set up parameters are summarized in **Table I.6.3.5** (above) and **Figure I.6.3.8**.

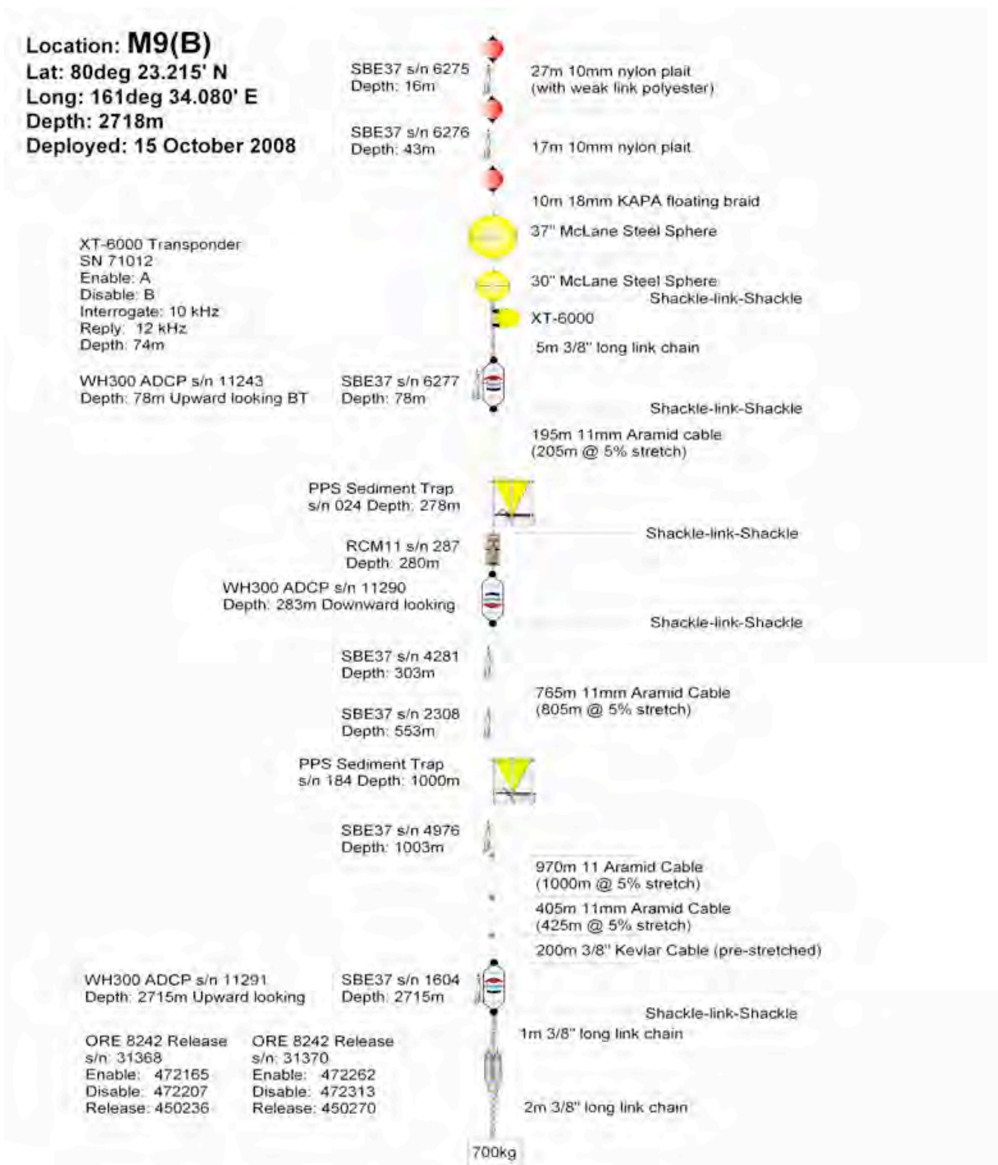


Figure I.6.3.8: NABOS-08 M9b mooring design and equipment.

I.6.3.2.4. Mooring recovery *(P.Keen)*

M1f mooring recovery. There were two attempts to recover the M1f mooring. The first attempt was made on October 8, 2008. A 1000m radius perimeter was defined and three points taken on this for triangulation positions. The vessel was requested to proceed to these positions where a range was taken to the acoustic transponder of the release units using an appropriate deck unit. These three ranges were then used to establish the mooring position after which the vessel was instructed to make a clearing in the ice cover in a position based on this position and in conjunction with observations of the ice-sheet drift.A marginally suitable opening in the ice was created at which point a release command was sent to one of the release pair (#32054). A lookout was kept for around 30 minutes during which there was no sign of the mooring on the surface. It seems that the release had for some reason jammed. It was decided to abandon this mooring for a later attempt on the return leg of the trip as light was fading, and to attempt a release would have left insufficient time to locate a surfaced mooring before dark. The second recovery attempt for M1f occurred 10 days later on the return from the eastern section of the cruise in the East Siberian Sea. However, the ice conditions did not favor a recovery. An attempt was made to clear the ice, but light failed during the clearance operation and the recovery operation was abandoned.

M8a mooring recovery. M8a was the second mooring recovery attempted on October 11, 2008. At the mooring location, ice cover was close to 100%. Three coordinates were defined on a 1000m radius from the nominal mooring position and passed to the bridge for triangulating the mooring position. At the first position (80°47.380′N 138°49.789′E) there was no response to the Edgetech or Benthos deck units. The vessel moved closer, to a range of 500m, and at the new position (80°47.226′N 138°49.419′E) there was also no response. The vessel was requested to move closer to the original deployment position, and at 80°47.078′N and 138°47.599′E no response was received, and the recovery attempt of M8a was abandoned.

M3d mooring recovery. This unsuccessful attempt was made on October 12, 2008. Again a 1km radius perimeter was defined and three points chosen that would give adequate triangulation of the mooring. First ranging on M3 releases was conducted, but there was no response of these interrogations. A command was given for the vessel to approach to 1000m from the previously surveyed position of mooring and a second enable/ranging attempt was made with no response on either set of frequencies or releases. The Benthos deck unit was moved to the bow in an attempt to get a quieter environment to communicate from. There was no response from this position either. One last attempt was made at this position using the Edgetech deck unit because of its greater power output, but still there was no response. It was decided to move vessel 90° around a circle with radius 1000m centered on the mooring and try again, but the result was the same. Ways to make the vessel quieter were discussed (such as shutting down engines or other machinery) but none of these options were considered possible at the time by bridge personnel. The best available technique was to continue operating with the Benthos deck unit on the bow, as far from the engines as possible. The decision was made to move to the mooring position and range from directly above. There was no response to interrogation from either the Benthos deck unit or the Edgetech. Another decision was made to clear ice over the assumed position of the mooring and send release commands anyway in case the releases were capable of responding even if they could not be heard. Release commands were sent with the Benthos unit. There was no response and there were no sightings. The vessel waited for 15–20 minutes, but since there was no sign of the mooring on the surface, it was decided to steam around and break up some of the larger ice floes in case the mooring has surfaced under these. The result was negative, and after these attempts the recovery attempts were abandoned.

M9a mooring recovery was successfully fulfilled on October 16, 2008. Ice conditions were relatively light; the ice was thin with large patches of open water. The wind was steady at around 1.6kts from the northwest and the ice drift appeared well entrained with this. A kilometer perimeter was defined around the mooring position and three points communicated to the bridge as triangulation positions. Once the triangulation position information was passed to the bridge, they began moving to the position. A command was sent and the mooring was released from the anchor. A grapnel was thrown and hooked the float, at which point the vessel proceeded forward as the buoy was led to the stern on its tether where the top floats were recovered individually. The chain under the floatation was accessed and stopped off. The mooring was recovered on to the Lebus winch.

M10a mooring was recovered on October 14, 2008. The vessel began clearing ice. A backwards clearance technique involving holding the wind on the port side of the ship and turning to port while going astern, which allowed the bow to sweep an arc of clear water as the wind carried the vessel sideways to starboard, was adopted. Because any gap subsequently opened then closed extremely fast, the portable deck unit was positioned near the bow, obviating the need to use prop-wash at the stern to clear ice before deploying the transducer, which all takes time. This allowed for a much faster response to the presence of clear water directly above the mooring when sending release codes under these circumstances. Release codes were sent and the buoy was sighted off the starboard bow. The vessel maneuvered to grapple the buoy. The top floats were grappled and recovery commenced.

M6a mooring recovery. The M6a was a Damocles/IOPAS MMP mooring. On arrival, sea ice was observed to be very compacted with multiple pressure ridges. It closed around the vessel's path almost immediately after the ship passed. Ranges were taken for triangulation and the ship maneuvered for ice clearance. Ice conditions made it very difficult to prepare an adequate hole. As the mooring passed approximately 60 meters off starboard aft of the vessel, the ship was moved forward and began a sweep back, release codes were sent as the mooring position exited from under the port bow. The vessel moved forward and back in to rubble of the last pass; the bridge GPS gave the mooring position as 130m off the port side, amidships. Eventually, the top floated to the surface about 20m off the port side amidships. The vessel maneuvered to position for recovery, and the bosun grappled the top-float and attached the line to the crane hook.

M5b mooring recovery occurred on October 22, 2008. Ranging confirmed that the mooring was healthy. The vessel maneuvered to clear ice. Ice was fairly new and thin with a few older thick patches. The vessel created a space down drift, so a good amount of open water became available. Release commands were sent and the top float was sighted surfacing in clear water 30m off the port bow. The mooring team prepared to receive the top floats in the normal position on the port side, aft poop deck. A grapnel eventually hooked the vinyl float, and the top flotation then was lifted by the crane and stopped off underneath to the poop deck railing.

M7a mooring recovery was attempted on October 27, 2008. Triangulation showed that the mooring was alive. However, the results of this triangulation were inconclusive and, while the work put in eventually reduced the margin of error to around 200m, by the time the triangulation was completed light was gone and a recovery that day was no longer an option. Ice conditions were difficult, and the vessel had spent a long time making any headway. The chief scientist decided to abandon recovery at the end of triangulation and concentrate efforts on M4 for recovery and deployment.

M4b mooring recovery. There were two attempts to recover the M4b mooring. The first onen on October 27, 2008, began with a triangulation of the mooring position. A 1km circle was defined around the position and three triangulation points were selected and passed to the bridge. Ice at the mooring location was very thick and hard with pressure ridges extremely difficult to negotiate. The sky was overcast and dull. By this stage, light was failing and the chief scientist decided that recovery was not an option at this time. The next day, using the triangulated position from the day before, the ship was placed in position about 2km down drift of the mooring position, to the south-southwest. Large patches of open water and thin ice sheet were evident. The vessel made preparatory maneuvers and waited for open water. A large patch opened on the starboard side and was right in the spot for the triangulated position. The decision was made to fire the release, and top floats were sighted port aft about 80m. Success!!

I.6.3.2.5. Summary *(P.Keen)*

The cruise objectives originally set for the mooring team were the deployment of four moorings, two for UAF and two for ArcticNet at Laval University, on transects towards the eastern limits of the cruise track, and the recovery of seven moorings located throughout the operational area on behalf of ArcticNet at Laval University, IOPAS, and UAF. At the end of the first leg, the operational tally stood at three out of the four deployments successfully deployed and four of the seven recoveries successfully recovered. In one case, M9, the equivalent of two moorings were deployed in the one deployment. Additionally two moorings north of Svalbard were added to the cruise profile at a late stage after ice conditions frustrated an earlier cruise tasked with their recovery and redeployment. Of these moorings, one was successfully recovered, while ice conditions and time constraints prevented the recovery of the second and the redeployment of both. Of the five moorings not recovered two, M3 and M8, could not be communicated with by any means available on board and must be considered lost. However, I refer the reader to comments made earlier in this report that suggest they may not be completely beyond hope. M8 and M3 both used paired Benthos release units that respond to frequencies, not coded signals. At the time of the recovery attempts a high level of ship noise was noted and this raising of the acoustic noise floor may have had a hand in the inability to communicate with the release units. Consequently it would be premature to consider these moorings beyond recovery and they may well respond in more favourable acoustic conditions.The other unrecovered moorings were all responding to telemetry and while it may not have been possible to recover them, they indicated a good state of “health” and in more favorable conditions should be easily recoverable on future expeditions. Accurate positions have been established for all of these moorings. In summary, three deployments out of five intended and five recoveries out of ten intended were accomplished.

The 2008 NABOS cruise was originally intended for the northern summer in August 2008. The eventual departure at the beginning of October meant that much heavier concentrations of ice than originally planned for were present throughout the area of operations. The I/B *Kapitan Dranitsyn* is a mighty vessel capable of providing access to areas of ice-covered ocean that lesser ships would have no hope of reaching under such conditions. This vessel is designed for breaking through heavy ice, creating paths for ice convoys, and supplying remote locations icebound over winter. Its master and crew are very proficient in these tasks and were willing to work extremely hard on the more delicate tasks required by scientific operations to achieve favorable outcomes for the expedition. The vessel, however, is not specifically designed for oceanographic research and as such presents quite specific drawbacks from a scientific perspective. Particular among these is the large superstructure that it presents to the wind, causing difficulty in handling at low speed, an aspect particularly apparent when approaching what are, by comparison to the vessel, extremely delicate moorings on the surface during their recovery. Moreover, the vessel is not equipped with any auxiliary propulsion systems such as bow or azimuth thrusters, making position keeping virtually impossible during operations where keeping station would be a distinct advantage. The inability of the vessel to maintain station, coupled with the near continuous ice cover encountered throughout the expedition (and the vagaries of its drift), frustrated two of the mooring deployment attempts that in other respects were proceeding smoothly. Mooring operations consequently presented a challenge for the vessel and crew, far removed from their normal mode of operations.The learning curve for how to get the best out of the vessel in the conditions encountered was extremely steep for both the technical personnel and the ship’s crew. All mooring operations were conducted in English, as this was the language most commonly spoken by members of the mooring team. It has to be noted that at times this language barrier presented problems due to information being lost in translation when describing complex maneuvering requirements or when a rapid response was needed. In the final analysis, the commitment and persistence demonstrated by all concerned prevailed to bring most operations to a successful conclusion under sometimes trying circumstances.

I.6.3.2.6. Preliminary Results *(V.Ivanov, SAMS; I. Polyakov, IARC; S.Kirillov, AARI; J. Piechura, IOPAS; L. Fortier, LU*)

Mooring M4b (φ=81^{o}33.685N, λ=30^{o}51.127E, H=1030m)

This mooring was deployed in 2006 and spent two years in the water. It included five SBE37 microcats deployed at 66, 106, 217, 460 and 1020m and three RCM9 deployed at 65, 218 and 1021m. One of the major outcomes of the two-year-long CTD records from SBE37 microcats and one-year-long current RCM records from M4b mooring is confirmation of a strong seasonal signal which was detected earlier at the same position from M4a mooring deployed in 2004–06 [*Ivanov et al*., 2009]. This fact indicates high robustness of processes at this location and provides solid justification for the use of this site for long-term monitoring purposes.

Current direction derived from all three RCMs deployed at 65, 218 and 1021m was remarkably stable throughout the entire two-year period of deployment. Both zonal and meridional current components remained positive and highly correlated, indicating steady northeastern, predominantly barotropic transport and low eddy activity (**Figure I.6.3.9**). Mean current speed was relatively high (>10 cm/s) compared with measurements in the Arctic Ocean interior and was comparable with current speed measured in Fram Strait.

Similar to data from the 2004–06 deployment, there were short (few weeks duration) winter episodes, when current speed increased by several times, reaching about 50 cm/s at the uppermost level. These episodes were accompanied by substantial (more than 100m) deepening of instruments.

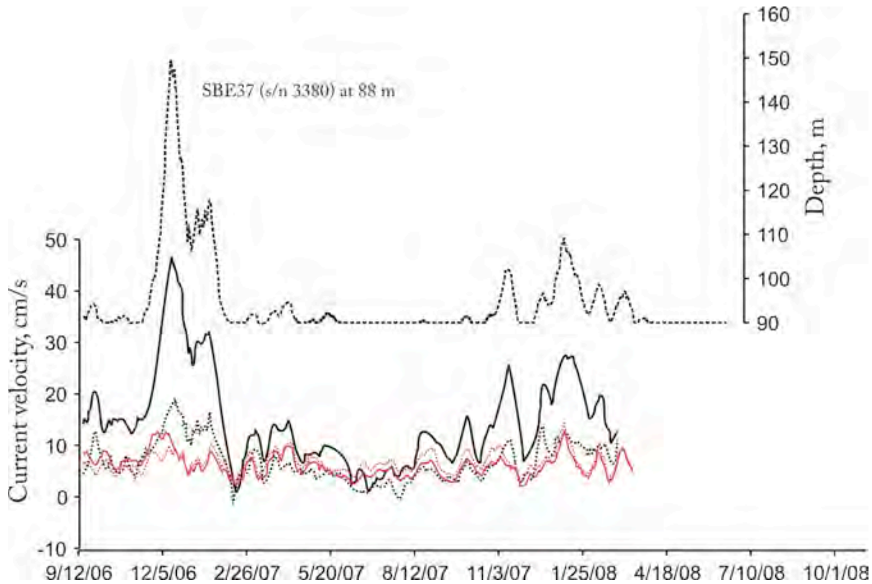


Figure I.6.3.9: The depth of the shallowest CTD and evolution of the current velocities at 87m (RCM9 #1149, black lines) and at 1053m (RCM9 #1147, red lines). Solid lines indicate the east-west component and dotted lines correspond to the north-south component of the currents.

A strong and persistent seasonal cycle in water temperature was observed at all five measurement levels (**Figure I.6.3.10**). Preliminary analysis shows that phase and amplitude of the seasonal cycle do not substantially change from year to year (see *Ivanov et al.* [2009]). Salinity records are more noisy and contaminated with erroneous data (**Figure I.6.3.11**). Specific attention has to be paid to salinity records from deeper levels (495 and 1052m), which were discarded for 2004–06 records as erroneous. During 2006–08 deployment similar features were found in the salinity records at these two depths, indicating that they may be not erroneous, but their nature should be thoroughly examined.

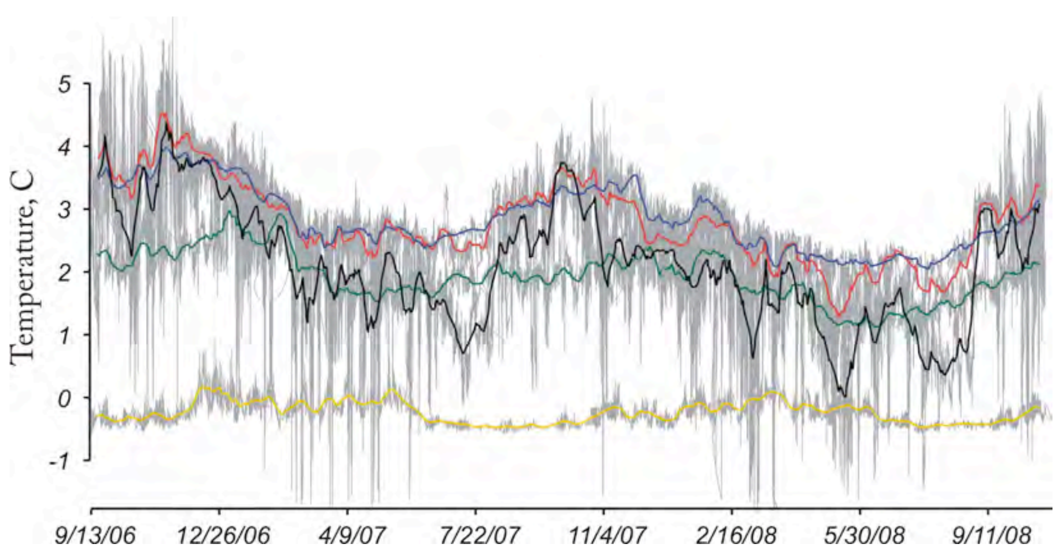


Figure I.6.3.10: Two-year-long records of water temperatures and their 10-days moving averages at 88m (black), 131 m (red), 236 m (blue), 495 m (green) and 1052 m (yellow) depths at M4a mooring.

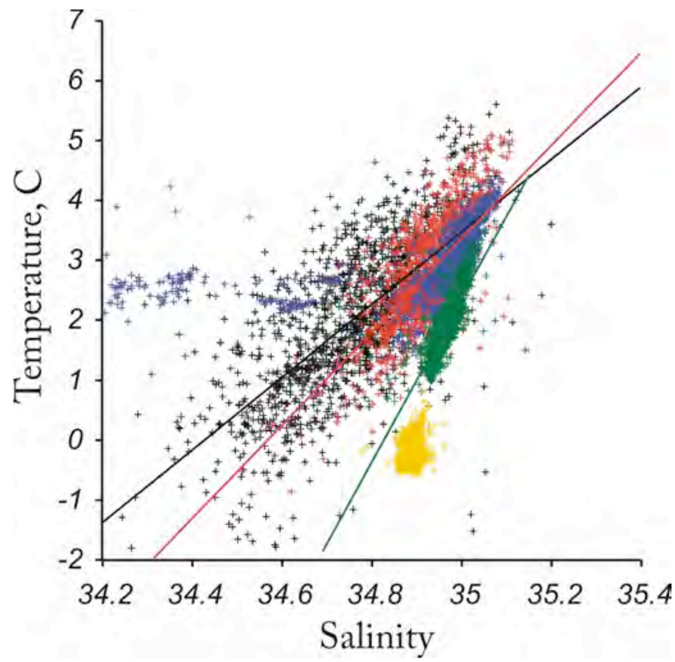


Figure I.6.3.11: Scatter plot of TS-properties at 88m (black), 131m (red), 236m (blue), 495m (green) and 1052m (yellow) depths at M4a mooring.

The combined four-year temperature record from the M4 mooring (**Figure I.6.3.11a**) clearly shows that the temperature reached its maximum in the fall of 2006. Starting from this point, temperature decreased, reaching the level of fall 2004 by the end of the record (i.e. almost 1°C drop). This is consistent with the temperature decrease identified by NABOS snapshot CTD sections carried out along 30°E.

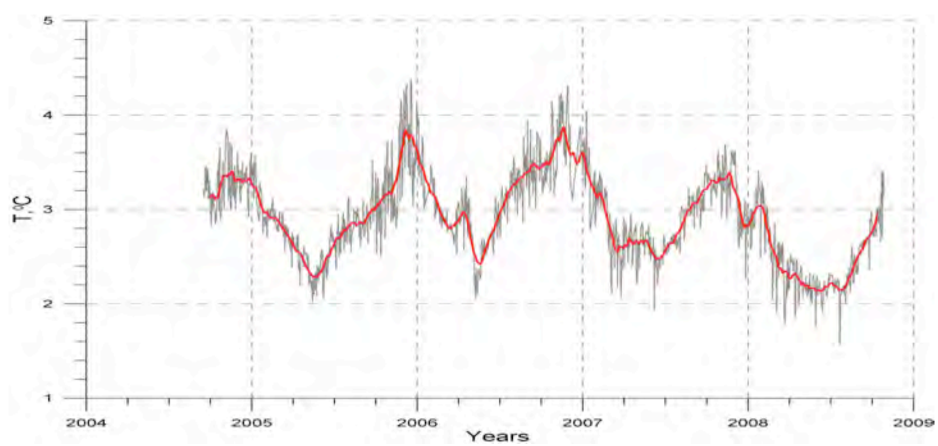


Figure I.6.3.12: Four-year-long temperature record from the M4 mooring at ~225m. A cooling trend is evident during the last two years of the record.

Mooring M5b (φ=81°00.64N, λ=105°17.44E, H=2400m)

This mooring was deployed in 2006 and spent two years in the water. It included one MMP profiler, one SBE37 microcat deployed at 141m, and one upward looking ADCP deployed at 143m.The MMP profiler performed full casts for the entire year since it was deployed in September 2006. Temperature and salinity recorded during this year are presented in **Figure I.6.3.13.** AW (~2°C in the core) occupied the 100–800m depth range, indicating that the warming event that started in February 2003 is still in progress. The salinity distribution in the 500–800m layer shows a burst of water with relatively low salinity between September 17 and October 7.

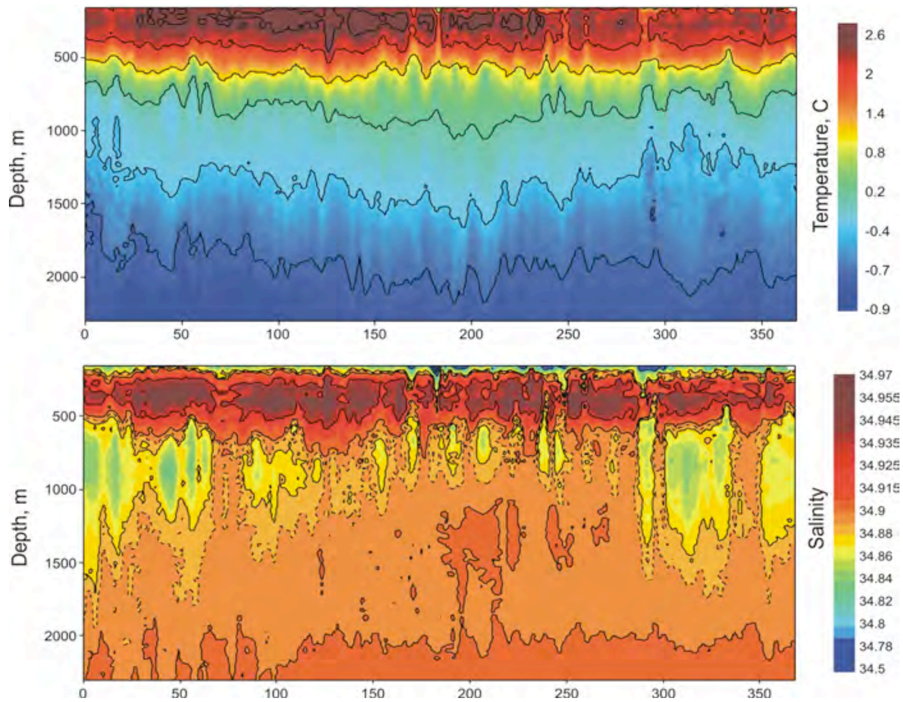


Figure I.6.3.13: Water temperature (top) and salinity (bottom) from the M5b MMP records.

During this time interval, the AW temperature was also lower than either before or after. Comparison of this record with the cross-slope salinity distribution shown in section A (**Figure I.6.3.2**) suggests that the instrument recorded a meander of the Barents Sea AW inflow, which is distinguished from the Fram Strait branch of the AW by lower salinity. Stronger currents measured in the deep water layers between September 15 and September 30 (not shown) are consistent with this possible explanation. Scatter plot of current velocities (**Figure I.6.3.14**) and some standard statistical estimates of two orthogonal current components (**Table I.6.3.8**) demonstrate rather low intensity of currents at the M5 mooring position. Mean current direction is southeastern (as expected, following bathimetry with shallow-to-right direction) and mean velocity is ~2cm/s.

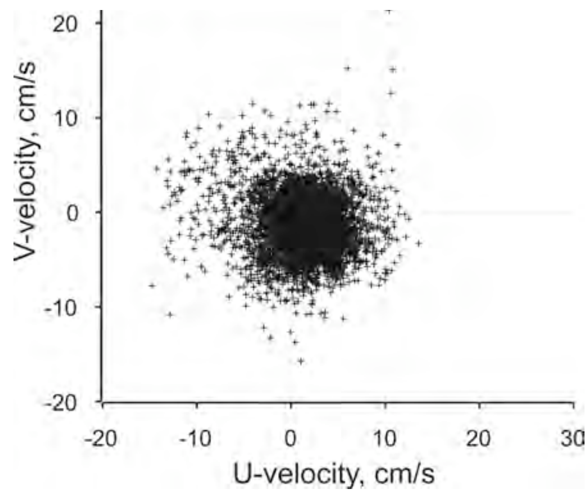


Figure I.6.3.14: Scatter-plot of MMP current velocity records at M5b mooring.

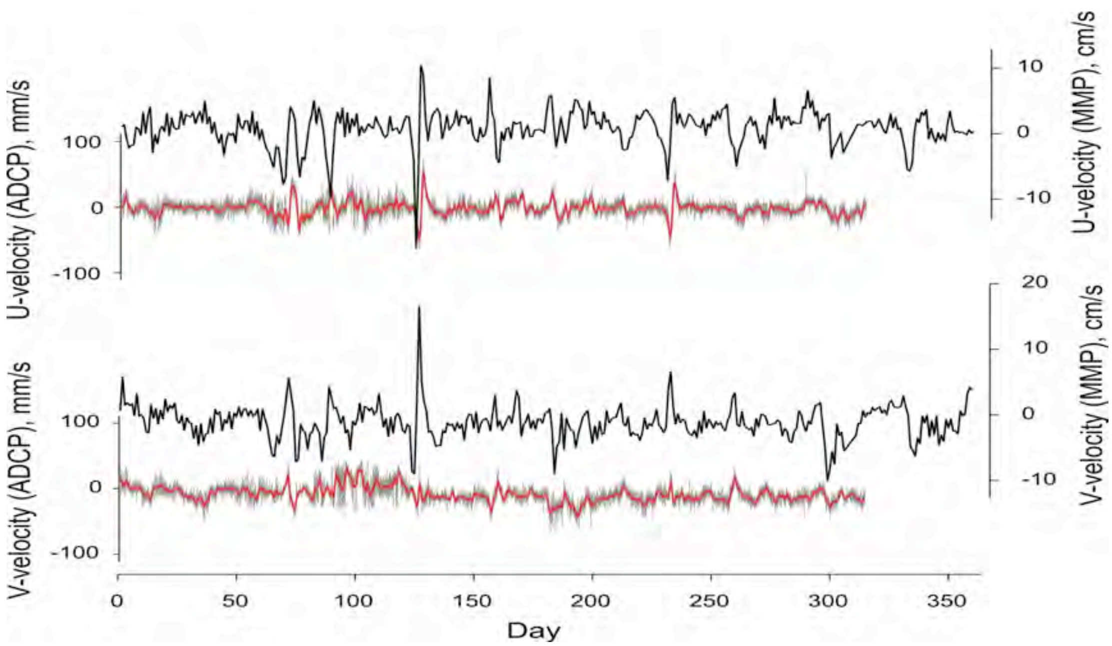


Figure I.6.3.15: Current components derived from MMP (160m, black) and ADCP (146m, red) records, M5b mooring. One-day running averages are shown in solid lines.

Table I.6.3.8: Means and standard deviations of MMP current velocity records at M5b mooring

Level, m	160	300	400	600	1000	1500	2100
U, cm/s	0.8	1.1	-1.3	1.3	1.7	1.4	1.3
U standard deviation, cm/s	2.7	3.0	3.3	3.2	3.8	2.1	2.3
V, cm/s	-1.1	-1.2	-1.2	-1.4	-1.3	-1.3	-0.5

V standard deviation, cm/s	2.6	3.0	3.1	2.7	3.2	1.8	2.3

The two-year temperature record in the upper part of the AW layer (152m, **Figure I.6.3.16**) has a signature of seasonal signal with temperature maximum in winter and temperature minimum in summer. This is consistent with the MMP record in the AW core, shown in **Figure I.6.3.13**. Extremely cold events, when temperature dropped down to almost the freezing point, may indicate cold intrusions of shelf waters as modeling suggests (e.g. [*Ivanov and Golovin*, 2007]). In 2008 temperature and salinity were changing coherently in phase, probably demonstrating seasonal cycle advected from upstream locations (**Figure I.6.3.16**).

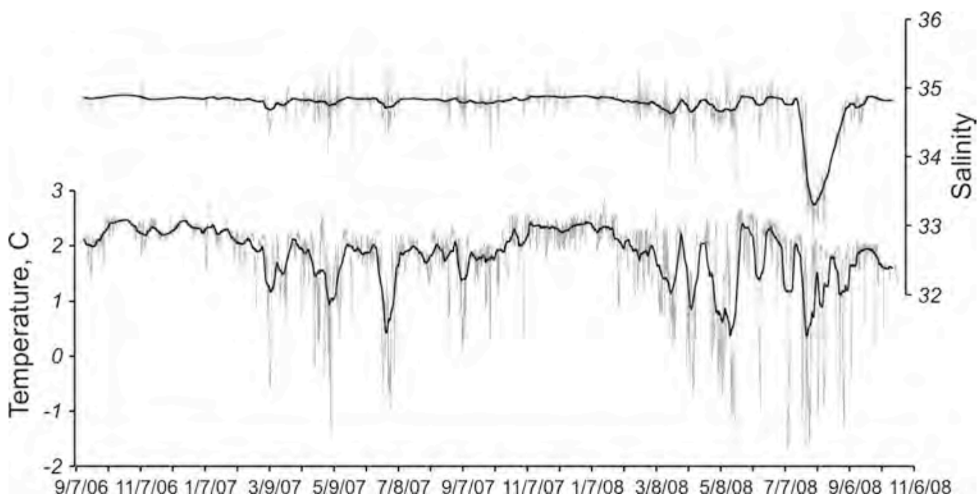


Figure I.6.3.16: The hourly temperature and salinity CTD records at 152 m of M5b mooring. Black solid lines indicate 10-days running average.

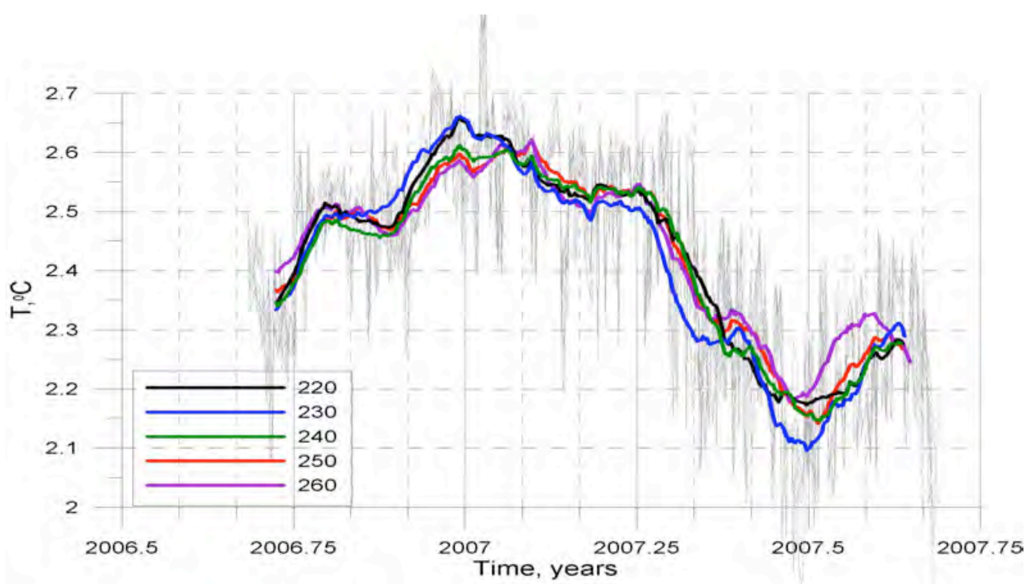


Figure I.6.3.17: Temperature distribution in the AW warm core (220-260m) at M5b mooring. Color lines show 1-month running average.

One-year-long MMP temperature records from the M5b mooring demonstrate a well-defined seasonal cycle with maximum in January and minimum in July. The range of these seasonal oscillations is about 0.5°C (estimated by 1-month running average curves, **Figure I.6.3.17**). Because the position of the M5 mooring is shifted off the warm core of AW toward the shelf, this gives comparable amplitude of seasonal cycle at this position compared with what was observed at upstream and downstream positions at moorings M4 and M1 (see #5 NABOS report).

Mooring M6a (φ=80°44.94N, λ=103°29.91E, H=1545m)

The M4b mooring was deployed in 2006 and spent two years in the water. It included one MMP profiler and two SBE37 microcats deployed at 92 and 1543m. Temperature, salinity, and depth records from the upper microcat are shown in **Figure I.6.3.18**. One of the most intriguing details of these records is the existence of bursts of warm water, particularly in winter, when the only source of warming at this level may be AW heat. This indicates that at this location, AW heat may penetrate stable halocline and reach the upper ocean layer with potential impact on ice. The rapid drop of temperature and salinity shown by records from the bottom instrument (**Figure I.6.3.19**) is probably caused by occasional intrusion of different water masses, probably the densest fraction of the Barents Sea branch of AW spilling through St.Anna Trough.

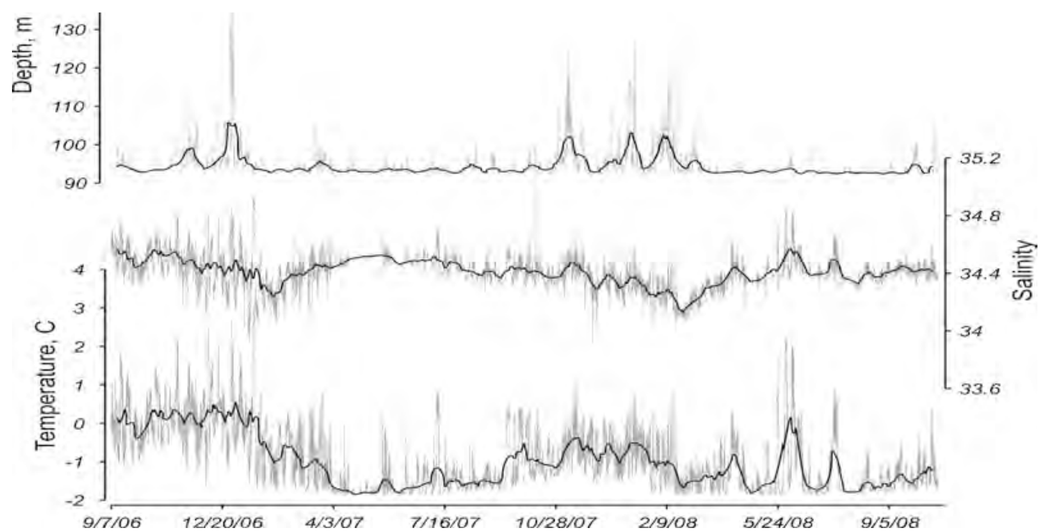


Figure I.6.3.18: Depth (top), salinity (middle) and temperature (bottom) derived from 15-min records from CTD at M6a mooring. 10-day running averages are shown in black solid lines.

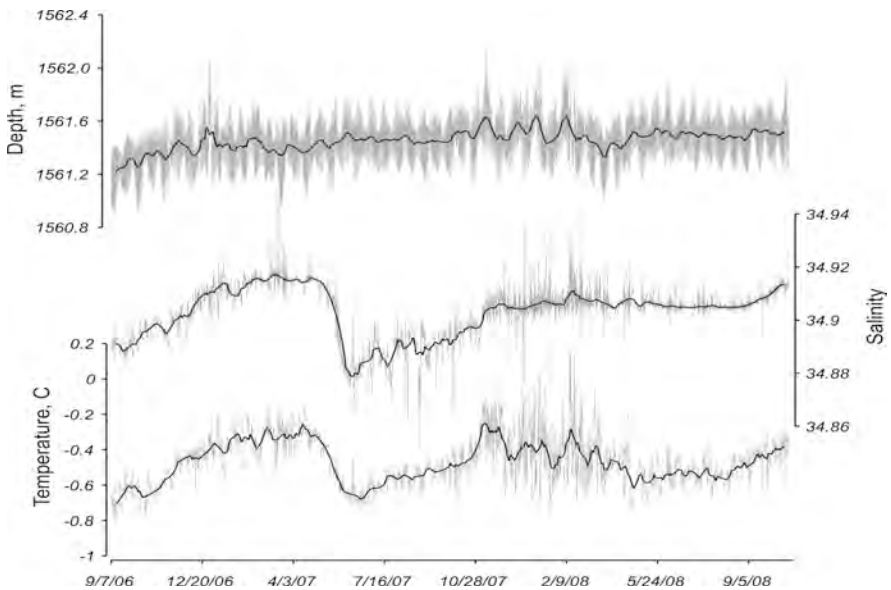


Figure I.6.3.19: Depth (top), salinity (middle) and temperature (bottom) derived from 15-min records from CTD at M6a mooring. 10-day running averages are shown in black solid lines.

Unfortunately, the MMP profiler did not work properly; it was stuck at 880m depth level right after deployment. The reason for this behavior is failure of the motor moving the instrument up and down along the line. Temperature and salinity records at 880m show a very well-pronounced seasonal cycle. The phase of this seasonal cycle is close to what was captured by one-year-long records from the neighboring M5 mooring at the same depth with winter (December–February) temperature/salinity maximum and summer (July–September) minimum. A positive trend in temperature and salinity of about 0.4ºC and 0.03 PSU is observed between the two maximums.

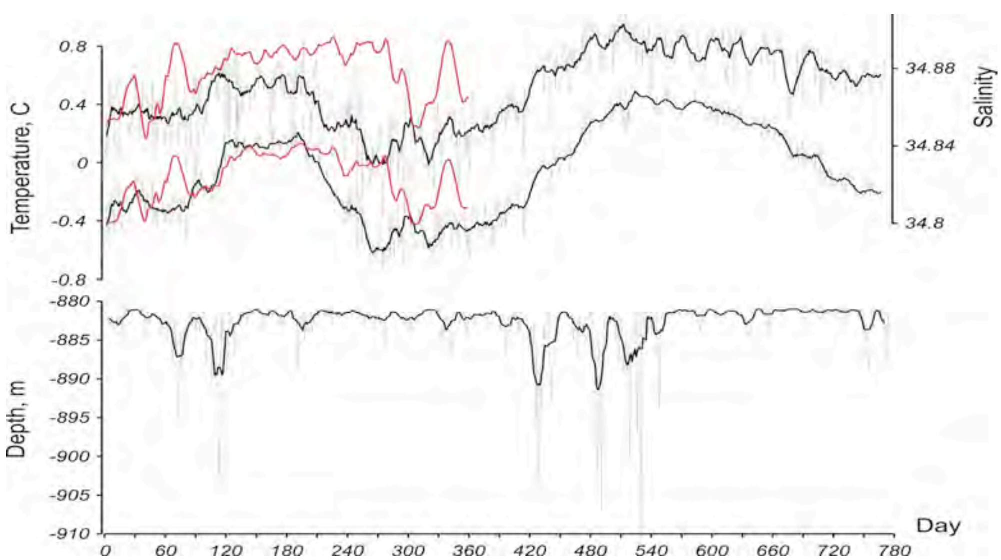


Figure I.6.3.20: Temperatures, salinities, and depths derived from daily MMP records at M6a mooring. 10-day running averages are shown in black solid lines. Red solid lines show the 10-day averaging of temperature and salinity at 880m from M5b MMP for comparison.

Current records from the M6a mooring (**Figures I.6.3.21** and **I.6.3.22**) show currents about twice as strong compared with currents at the M5 mooring location. This possibly indicates that the core of the major transport and the warm core of AW stay apart in this region. The largest transport is located close to the slope, while the warm core is shifted as far offshore as the isobath 3000–3500m (AARI data from *Akademik Fedorov* cruise in 2007). This fact may provide a reasonable explanation of why the propagation speed of temperature anomalies in the AW (including seasonal harmonic) strongly decelerate somewhere at the Nansen Basin slope.

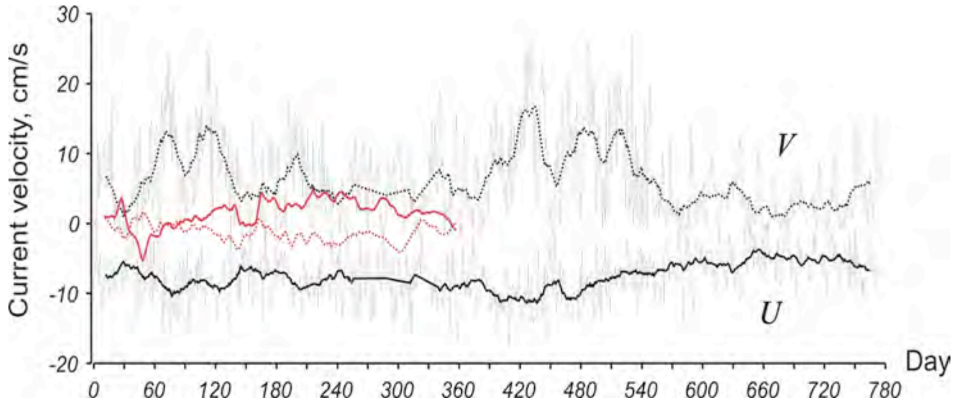


Figure I.6.3.21: Current components derived from daily MMP records, M6a mooring. 10-day running averages are shown in black solid (U) and dotted (V) lines. Red solid lines show the 10-day averaging of U and V at 880 m from M5b MMP for comparison.

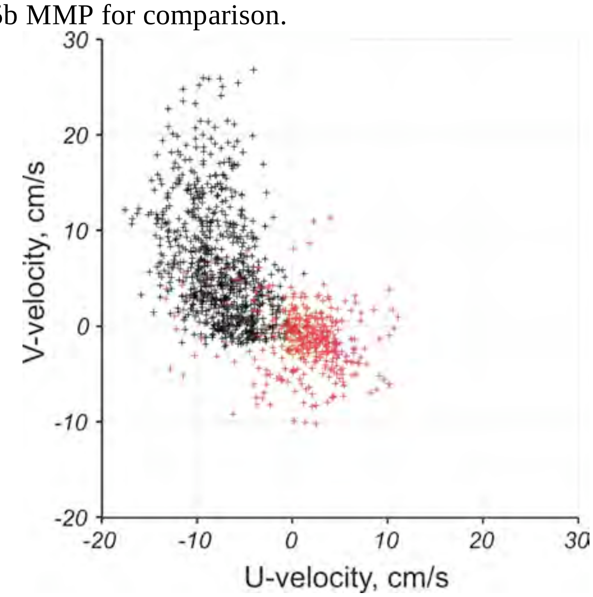


Figure I.6.3.22: Scatter plot of MMP current velocity records from M6a mooring (black) and M5b mooring (red).

Mooring M9a ***(φ=80°20.93N, λ=161°15.837E, H=2690m)***

This mooring was deployed in 2007 and spent one year in the water. It included one MMP profiler, one SBE37 microcat, and one ADCP both deployed at 98m. ADCP current records are summarized in **Figure I.6.3.23** and **Table I.6.3.9**. Current velocities show strong southward transport in the pycnocline in summer and the well-pronounced seasonal cycle. To our surprise, we found no seasonal cycle in the zonal current component.

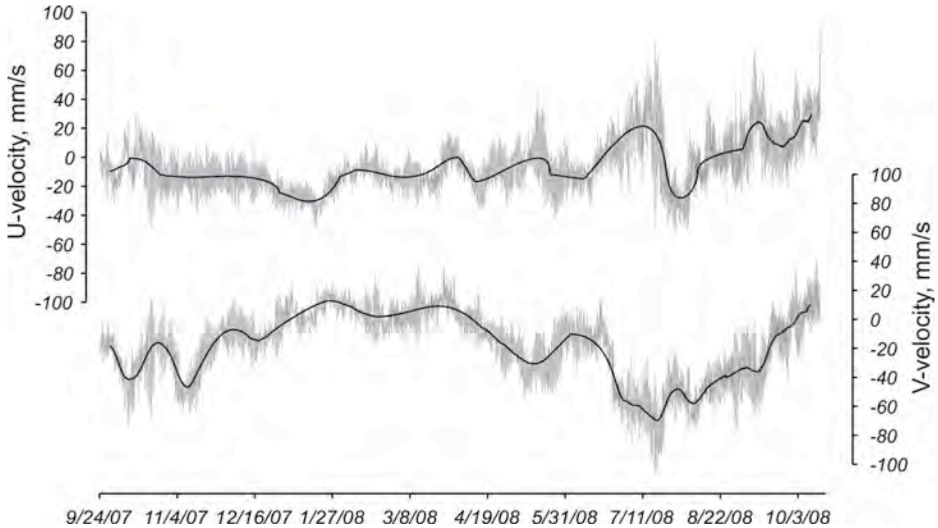


Figure I.6.3.23: Current velocities (mm/sec) from 30-min ADCP records at 129m of M9a mooring. Solid lines show 10-day running averages.

Table I.6.3.9: Means and standard deviations from ADCP current velocity records at M9a mooring

Level, m	49	57	89	129
U, cm/s	-0.8	-0.5	-0.5	-0.2
U standard deviation, cm/s	4.0	3.2	2.6	1.8
V, cm/s	-0.8	-1.2	-1.7	-1.3
V standard deviation, cm/s	4.1	3.6	3.0	2.5

Temperature and salinity records from SBE37 microcat (actual depth ~139m, **Figure I.6.3.24**) show no seasonal cycle with high-frequency variability of ~0.2°C and 0.3-0.5psu. There is no visible trend in temperature and salinity records. The salinity record shows some problem at the end of April, which requires further investigation.

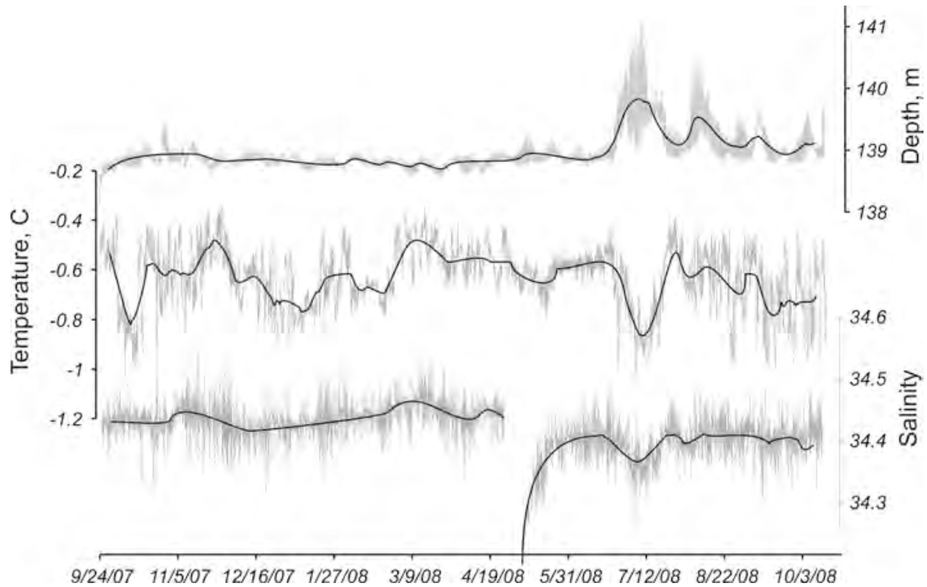


Figure I.6.3.24: Depth, temperature, and salinity derived from 60-min CTD records at the M9a mooring. Solid lines show 10-day running averages.

According to colleagues from Laval University, the owner of the MMP profiler, the instrument did not work for the entire period of observations. The reason for such a failure is under investigation.

Mooring M10a (φ=79°45.407N, λ=159°20.006E, H=1464m)

This mooring was deployed in 2007 and spent one year in the water. It included two RCM11s deployed at 260 and 902m, one ADCP deployed at 306m, and two sediment traps deployed near RCMs at 258 and 904m.

Current velocities derived from all instruments (RCMs and ADCP) are comparable, attesting to the good quality of the observations (see **Figures I.6.3.25–27**). Averaged over the entire available record, both zonal and meridional components of the currents are negative (**Table I.6.3.10**). That, for this location, suggests along-slope propagation of water transports. Currents derived from the shallowest 234m ADCP level (U = –1.1 and V = –1.4cm/s) and from nearby mooring M9 for its deepest 129m ADCP level (U = –0.2 and V = –1.3cm/s) are also comparable with the shallow-to-right general direction of flow.

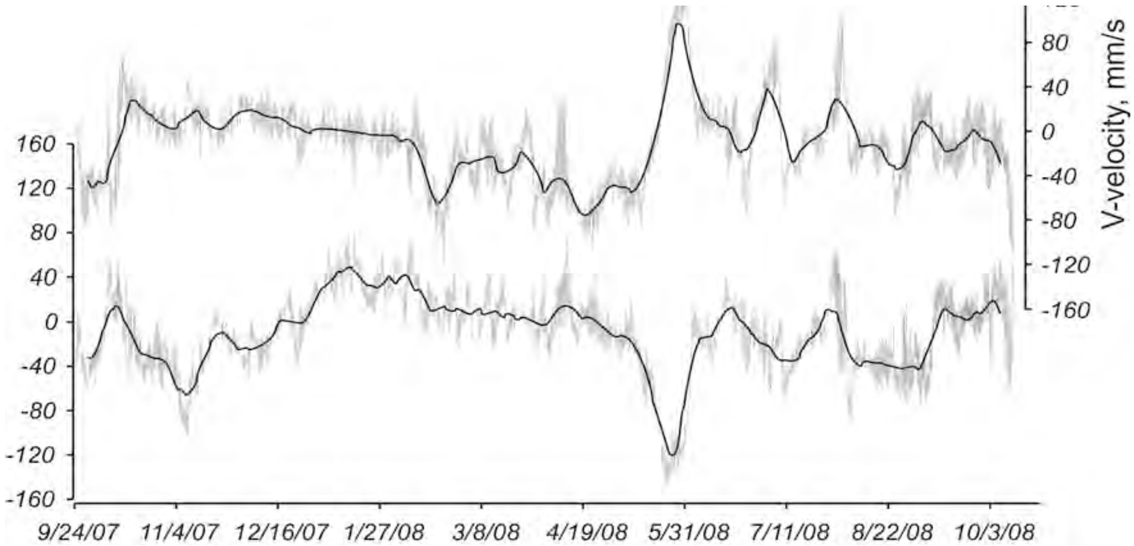


Figure I.6.3.25: Current velocities from 30-min ADCP records at 306 m of M10a mooring. Solid lines show 10-days running averages.

Table I.6.3.10: Means and standard deviations from ADCP current records from M9a mooring

Level, m	234	274	306
U, cm/s	-1.1	-1.0	-1.0
U standard deviation, cm/s	4.3	3.9	3.7
V, cm/s	-1.4	-1.2	-1.0
V standard deviation, cm/s	4.4	3.9	3.7

Temperature and salinity records derived from the RCM instruments (**Figures I.6.3.26–27**) should be analyzed with care. The range of temperature variations from 260m (**Figure I.6.3.26**) is well above the level of accuracy of the instrument and may be accepted as reliable. However, temperature from the deeper instrument (**Figure I.6.3.27**) does not show variations which exceed the instrument accuracy. Salinities derived from RCM do not look realistic, varying within an excessively wide range (**Figures I.6.3.26–27**), and should not be considered as realistic.

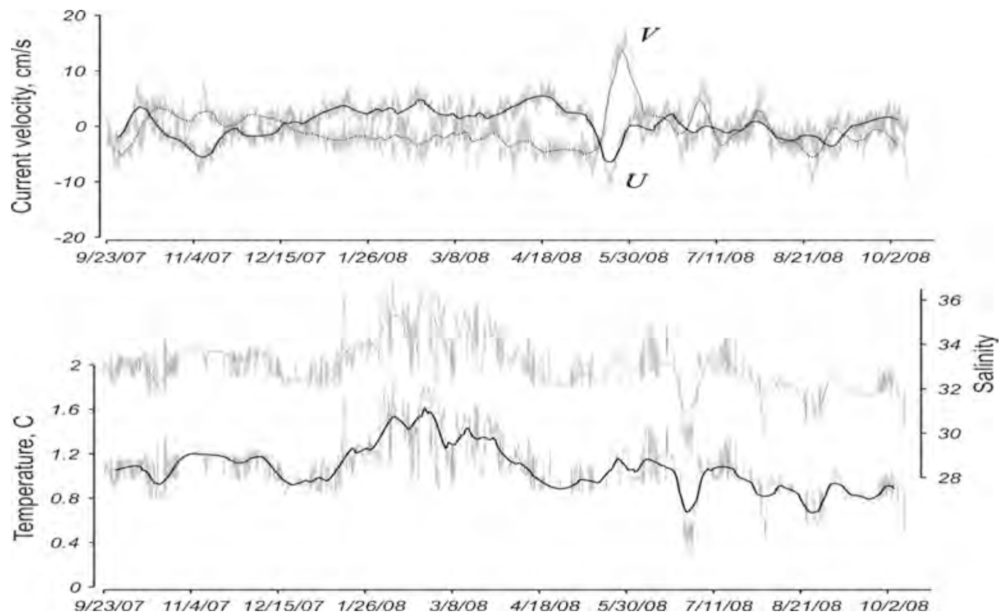


Figure I.6.3.26: Current components, temperature, and salinity derived from 60-min RCM records at 260m of M10a mooring. Solid lines show 10-day running averages.

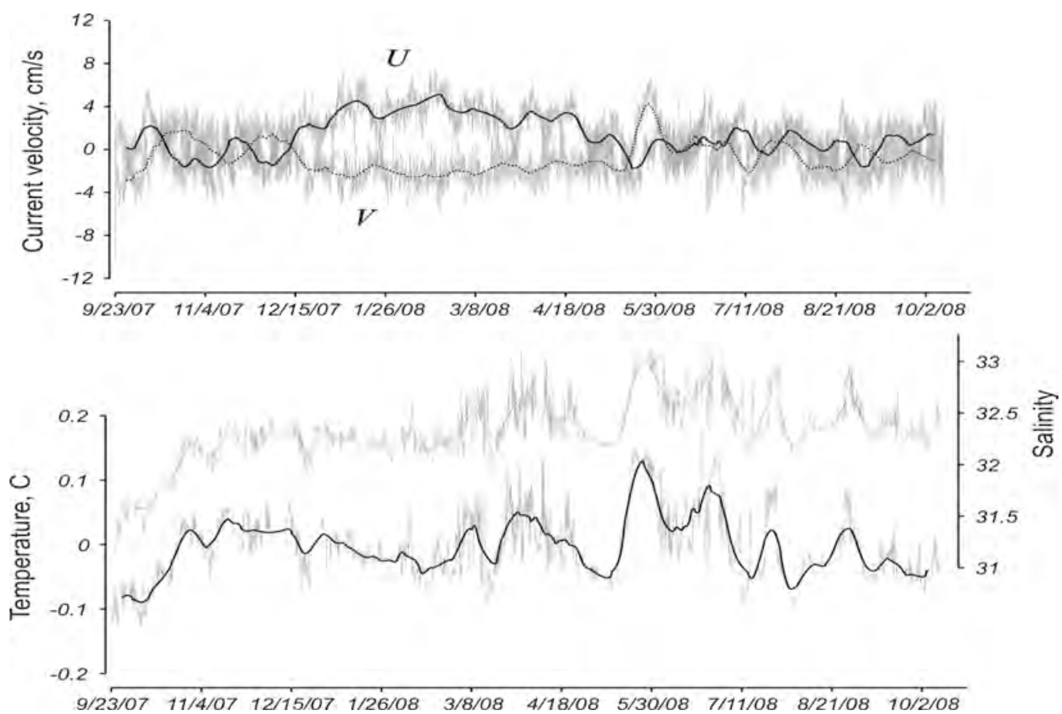


Figure I.6.3.27: Current components, temperature, and salinity derived from 60-min RCM records at 902m of M10a mooring. Solid lines show 10-day running averages.

I.6.4. TURBULENCE MEASUREMENTS (*Yueng-Djern Lenn, Bangor University*)

I.6.4.1. Equipment set-up

Turbulence and microstructure observations were made by Benny Lincoln, Ben Powell, and Yueng-Djern Lenn using a VMP500 instrument deployed from the forward portside of the I/B *Kapitan Dranitsyn* (**Figure I.6.4.1**). As during the 2007 field season, the VMP probe was used in a tethered free-fall mode. Unlike the September 2007 field season, there was a prevalence of sea-ice (100% coverage was common) during the October 2008 cruise. Hence, prior to station operations, the ship had to maneuver to break ice and create a large enough open water gap for deployment of CTD, VMP, and zooplankton nets. The ship's air bubbler system produced a directed sheet of bubbles from the bow and was used to help maintain the size of the open-water gap during the VMP deployment. Due to the nature of the icebreaker operation, the propeller was not typically disengaged while on station. As the ship was ~120m long and the propellers were located beneath the stern, there was little risk to the VMP conducting cable, except rare occasions when the bridge decided to move the ship while our instrument was in the water. Typically the vessel was oriented such that the wind was blowing from the portside in order that the ship drift would prevent the deployed instruments and cables from being dragged under the ship or encountering the propellers. The new cold-weather hazard to the turbulence operations included accumulation of ice on cones and pulleys that guide the cable on the line-puller, increased viscosity of the hydraulic fluid at very low temperatures, and competing hazards of ship-drift versus the encroachment of sea-ice. To equilibrate/defrost the VMP and seabird sensors prior to recording data, we found it neccessary to lower the VMP down to about 100m for several minutes before bringing the instrument back to 10-m below the surface before commencing data collection. The instrument was not brought to the surface in order to avoid data contamination due to noise from the air bubbler.

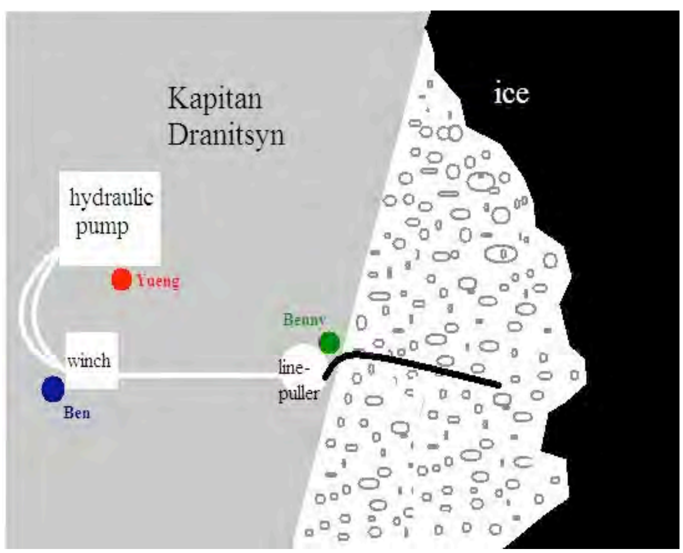


Figure I.6.4.1: Map of turbulence and temperature/conductivity microstructure observations for the 2008 NABOS/ASBO cruise.

The VMP probe was fitted with two shear probes, two fast-response thermistors, and one fast-response conductivity meter mounted on the nose cone. The microsctructure shear probes and thermisters were each replaced at least once during the cruise. Seabird temperature (SBE3) and salinity (SBE4) sensors were attached to the body at the lower end of the VMP. A new custom-made brush was mounted to the upper-end of the VMP to provide adequate drag such that the instrument free-fall rate allowed resolution of the turbulent dissipation wavelengths. Turbulence profiles were collected on as many stations as possible, where the winds, weather, and currents allowed.

I.6.4.2. Observations

During the 2008 field season, turbulence and microstructure were successfully observed on 76 profiles along four different cross-sections of the arctic boundary current and at a 12-hour shelf station (**Figure I.6.4.2**). At the shelf station in the Laptev Sea, the 48 profiles were collected over a 12-hour period in an attempt to resolve the tidal cycle of turbulent dissipation. The seabird temperature and salinity were also collected for calibration purposes, but as in the 2007 data, we found the response of the seabird conductivity cell to be too slow as compared with the Seabird thermistors. Therefore we anticipate that, as in 2007, the microstructure temperatures and conductivities will be best calibrated to the local CTD observations.

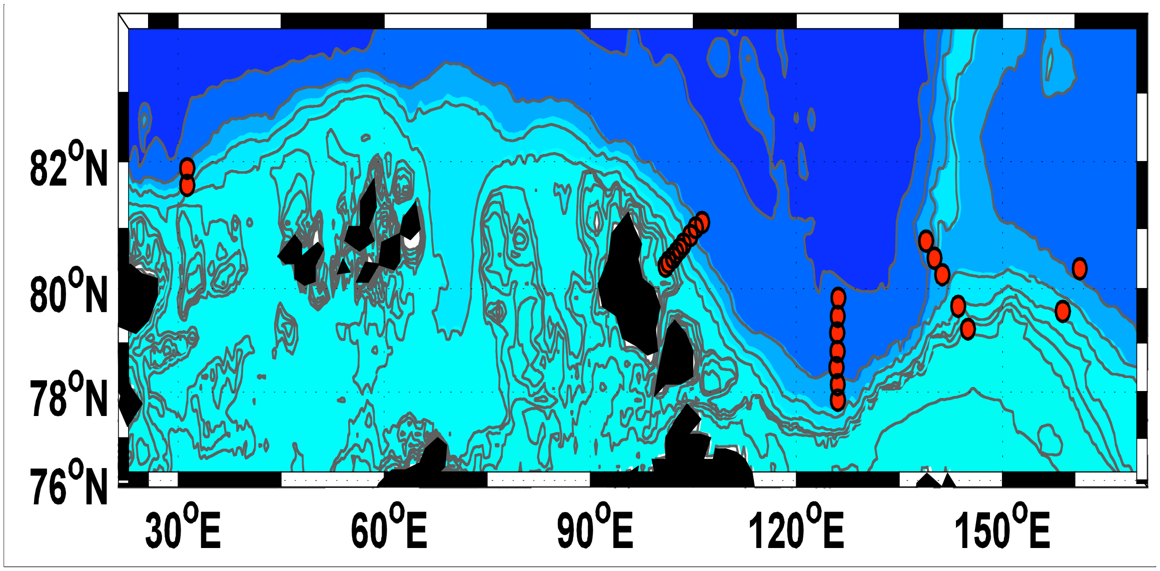


Figure I.6.4.2: Map of turbulence and temperature/conductivity microstructure observations for the 2008 NABOS/ASBO cruise.

I.6.4.3. Preliminary Results

The data presented are all preliminary. In particular, the Seabird salinities should be viewed with some suspicion due to the slow response of the conductivity cell. The microstructure temperature and salinites are not presented, as these have yet to be calibrated to the final CTD data. In general, the biggest difference with the previous year's data is the absence of the thin warm surface layer that coincided with the ice-free 2007 summer. In October 2008, the cold fresh polar mixed layer ($T<-1.5^{o}C$, $S<33$) was found just below the sea-ice overlaying the shallow arctic halocline that was evident in all observations (**Figures 6.4.3–6.4.7**). The arctic halocline was located in the 20–40m depth range at all oceanographic sections. As observed during the last year, the turbulent kinetic energy dissipation below the halocline was very low, typically $O(10^{-6}\ W\ m^{-3})$ (**Figures 6.4.3-6.4.5**). In the boundary current sections, there were pronounced staircase structures in the microstructure temperature and conductivity profiles. This is very similar to the results from the 2007 field season, which demonstrated that the weak vertical mixing occurring at intermediate depths in this region is primarily due to double diffusive processes [*Lenn et al.*, 2008].

The new results for the 2008 field season include the occupation of a new section north of Severnaya Zemlya (SZ) and the 12-hour shelf station. The new SZ section turned out to be the most densely occupied turbulence section, as the environmental conditions allowed us to profile at every station here (**Figure I.6.4.6**). We observed slightly enhanced dissipations along the bottom near the shelf-break at the 300–400m depth (**Figure**

I.6.4.6, top panel). This coincided with the northward extension of cold shelf water (**Figure I.6.4.6**, middle panel) and may be associated with a down-welling polynya-derived shelf water plume.

At the 12-hour Laptev Sea shelf station, ~5 profiles were collected for the first half-hour of each hour, except for the third and fourth hours, whichwe lost to re-positioning the ship. We observed two periods of enhanced turbulent kinetic energy dissipation along the bottom boundary at the beginning and end of the 12-hour cycle (**Figure I.6.4.7**). An ADCP was lowered over the side of the ship at the shelf station and provided data for the first two hours before the batteries died. From this short ADCP time series, it is clear that the tidal currents were strengthening at the same time as the bottom dissipation was growing in amplitude. In between the high bottom dissipation periods, we also observed very high turbulence kinetic energy dissipation near the surface in the 20–40m depth range (**Figure I.6.4.7**, bottom panel). On station, the winds were primarily from the southwest, such that the ship drift was toward the northeast.

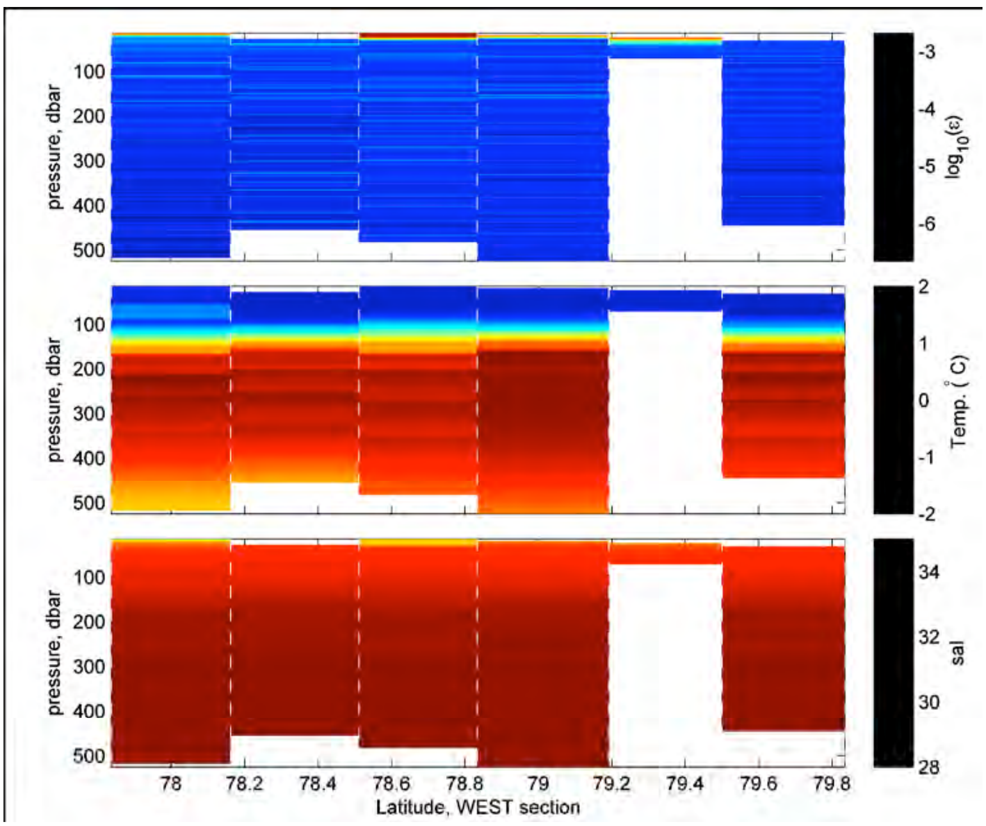


Figure I.6.4.3: Observations from the West section. (Top) turbulence kinetic energy dissipation, $\log_{10}(W/m^3)$. (Middle) Seabird temperature (^{o}C). (Bottom) Seabird salinity. Dashed white lines indicate station locations.

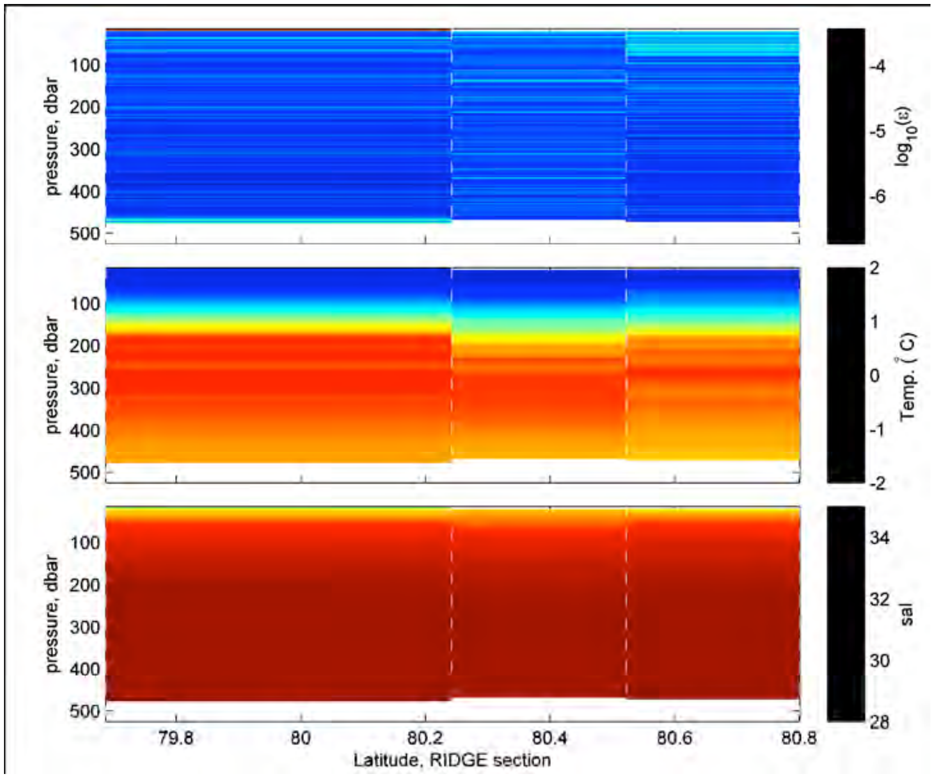


Figure I.6.4.4: Observations from the Ridge section. (Top) turbulence kinetic energy dissipation, $\log_{10}(W/m^3)$. (Middle) Seabird temperature (^oC). (Bottom) Seabird salinity. Dashed white lines indicate station locations.

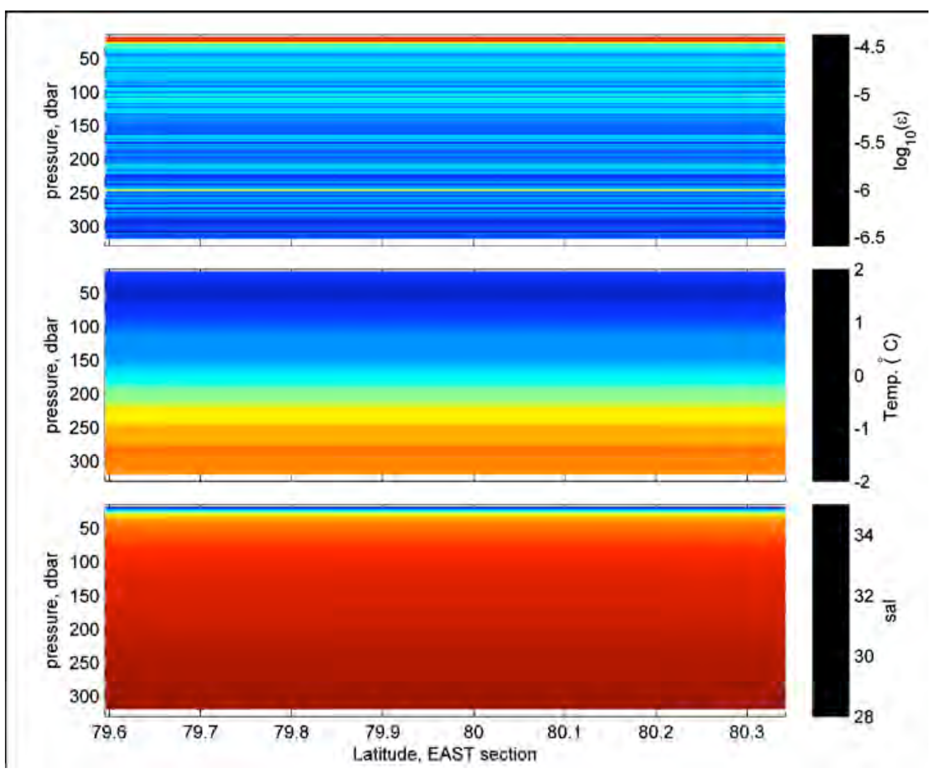


Figure I.6.4.5: Observations from the eastern section. (Top) turbulence kinetic energy dissipation, $\log_{10}(W/m^3)$. (Middle) Seabird temperature (^oC). (Bottom) Seabird salinity. Only two stations were occupied at this section due to weather conditions.

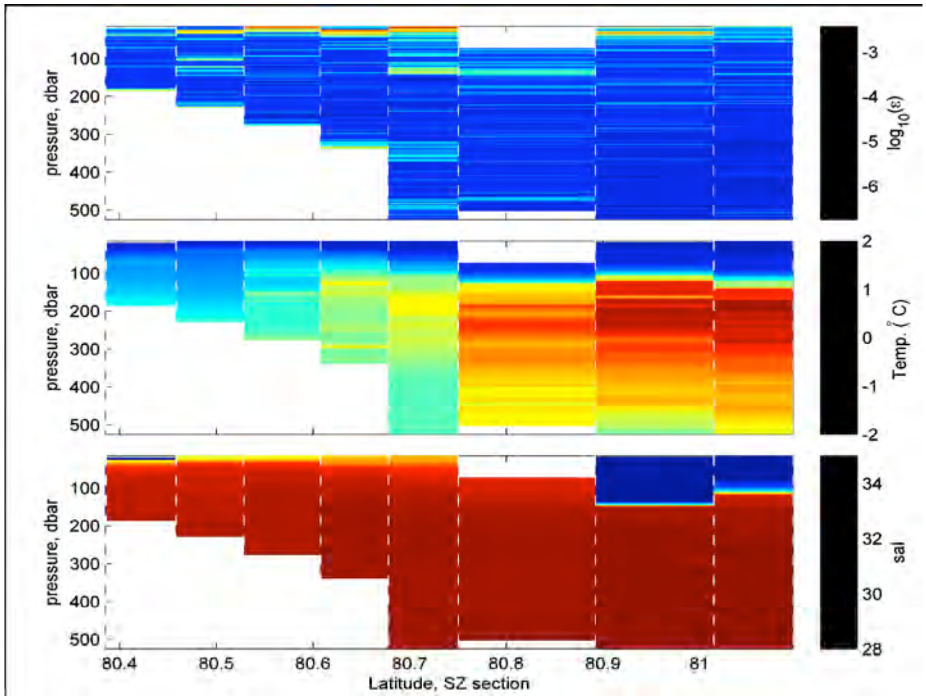


Figure I.6.4.6: Observations from the section north of Severnaya Zemlya. (Top) Turbulence kinetic energy dissipation, $\log_{10}(W/m^3)$. (Middle) Seabird temperature (^oC). (Bottom) Seabird salinity. Dashed white lines indicate station locations.

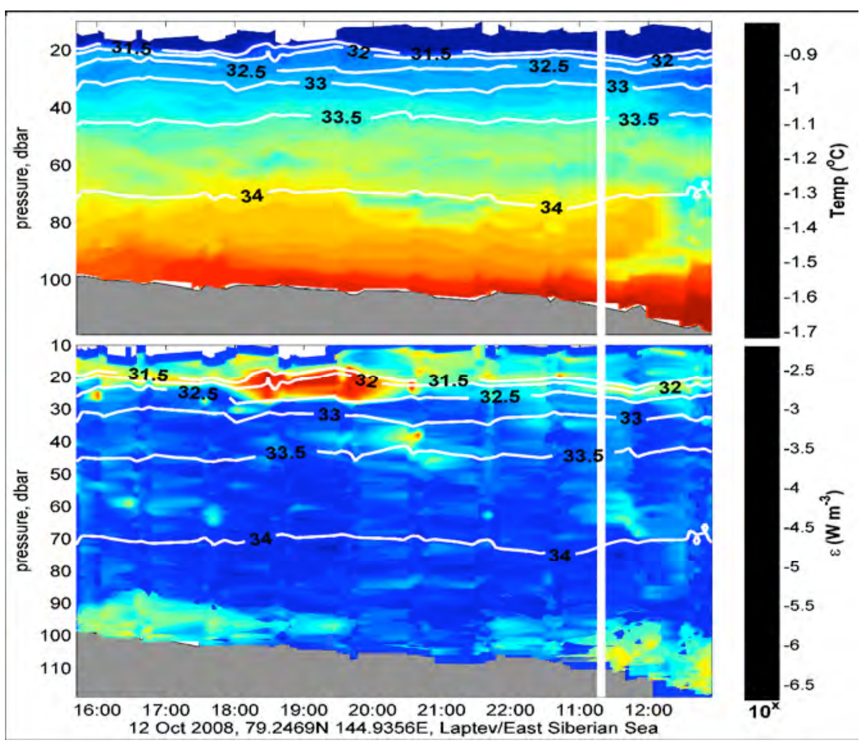


Figure I.6.4.7: 10-hour time series from the Laptev Sea. (Top) Temperature (^oC, contoured shading) and salinity (white lines). (Bottom) Turbulent kinetic energy dissipation, $\log_{10}(W/m^3)$ and salinity (white lines). X-axis is labelled with hour of day, and the first two hours of observations are plotted at the end of the time series to complete the semi-diurnal cycle. The thick white vertical line in each panel indicates the time-series gap.

I.6.5. HYDROCHEMICAL OBSERVATIONS (*Sinhue Torres-Valdes, NOCS; Karl Kaiser, USC; Povl Abrahamsen, BAS and Polona Rozman, AARI*)

I.6.5.1. Introduction

46 CTD casts arranged in sections cutting across the main pathways of the Atlantic Water into the Arctic Ocean (**Figure I.6.5.1**) were sampled for $\delta^{18}O$, barium, dissolved inorganic nutrients, dissolved oxygen, salinity, dissolved organic matter (DOM), dissolved inorganic ^{14}C-carbon ($DI^{14}C$), and suspended particulate matter (SPM). Dissolved inorganic nutrients, dissolved oxygen, and salinity samples were measured on board, while samples for the remaining variables were stored and sent to their respective institutions for further processing and analysis. $\delta^{18}O$, barium, dissolved inorganic nutrients, dissolved oxygen, and salinity samples were taken as part of the Arctic Synoptic Basin wide Oceanography (ASBO) programme, UK. In general, 22 Niskin bottles were sampled per cast for the ASBO programme. DOM samples were taken for/by the University of South Carolina. $\delta^{18}O$ samples were also taken on behalf of the Leibniz Institute of Marine Sciences (IFM-GEOMAR), University of Kiel, Germany. $DI^{14}C$ and SPM samples were taken on behalf of the Environmental Chemistry Division, National Institute for Environmental Studies, Japan. Hydrochemistry team on board the I/B "*Kapitan Dranitsyn*" was Ruth Mugford (University of Reading), Ekaterina Chernyavskaya (AARI), Polona Rozman (AARI), Povl Abrahamsen (BAS), Karl Kaiser (USC) and Sinhue Torres-Valdes (NOCS).

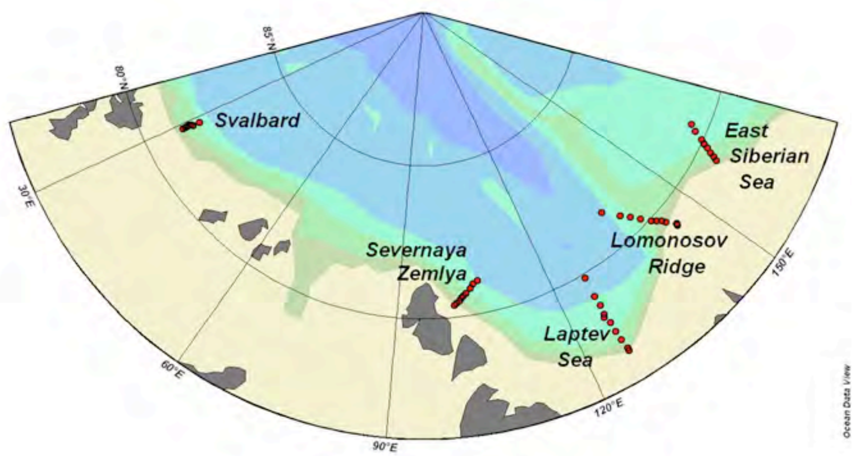


Figure I.6.5.1: KD08, map showing hydrochemical sampling stations and regions occupied.

I.6.5.2. Sampling and analysis

Dissolved oxygen

Sampling for dissolved oxygen was done before sampling of any other variable. Seawater samples were directly collected from the Niskin bottles into pre-calibrated glass bottles using a silicon tube. Before the sample was drawn, seawater was allowed to flush for several seconds (about 2–3 times the volume of the glass bottle). Care was taken to avoid bubbles inside the sampling tube and bottles. Fixing reagents (i.e., manganese chloride and sodium hydroxide/sodium iodide solutions) were added just after the temperature of the sample was recorded. Samples were mixed thoroughly following the addition of reagents and were then kept in a dark plastic crate for 30–40 minutes in order for the precipitate to settle down below 50% of the volume of the bottle. Once the precipitate settled, all samples were thoroughly mixed for a second time in order to maximize the efficiency of the reaction.

Dissolved oxygen determinations were carried out within 2 hours of sample collection using a Winkler Ω-Metrohm titration unit (794 DMS Titrino) with an amperometric system to determine the end point of the titration [*Culberson and Huang*, 1987]. Chemical reagents were previously prepared following the procedures described by *Dickson* [1994] and adopting recommendations given by *Dickson* [1994] and by *Holley and Hydes* [1994]. Thiosulphate calibrations were carried out every 4–6 days. For this purpose 1.667 mM certified

OSIL iodate standards were used. Replicate measurements of samples randomly selected were also carried out in order to test for reproducibility. Results showed that variability of replicate measurements was ≤0.8 μmol-O_2 L^{-1}. Variability between replicates during the VB07 expedition was better (≤0.3 μmol-O_2 L^{-1}). During KD08 we encountered problems with the oxygen bottle lids falling apart due to manufacturing defects. This situation prompted us to use bottles of different makes and lid designs, which we believe was the main reason for obtaining slightly less precision of replicate samples.

Dissolved inorganic nutrients

Seawater samples were collected into 30mL plastic pots for the analysis of NO_3^-+NO_2^- (hereafter NO_3^-), PO_4^{3-} and $Si(OH)_4$. Pots were rinsed three times with seawater before the sample was drawn. Analyses were carried out within 30 minutes of sample collection using a segmented continuous-flow Skalar San^{plus} autoanalyser set up for analysis and data logging with the Flow Access Software version 1.3.11. The analysis was calibrated using the set of standards shown in **Table I.6.5.1**. Stock standard solutions with a concentration of 5mM prepared in Milli-Q water were used to produce working standards. In turn, working standards were prepared in a saline solution (40 g NaCl/L of Milli-Q water) which was also used as a diluent for the analysis. Analysis runs consisted of a set of calibration standards, wash and drift cups, certified low nutrient seawater (in order to test for contamination of the saline solution) and samples. Wash and drift cups are used by the software to correct for any deviation of the analysis base-line. Given the ship's lack of a Milli-Q system, 350L of ultra pure (Milli-Q) water for general lab use were transported from the NOCS (UK) using 25L acid washed (15% HCl) carboys. Analyses carried out during KD08 showed the stored supply of Milli-Q water did not get contaminated. Dry chemicals and wet reagents were either pre-weighed or previously prepared at NOCS.

Table I.6.5.1. Set of calibration standards (*Std*) used for dissolved inorganic nutrient analysis. Concentration units are μmol L^{-1}. *Std 1_b* was only used towards the end of the expedition.

	NO_3^-	PO_4^{3-}	$Si(OH)_4$
Std 1_a	20.0	2.0	20.0
Std 1_b	19.1	1.9	20.3
Std 2	10.0	1.0	10.0
Std 3	5.0	0.5	5.0
Std 4	1.0	0.25	1.0
Std 5	0.5	0.1	0.5

The precision of the method was analyzed by looking at the variations of the complete set of standards measured throughout the cruise. Results of the standards measurements are summarized in **Table I.6.5.2** and shown in **Figure I.6.5.2**. Triplicates were done for the first and last sample on a given run in order to test for reproducibility. These showed that variability of replicates from mean concentrations was <3.2%. The limits of detection of this method during KD08 were 0.03 μmol L^{-1} for PO_4^{3-}, 0.24 μmol L^{-1} for NO_3^- and 0.03 μmol L^{-1} for $Si(OH)_4$.

Table I.6.5.2: Mean and variation of all standards measured, and precision of the analysis at each concentration (μmol L^{-1}).

	NO_3^-	Prec.	PO_4^{3-}	Prec.	$Si(OH)_4$	Prec.
Std 1_a	20.3 ± 1.0	4.9%	2.0 ± 0.02	0.8%	20.1 ± 0.2	1.0%
Std 1_b	19.1 ± 0.2	1.3%	1.95 ± 0.01	0.4%	20.3 ± 0.1	0.6%
Std 2	10.1 ± 0.2	1.5%	1.00 ± 0.01	1.2%	10.0 ± 0.1	0.9%
Std 3	5.0 ± 0.1	2.3%	0.49 ± 0.01	2.1%	5.0 ± 0.1	0.9%
Std 4	1.0 ± 0.2	19.3%	0.24 ± 0.01	3.2%	1.0 ± 0.1	1.5%
Std 5	0.6 ± 0.1	14.3%	0.11 ± 0.01	6.4%	0.5 ± 0.01	2.3%

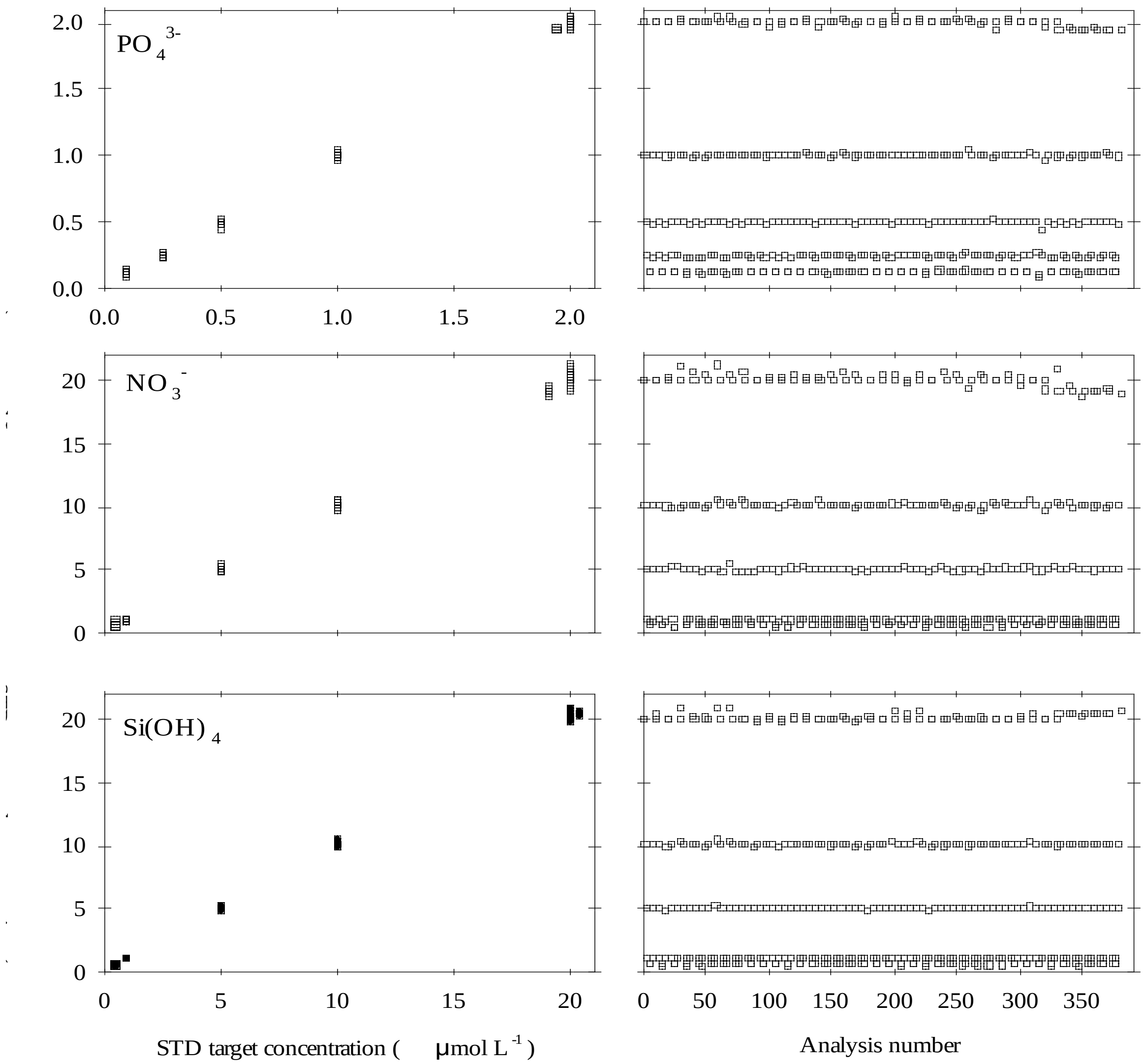


Figure I.6.5.2: Complete set of "measured" standards plotted against the "prepared or target" concentration (left side panels), and 'measured' standards plotted against respective analysis number (right side panels). Y-axis on left side panels are the same as Y-axis on the right side panels.

Salinity

Samples were collected into 200mL glass bottles after rinsing each bottle three times with sampled water. Bottles were filled up to the neck and then sealed with plastic stoppers (inserts). Samples were taken to the designated salinity laboratory on board the *KD* and stored for at least 24 hours to allow samples to reach room temperature before the conductivity of the sample was measured. Just before conductivity measurements were done, salinity bottles were agitated, screw caps removed, bottle necks wiped to remove seawater droplets and/or salt crystals, and finally inserts were carefully removed. Salinity determinations were carried out using a Guildline 8410 Portasal Salinometer, #62507, with an external peristaltic pump attached. OSIL/IAPSO standard seawater from batch P149 was measured at the beginning and end of each run, and approximately every 36 samples. Five replicate conductivity measurements were done for standards and three replicates or more for samples, until consecutive conductivity ratio readings were within .00002. Salinity was computed in Matlab using the CSIRO seawater toolbox, version 3.0. All salinity measurements were carried out onboard; a total of 809 water samples were analyzed, excluding standards.

Because of temperature variations in the laboratory, the cell temperature was changed several times and the salinometer restandardized; the temperature started out at 24°C, was increased to 25°C and finally to 27°C. Standard readings were very consistent throughout, remaining within 0.00002 of the label value of 0.99984. As this is well within the rated precision of the salinometer, no corrections to the measured conductivity ratios were applied. The flushing system for the conductivity cell, which is driven by an air pump at the rear of the unit, failed several times during the cruise and had to be repaired. A diagnosis by the manufacturer following the cruise has indicated that there may have been a partial blockage in the heat exchanger. However, we have no reason to believe that this affected the measurements during the cruise.

Barium

A total of 796 water samples were collected into acid washed 15mL Nalgene bottles after rinsing each bottle three times with sampled water. Bottles were filled up to the bottle neck in order to avoid leakage upon expansion of cold water warming up. Once at room temperature, all bottle lids were checked for tightness in order to avoid leakage. All samples were stored and freighted to the UK. BAS will send these samples to Dr. Kelly Falkner (Oregon State University, USA) for analysis.

$\delta^{18}O$

The ASBO water samples were collected into 50mL glass bottles after rinsing each bottle three times with sea water. A small air gap was left, and the bottles were then closed using rubber stoppers and crimped with tin caps. All 801 samples were stored and freighted to the UK. BAS will send these samples to Dr. Melanie Leng of the UK NERC Geoscience Isotope Laboratory (British Geological Survey, Keyworth) for processing. Samples obtained for IFM-GEOMAR were taken in a similar way, although glass bottles with screw caps were used instead. 409 samples from 30 stations were taken. These were sent to Oregon State University, where Dr. Dorothea Bauch is currently on sabbatical. These samples will be analyzed in collaboration with Prof. Alan Mix at the COAS/OSU Stable Isotope Laboratory.

I.6.5.3. Preliminary results for dissolved inorganic nutrients and oxygen

Results show typical dissolved nutrients and dissolved oxygen profiles (**Figure I.6.5.3**). As compared with last year's expedition (VB07), the range of nutrient concentrations close to the surface is much lower due to the ice cover limiting the supply of nutrient-rich fresh water from Siberian rivers. A feature that still holds is the fact that nitrate concentrations close to the surface are lower relative to phosphate and silicate. Nutrients and oxygen concentrations ranged as follows: nitrate, from non detectable (nd) values to 19.2 μmol L^{-1}; silicate, 0.48 to 15.27 μmol L^{-1}; phosphate 0.10 to 0.96 μmol L^{-1} and dissolved oxygen from 340.3 to 400.3 μmol L^{-1}. Also, as compared with VB07 data, surface concentrations of phosphate and silicate were lower during KD08. However, nitrate and oxygen surface concentrations were slightly higher during KD08 relative to VB07. In general, surface concentrations for phosphate, silicate, and dissolved oxygen increase eastward, while the opposite seems to be the case for nitrate (**Figure I.6.5.4**).

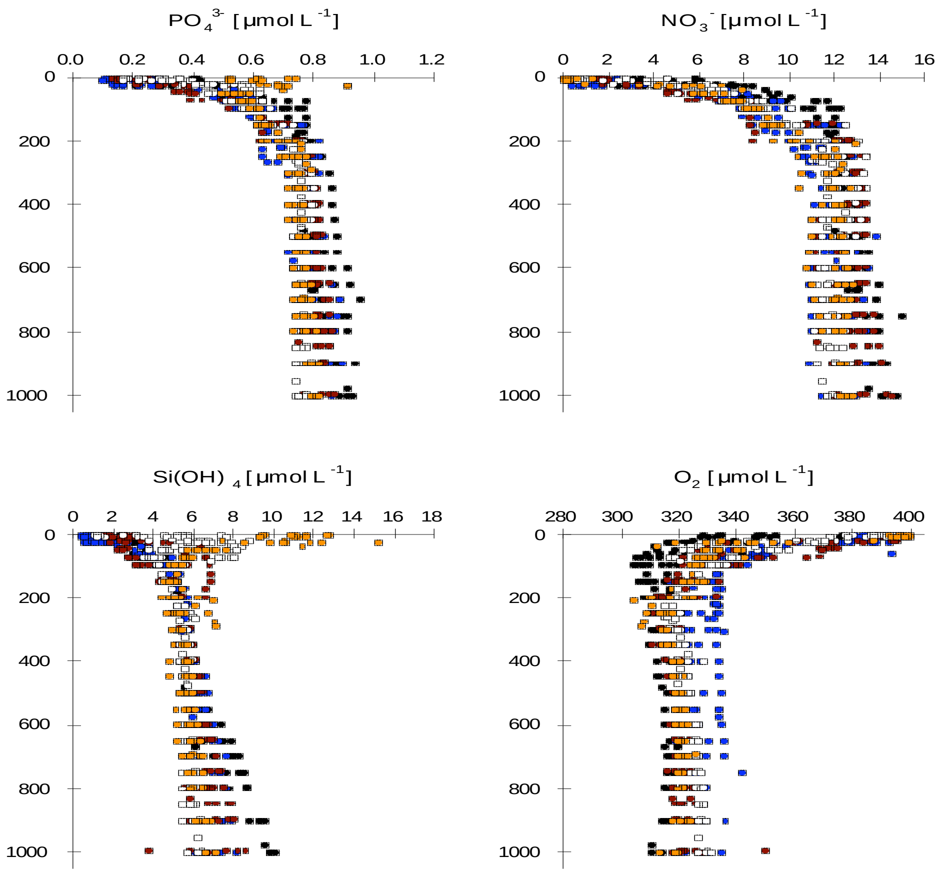


Figure I.6.5.3: KD08 dissolved inorganic nutrients and dissolved oxygen profiles. Colors represent cruise sections as follows: Svalbard (black), Severnaya Zemlya (blue), Laptev Sea (dark red), Lomonosov Ridge (white) and East Siberian Sea (orange).

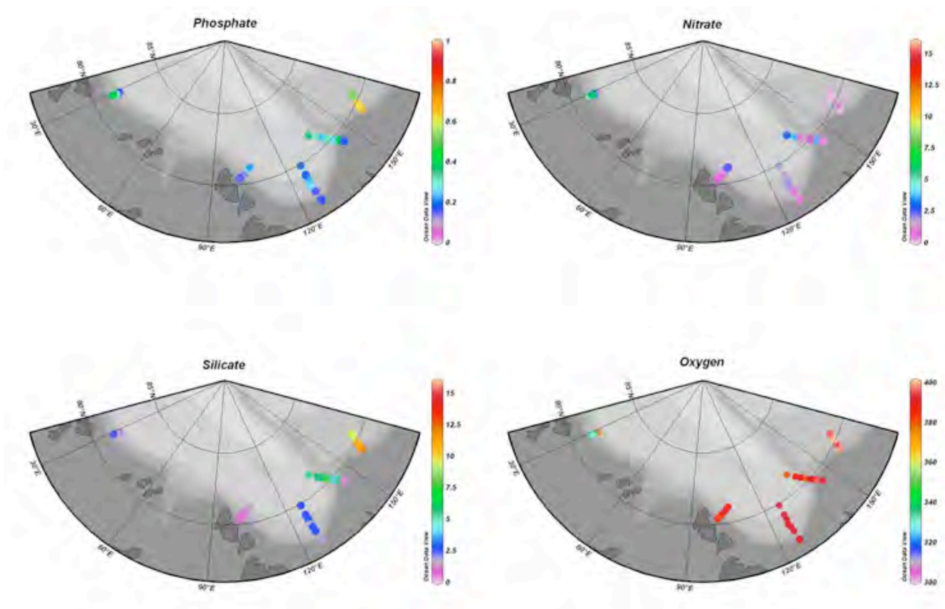


Figure I.6.5.4: Surface (10db) nutrients and dissolved oxygen concentrations for the sections shown in **Figure I.6.5.1**. Color scales are in µmol L^{-1}.

I.6.5.4. Dissolved Organic Matter and CDOM

Project objectives

The primary objective is to study the optical properties and chemical composition of dissolved organic matter (DOM) in the Laptev Sea and East Siberian Sea. Colored dissolved organic matter (CDOM) measurements will be used as sensitive tracers of river water and ventilation of arctic halocline waters. The distribution of lignin phenols will provide information on the decomposition of terrigenous DOM exported from Siberian rivers.

Samples and data collected

We collected data on every CTD cast with a flash fluorometer that provides a measure of the chromophoric component of DOM (CDOM). A total of 190 samples from surface waters, the halocline, and deep water (200-1000m) were collected for DOM chemical characterizations. In addition, DOM was extracted from 60 large volume samples (8-10 L) by solid phase extraction.

Preliminary results

CDOM fluorescence data collected at sections Svalbard, Severnaya Zemlya, Laptev Sea, Lomonosov Ridge, and East Siberian Sea show pronounced patterns (**Figure I.6.5.5**). A fluorescence maximum was observed in the East Siberian Sea. High fluorescence was also detected in patches over the Lomonosov Ridge and the Laptev Sea. The Svalbard and Severnaya Zemlya sections showed very weak fluorescence. In general, high fluorescence was associated with salinities of 27–33.

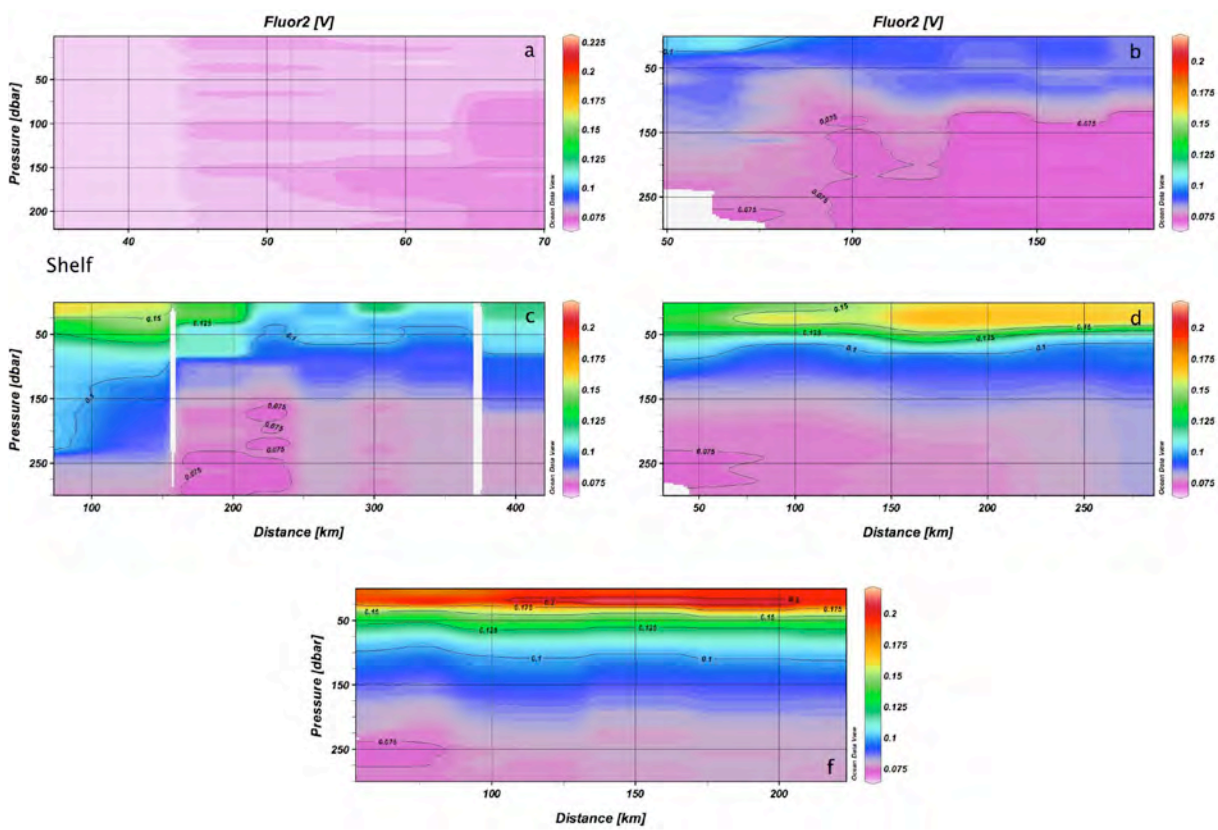


Figure I.6.5.5: CDOM fluorescence (Fluor2 (V), excitation 350-450 nm, emission 550 nm) plots for sections Svalbard (a), Severnaya Zemlya (b), Laptev Sea (c), Lomonosov Ridge (d) and East Siberian Sea (f).

Dissolved Inorganic Carbon (DIC) and Suspended Particulate Matter (SPM)

100 samples from 12 stations were taken for $DI^{14}C$ determinations, and 128 samples from 15 stations were taken for SPM. Upon arrival in Kirkenes, Norway, these samples were sent to the Environmental Chemistry Division, National Institute for Environmental Studies, Japan. Dr Masao Uchida, from the above institute, is currently processing these samples.

I.6.6. BIOLOGICAL OBSERVATIONS (*L. Fortier,ArcticNet at Laval University*)

I.6.6.1. Composition and distribution of zooplankton

Objective: To determine the composition and distribution of zooplankton in the Laptev and Barents seas.

Methods: Two zooplankton nets of 200µm mesh (1 m^2 mouth aperture each) mounted side by side on a metal frame equipped with a TSK flowmeter and a small net of 50µm mesh were deployed vertically down to 1000m or close to bottom. Zooplankton samples were preserved in 4% buffered formalin solution for later determination of composition and distribution. In the case of a fish capture, fish were individually measured and photographed before preservation in 95% ethanol.

Preliminary results: Vertical nets were deployed at 41 stations (**Figure I.6.6.1**). Zooplankton samples (200 and 50µm) were collected at all stations. Only one fish (**Figure I.6.6.2**) was caught since vertical nets do not favor fish collection and oblique nets could not be deployed due to heavy ice conditions.

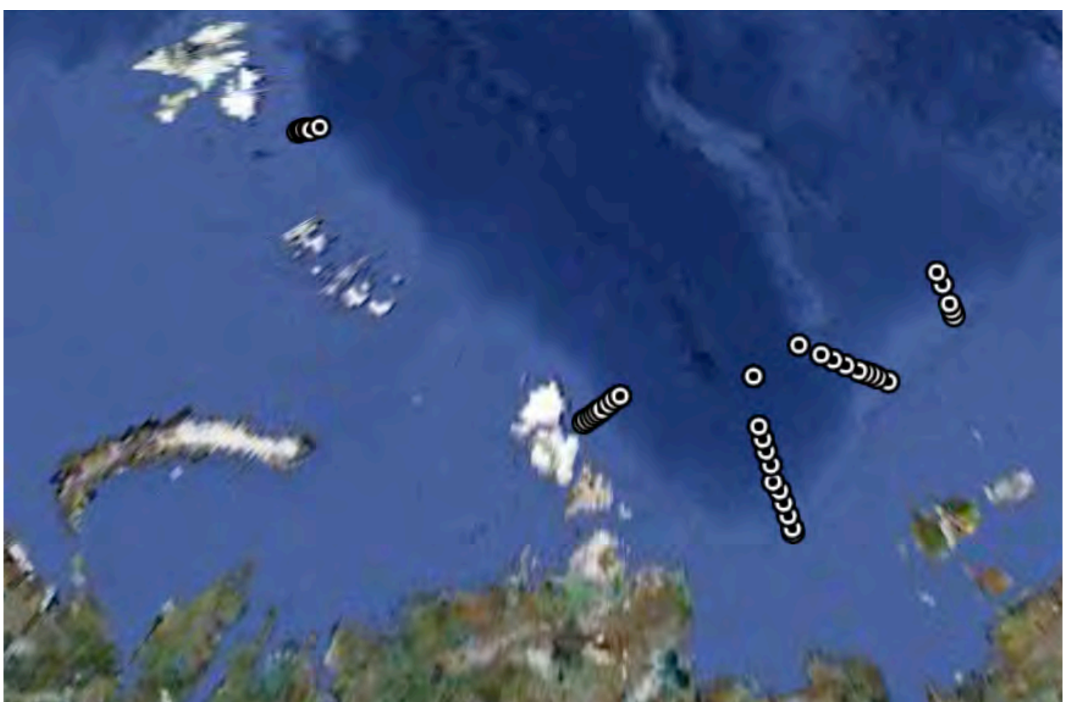


Figure I.6.6.1: 41 stations sampled with zooplankton nets in the Laptev and Barents seas.

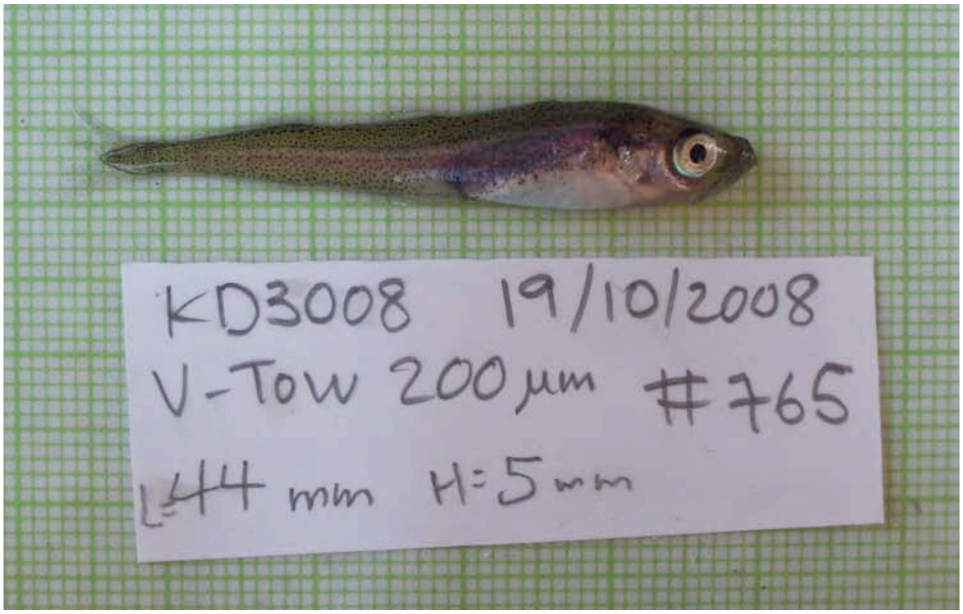


Figure I.6.6.2: Only one fish was captured during the NABOS 2008 expedition.

I.6.6.2. Contaminant analyses of zooplankton (*Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, Canada*).

Objective: To measure the contaminant content of dominant zooplankton species in the Laptev and Barents seas.

Methods: For contaminant analyses, animals from the dominant zooplankton species collected at each station were stored in cryovials at -20°C. Frozen samples were freeze-dried and then ground and mixed within their individual vials. The samples were digested using aqua regia (HCL and $HN0_3$), and total mercury was determined by cold vapour atomic absorption spectrophotometry. This process oxidizes organic mercury into inorganic mercury. Samples are further reduced to the elemental state by the addition of a reductant solution (stannous chloride). Trace metal purity acids are used for the digestions in order to minimize any contamination. Method blanks, certified reference materials, and occasional replicate samples ensure quality control and precision of the method.

Preliminary results: To date, only the *Calanus sp.* and *Themisto sp.* have been analyzed for total mercury. They will also be submitted for methyl mercury and C and N isotopic analyses. We expect those results by June 2009. The data will be included in a paper summarizing the spatial variability of total mercury, methyl mercury, and stable isotopes in these species across the arctic water bodies.

I.6.6.3. Vertical export of particulate organic carbon

Objective: To monitor vertical export of particulate organic carbon in the Laptev Sea.

Methods and preliminary results: Two sediment traps (Technicap PPS 3/3, 12 cups per trap) deployed on the M10 line (180m and 850m) were recovered and indicated a successful collection of sinking particles for a complete 12-month period from September 2007 to August 2008. These sediment traps were redeployed on the M9 line. Six sediment traps (Technicap PPS 3/3, 24 cups per trap) deployed on the M3 line (100m, 200m, 400m, 600m, 1000m, and 1300m) were not recovered. We expect results from sediment traps recovered at M10 by the end of 2009.

I.6.7. METEOROLOGICAL OBSERVATIONS USING VAISALA RADIOSONDES

(*V. Alexeev, IARC/UAF and D. Chechin, Moscow State University*)

We were a part of the meteorological team during the 2008 NABOS cruise. Our main task was to launch radiosondes for measuring atmospheric parameters. The sondes used were of RS92-SGPD type (Vaisala). They allow measuring air temperature, humidity, and wind direction and speed. We were able to obtain 30 successful vertical profiles of the atmospheric parameters. Some radiosondes were lost for various reasons: early loss of signal, explosion of a balloon due to severe weather conditions, which usually led to destroying sondes. Our team reported the meteorological profiles during the cruise by posting the results for public view. The obtained profiles will serve as input to a number of research projects. These include study of the super-stable arctic boundary layer using the Large-Eddy-Simulation technique, verification of reanalysis products using three years of NABOS data, and study of polar amplification of global warming. Shown in **Figure I.6.7.1** are two profiles taken within 24 hours at our mooring location near Svalbard. One can see how different these two soundings are. The meteorological situation in the Arctic changes very quickly. Models and reanalysis products usually do not capture many important features of atmospheric circulation in the Arctic. Verification of reanalysis products and careful analysis of the structure of the boundary layer are extremely important for understanding climate sensitivity in the Arctic. The sounding equipment (Vaisala radiosounding station, ground check kit and antennas) was kindly provided by Peter Minnett, Erica Key, and Miguel Angel Zaguirre of the University of Miami. We would like to thank Irina Repina, Alexander Smirnov, Anatoly Saliuk, Jack Greenberg, Ian Beliveau, and Peter Keen for their help with installing the equipment, and the rest of the expedition members for participating in launching the balloons.

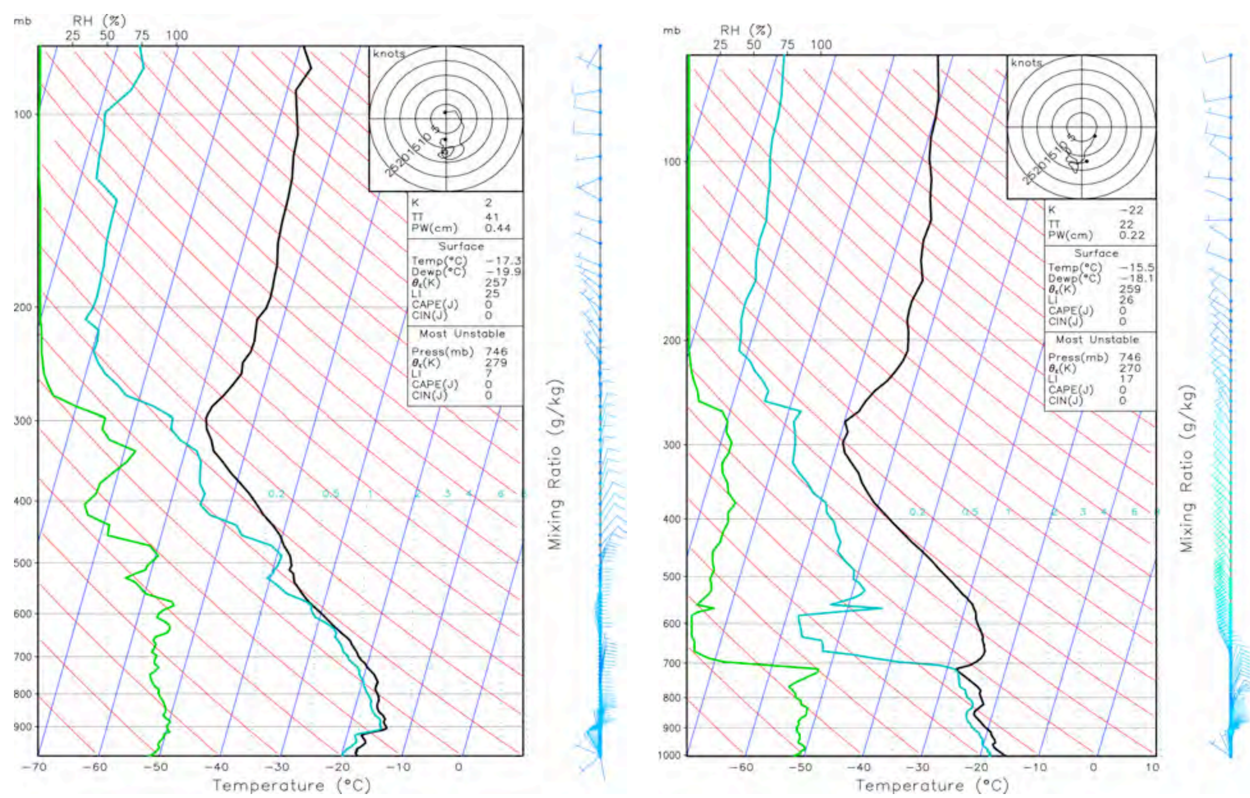
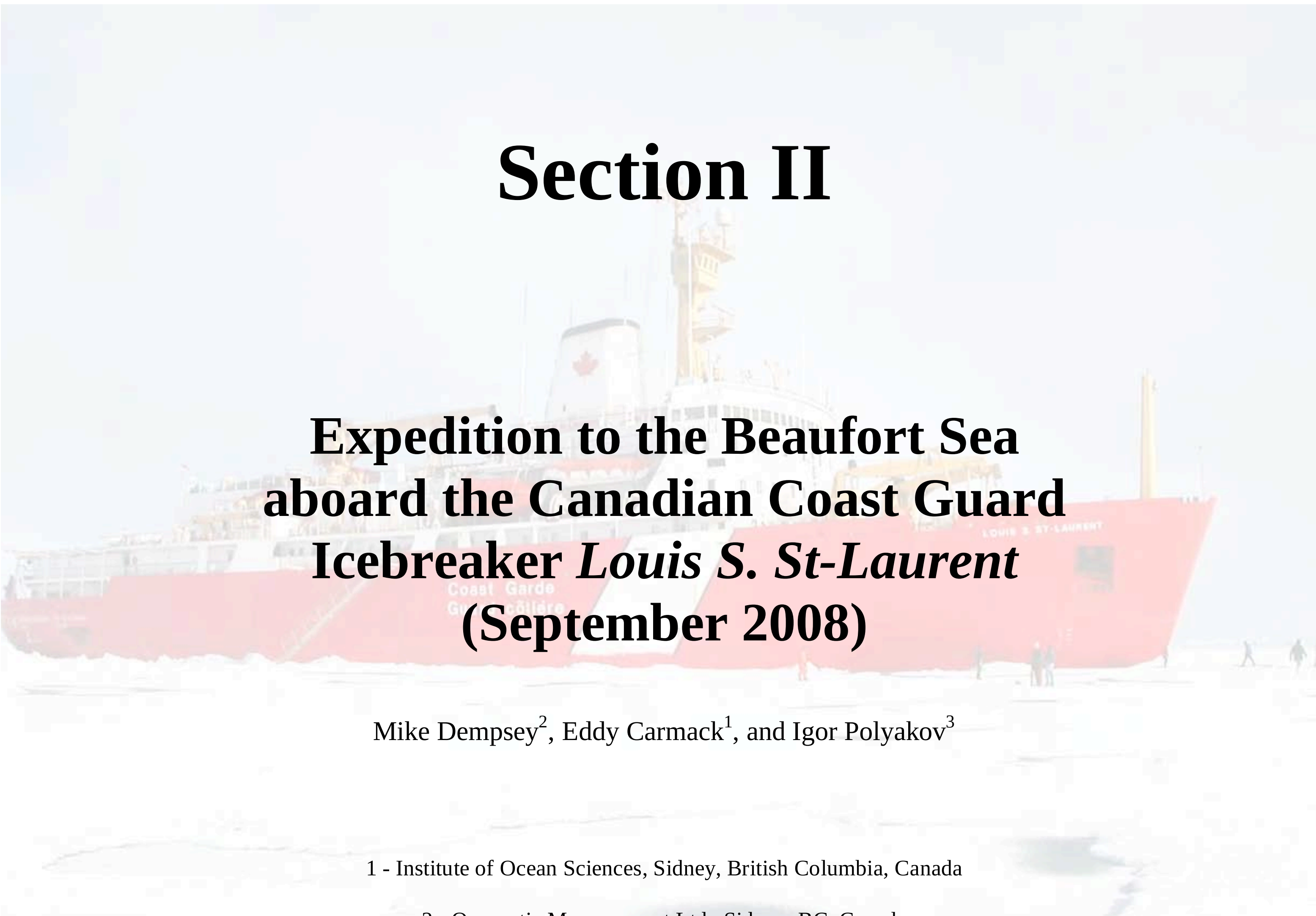


Figure I.6.7.1: Two profiles taken within 24 hours at our mooring location near Svalbard. (Left) October 27, 2008, 08:38 UTC at 81°56N 30°85E and (right) October 28, 2008 08:54 UTC at 81°56N 30°87E.

CABOS

Canadian Basin Observational System



Section II

Expedition to the Beaufort Sea aboard the Canadian Coast Guard Icebreaker *Louis S. St-Laurent* (September 2008)

Mike Dempsey[2], Eddy Carmack[1], and Igor Polyakov[3]

1 - Institute of Ocean Sciences, Sidney, British Columbia, Canada

2 - Oceanetic Measurement Ltd., Sidney, BC, Canada

3 - International Arctic Research Center, University of Alaska Fairbanks
Fairbanks, Alaska, USA

II.1. INTRODUCTORY NOTE

The Canadian Basin Observation System (CABOS) mooring (**Figure II.1**) has been deployed on Institute of Ocean Sciences (IOS) arctic cruises on behalf of IARC every year since 2003, except 2007. The location of the mooring has varied due to ice conditions but has been continuously placed to monitor the flow of AW around the southeast slope of the Canada Basin. The mooring is part of a string of moorings deployed by IARC to observe the movement of AW through the Arctic and measure the heat flux to upper waters. The NABOS consists of a series of MMP and conventional moorings located around the shelf break of the Eurasian Basin. The CABOS mooring provides complementary data in the Canada Basin for the NABOS array. In 2008 there was deployment but no recovery of the CABOS mooring because in 2007 it was decided not to re-deploy the CABOS mooring.

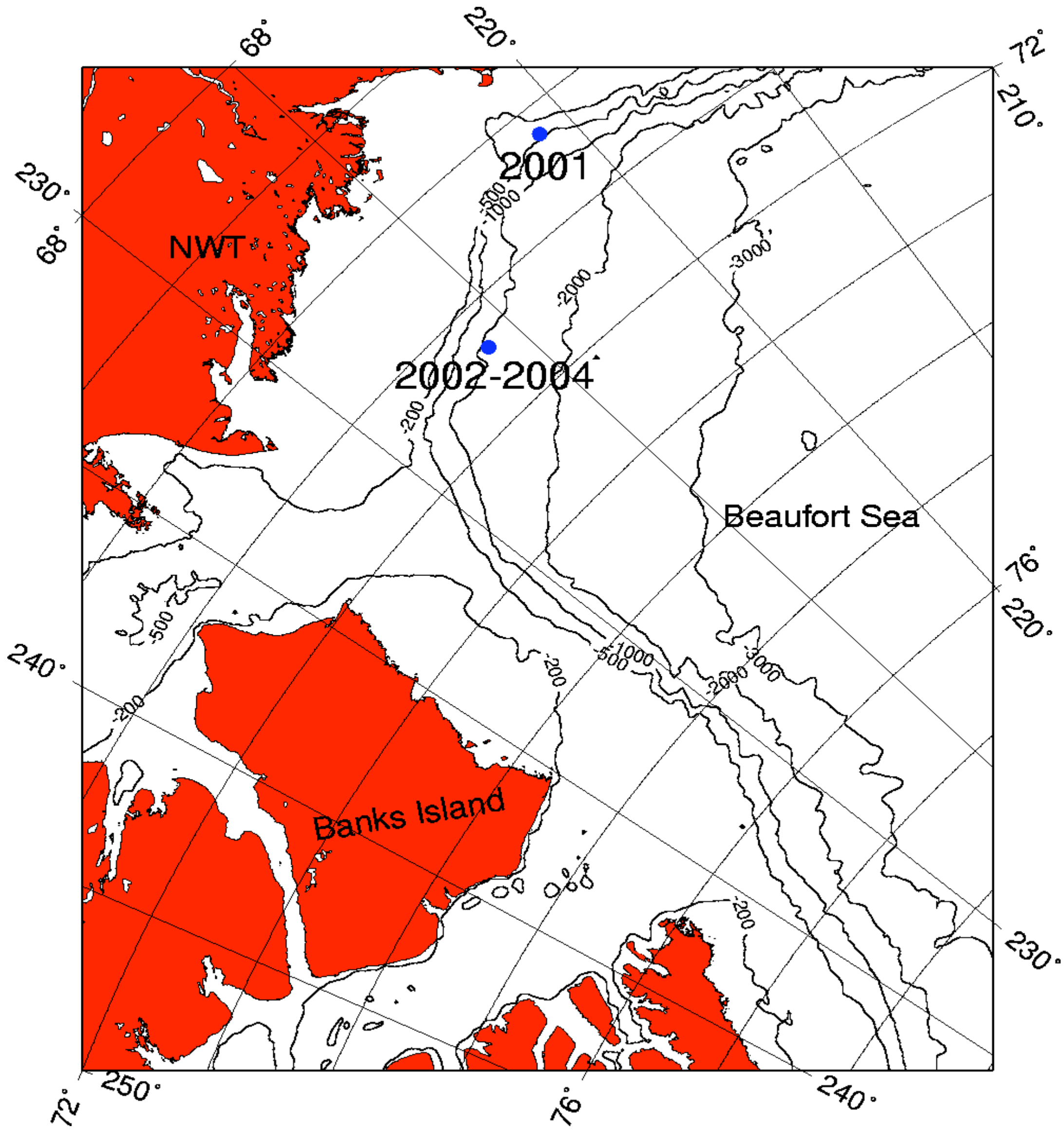


Figure II.1. Map with CABOS mooring location.

II.2. RESEARCH VESSEL

A brief description of the ship used for CABOS mooring deployment and recovery is taken from the web page http://www.ccg-gcc.gc.ca/vessels-navires/details_e.asp?id=A-1 and is shown in **Table II.1.**

Table II.1. Canadian Coast Guard (CCGS) *LOUIS S. ST-LAURENT*

Official No:	328095
Type:	Heavy Gulf Icebreaker
Port of Registry:	Ottawa
Region:	Maritimes
Home Port:	Dartmouth, Nova Scotia, Canada
Call Sign:	CGBN
When Built:	1969
Builder:	Canadian Vickers, Montreal, Québec, Canada
Modernized:	1988 - 1993 - Halifax Shipyard & 2000 new props

Certificates		**Complement**	
Class of Voyage:	Home Trade I	Officers:	13
Ice Class:	100 A	Crew:	33
MARPOL:	Yes	Total:	46
IMO:	6705937	Crewing Regime:	Lay Day
		Available Berths:	53

The program for the extended cruise of the Canadian icebreaker in 2008 included several mooring deployments and recoveries for several scientific programs and a CTD survey, including CABOS mooring recovery and deployment (see **Figure II.I** for mooring location).

II.3. MOORING DEPLOYMENT *(M. Dempsey,O.M.)*

Table II.2: 2008 Operations, CABOS mooring

Investigator	Deployment Depth (m)	Deployment Location	Deployment Time (UTC)
UAF/IARC I. Polyakov	1114	71° 49.702'N 131° 46.591'W.	22 July 2008 1525 (UTC)

Chronology: 22/07/2008 (all times UTC). Conditions: 1 to 2 tenths old ice. Wind 346°T at 10 kts.

14:05 Releases, bottom glass spheres and anchor ready to sling into position.
14:15 Hook up Nilspin on winch through Gifford block in A frame.
15:04 MMP s/n 11494 lowered into water on bottom bumper.
15:54 SBE37 Microcat lowered into water.
15:55 Mooring suspended from pelican hook on 1" nylon rope trough A frame.
15:25 Mooring released. GPS position on bridge: 71°49.681′N 131°46.575′W. Corrections made for draught and sound speed (calculated from that morning's rosette cast) give corrected sounder depth of 1114 m (sound velocity 1457ms-1).
15:30 Enable command 376617 sent to release 28388. SR 1119 m
15:31 Use MCAL 1.04 to do survey of CABOS release position. Conduct 30 point survey covering 270° arc around mooring. Surveyed position: 71°49.702′N 131°46.591′W.
16:25 Complete survey
16:30 Ping top transponder (Interogate 11.0 kHz Reply 14.0 kHz) SR 489-496 m
16:31 Send disable command 376637 to acoustic release s/n 28388. Acknowledgement received and no further replies.
16:05 Move ship off station.

The deployment of the CABOS 2008 mooring was accomplished quickly with the help of many others. The assistance of a trained and motivated deck crew was much appreciated. Also the station keeping of the ship during recovery and deployment was excellent. Many thanks also to Will Ostrom, Jim Dunn, and Rick Krishfield of WHOI for their help and the use of their Lebus dual capstan traction winch.

As deployed in 2008

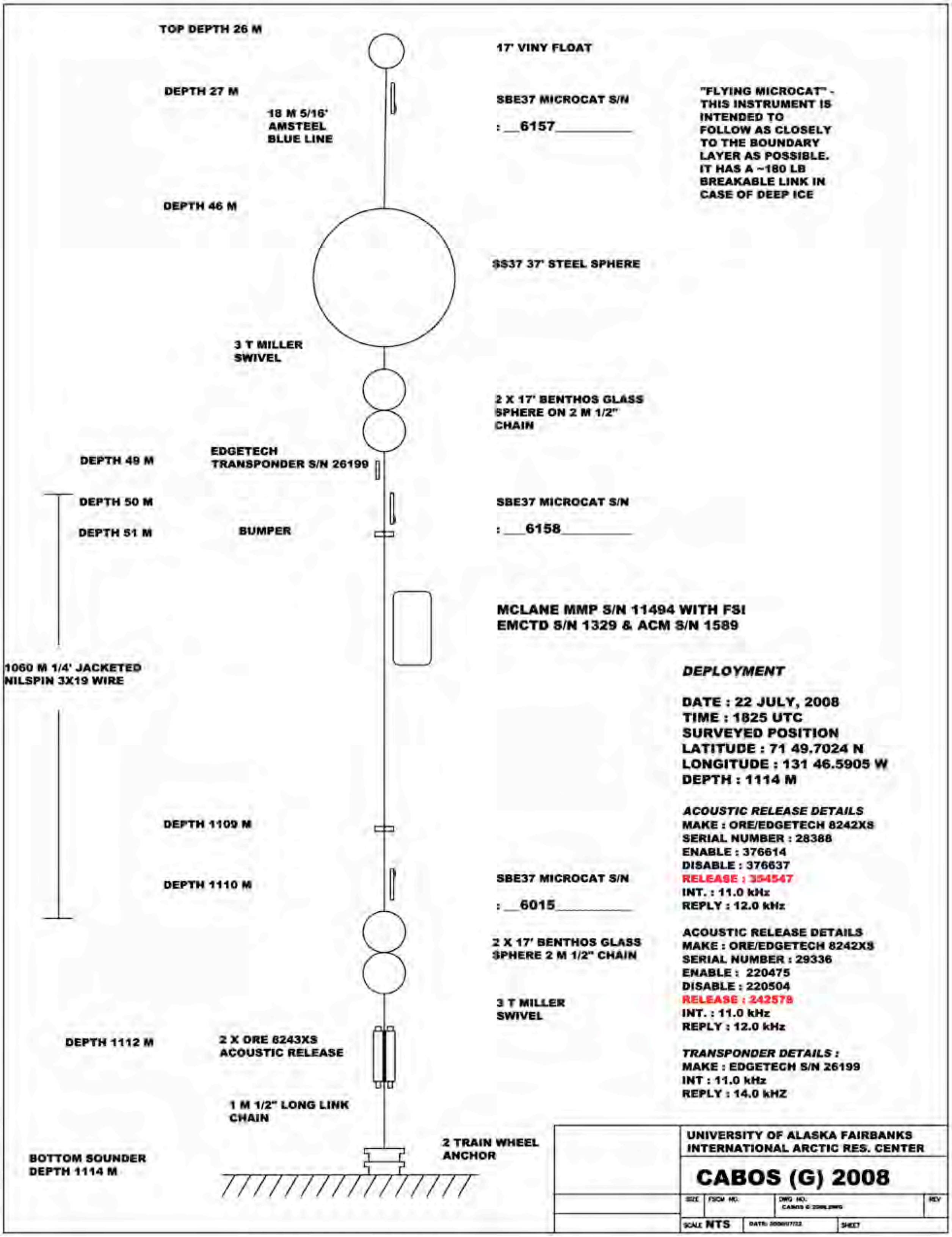


Figure II.2. Deployed CABOS mooring design and equipment.

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Acknowledgments:

This work was supported by IARC/UAF. We would like to thank NSF, NOAA and Shell for providing financial support. Deployment of the CABOS mooring was accomplished with the help of many colleagues from IOS and WHOI.

Peter Keen would like to acknowledge the contribution made by members of the mooring team: Ian Beliveau, Sylvain Blondeau, Jack Greenburg, Piotr Wieczonek, and Larry Hastings. They worked professionally and with unfailing good humour, always with a critical eye to achieving the task at hand and adapting to changing situations with alacrity.

APPENDIX: NABOS-08 Station List (*S. Kirillov, AARI; V. Ivanov, SAMS; I. Polyakov, IARC*)

Station Number: KD0108 Data: 07/10/08 (dd/mm/yy) Time of beginning: 08:26 (hh:mm (GMT))
Latitude: 78° 30,67' N Longitude: 125° 49,41' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	11:53	12:52	= 78° 30,80' =125° 45,82'	= 78° 30,98' =125° 44,45'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	13:14	14:07	= 78° 31,09' =125° 43,71'	= 78° 31,30' =125° 42,80'	
5	Mooring recovering	------		--------		
6	Microstructure	06:26	09:36	= 78° 30,67' =125° 49,41'	= 78° 30,69' =125° 48,88'	

Station Number: KD0208 Data: 07/10/08 (dd/mm/yy) Time of beginning: 18:00 (hh:mm (GMT))
Latitude: 78° 49,9' N Longitude: 125° 59,6' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	18:00	19:04	= 78° 49,9' =125° 59,6'	= 78° 50,0' =125° 59,92'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	19:43	20:54	= 78° 50,0' =125° 59,9'	= 78° 50,0' =125° 59,6'	
5	Mooring recovering	------		--------		
6	Microstructure	18:49	19:33	= 78° 49,99' =125° 59,86'	= 78° 50,0' =125° 60,0'	

Station Number: KD0308 Data: 07/10/08 Time of beginning: 23:40
dd/mm/yy hh:mm (GMT)
Latitude: 78˚ 30,1' N Longitude: 125˚ 48,6' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	------	-----	-------	-------	Sampling levels:
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------		-------	
5	Mooring recovering	23:53	01:45	= 78˚ 29,6' =125˚ 49,1'		triangulation
6	Microstructure	-------	-------	-------	-------	

Station Number: KD0408 Data: 08/10/08 Time of beginning: 16:06
dd/mm/yy hh:mm (GMT)
Latitude: 79˚ 10,88' N Longitude: 125˚ 56,50' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	16:06	17:00	= 79˚ 10,88' =125˚ 56,53'	= 79˚ 11,68' =125˚ 56,55'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	17:10	18:12	= 79˚ 11,70' =125˚ 56,59'	= 79˚ 11,87' =125˚ 57,64'	
5	Mooring recovering	------		--------		
6	Microstructure	16:55	17:10	= 79˚ 11,49' =125˚ 56,18'	= 79˚ 11,70' =125˚ 56,59'	

Station Number: KD0508 Data: 08/10/08 Time of beginning: 21:20
dd/mm/yy hh:mm (GMT)
Latitude: 79˚ 29,9' N Longitude: 126˚ 00' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	End	
1	CTD/Rosette	-------	-------	-------	-------	Sampling levels:
2	XCTD	23:05	23:09	= 79˚ 30,1' =126˚ 01,6'	= 79˚ 30,12' =126˚ 01,67'	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	22:09	23:03	= 79˚ 30,09' =126˚ 01,60'	= 79˚ 30,10' =126˚ 01,61'	
5	Mooring recovering	------		--------		
6	Microstructure	21:20	21:56	= 79˚ 29,9' =126˚ 00'	= 79˚ 29,9' =126˚ 00'	

Station Number: KD0608 Data: 09/10/08 Time of beginning: 01:39
dd/mm/yy hh:mm (GMT)
Latitude: 79˚ 49,86' N Longitude: 126˚ 03,5' E Depth: >1000 m Ice: 9

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	05:07	06:10	= 79˚ 52,43' =126˚ 14,93'	= 79˚ 52,59' =126˚ 16,47'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	X TD	03:20	03:22	= 79˚ 50,07' =126˚ 06,41'	= 79˚ 50,08' =126˚ 06,51	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	01:56	02:48	= 79˚ 49,9' =126˚ 04,1'	= 79˚ 49,9' =126˚ 05,4'	
5	Mooring recovering	------		--------		
6	Microstructure	02:45	03:15	= 79˚ 49,9' =126˚ 05,4'	= 79˚ 49,9' =126˚ 06,2'	

Station Number: KD0708 Data: 10/10/08 Time of beginning: 04:53
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 16,3' N Longitude: 136˚ 29,7' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	05:09	06:05	= 81˚ 16,3' =136˚ 29,7'	= 81˚ 16,7' =136˚ 32,8'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	06:13	07:03	=81˚ 16,76' =136˚ 33,27'	= 81˚ 17,11' =136˚ 36,36'	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD0808 Data: 10/10/08 Time of beginning: 07:00
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 02,33' N Longitude: 137˚ 43,65' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		Beginning	end	beginning	end	
1	CTD/Rosette	08:04	09:15	= 81˚ 02,32' =137˚ 43,57'	= 81˚ 02,44' =137˚ 45,85'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
1'	CTD/Rosette	11:02	12:08	= 81˚ 02,70' =137˚ 48,72'	= 81˚ 02,98' =137˚ 50,50'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	X TD	12:20	12:25	= 81˚ 03,12' =137˚ 50,68'	--------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	09:16	10:19	= 81˚ 02,44' =137˚ 45,88'	= 81˚ 02,57' =137˚ 47,03'	
5	Mooring recovering	------		--------		
6	Microstructure	10:30	10:48	= 81˚ 02,59' =137˚ 47,93'	= 81˚ 02,64' =137˚ 48,36'	
7	Ice sampling	07:40		= 81˚ 02,70' =137˚ 48,72'		

Station Number: KD0908 Data: 10/10/08 Time of beginning: 19:00
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 47,92' N Longitude: 138˚ 51,20' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	19:00	20:00	= 80˚ 47,91' =138˚ 51,18'	= 80˚ 48,11' =138˚ 53,71'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	20:20	21:16	=80˚ 48,19' =138˚ 54,49'	= 80˚ 48,34' =138˚ 56,17'	
5	Mooring recovering	21:55	23:25	=80˚ 47,16' =138˚ 50,08'	=80˚ 47,16' =138˚ 48,47'	Triangulation, cleaning, unsuccess
6	Microstructure	19:00	20:15	=80˚ 47,91' =138˚ 51,18'	=80˚ 48,34' =138˚ 56,17'	

Station Number: KD1008 Data: 10/10/08 Time of beginning: 23:53
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 47,16' N Longitude: 138˚ 48,53' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	23:55	00:51	= 80˚ 47,16' =138˚ 48,53'	= 80˚ 47,53' =138˚ 50,67'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------			
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD1108 Data: 11/10/08 Time of beginning: 04:11
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 31,03' N Longitude: 140˚ 02,86' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	Beginning	end	
1	CTD/Rosette	04:15	05:14	= 80˚ 31,03' =140˚ 02,88'	= 80˚31,32' =140˚ 04,73'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	05:48	06:40	=80˚ 31,49' =140˚ 05,60'	= 80˚ 31,72' =140˚ 07,00'	
5	Mooring recovering	------		--------		
6	Microstructure	05:17	05:41	=80˚ 31,33' =140˚ 04,78'	= 80˚ 31,46' =140˚ 05,44'	

Station Number: KD1208 Data: 11/10/08 Time of beginning: 09:10
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 13,63' N Longitude: 141˚ 12,39' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	Beginning	end	
1	CTD/Rosette	09:28	10:31	= 80˚ 13,82' =141˚ 12,52'	= 80˚ 14,30' =141˚ 13,30'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	11:37	12:32	=80˚ 14,82' =141˚ 13,82'	= 80˚ 15,29' =141˚ 13,64'	
5	Mooring recovering	------		--------		
6	Microstructure	10:48	11:28	=80˚ 14,43' =141˚ 13,48'	= 80˚ 14,74' =141˚ 13,85'	

Station Number: KD1308 Data: 11/10/08 Time of beginning: 15:20
dd/mm/yy hh:mm (GMT)
Latitude: 79° 56,62' N Longitude: 142° 19,96' E Depth: >1000 m Ice: 9-10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	15:28	16:27	= 79° 56,62' =142° 19,96'	= 79° 56,89' =142° 22,81'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	16:53	17:45	=79° 56,99' =142° 24,17'	= 79° 57,22' =142° 26,94'	
5	Mooring recovering	------		--------		
6	Microstructure	15:50	16:44	=79° 56,8' =142° 21,9'	= 79° 44,25' =142° 33,68'	

Station Number: KD1408 Data: 12/10/08 Time of beginning: 00:05
dd/mm/yy hh:mm (GMT)
Latitude: 79° 48,35' N Longitude: 142° 57,97' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	00:12	01:01	= 79° 48,76' =142° 58,53'	= 79° 49,21' =142° 59,08'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700, 750, 800, 850, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	01:08	01:55	=79° 49,26' =142° 59,19'	= 79° 49,76' =143° 00,27'	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD1508 Data: 12/10/08 Time of beginning: 03:30
dd/mm/yy hh:mm (GMT)
Latitude: 79° 40,81' N Longitude: 143° 30,75' E Depth: 500 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	03:37	04:07	= 79°40,81' =143° 30,76'	= 79° 41,04' =143° 31,86'	
2	CTD/Rosette	05:15	05:42	= 79°41,48' =143° 34,64'	= 79° 41,61' =143° 35,02'	Sampling levels: 5, 10, 20, 30, 40, 50, 75, 100, 150, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475 m
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	05:43	06:11	=79° 41,62' =143° 35,05'	= 79° 41,74' =143° 35,1'	
5	Mooring recovering	------		--------		
6	Microstructure	04:09	05:01	=79° 41,11' =143° 32,18'	= 79° 41,32' =143° 33,71'	

Station Number: KD1608 Data: 12/10/08 Time of beginning: 07:52
dd/mm/yy hh:mm (GMT)
Latitude: 79° 32,93' N Longitude: 144° 00,04' E Depth: 300 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	08:07	08:28	= 79° 32,97' =144° 00,09'	= 79° 33,05' =144° 00,41'	Sampling levels: 3, 5, 7, 9, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	08:35	08:54	=79° 33,08' =144° 00,5'	= 79° 33,17' =144° 00,76'	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD1708 Data: 12/10/08 Time of beginning: 11:08
dd/mm/yy hh:mm (GMT)
Latitude: 79° 17,43’ N Longitude: 144° 57,25’ E Depth: 100 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	11:21	11:36	= 79° 17,51’ =144° 57,37’	= 79° 17,6’ =144° 57,44’	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 80, 90 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	11:46	12:03	=79° 17,65’ =144° 57,63’	= 79° 17,76’ =144° 57,82’	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	
7	CTD/Rosette	14:55	15:11	= 79° 12,24’ =144° 50,4’	= 79° 12,35’ =144° 50,52’	Cast 2
8	CTD/Rosette	18:25	18:35	= 79° 13,78’ =144° 55,5’	= 79° 13,83’ =144° 55,68’	Cast 3
9	CTD/Rosette	20:35	20:45	= 79° 14,47’ =144° 57,29’	= 79° 14,66’ =144° 57,64’	Cast 4
10	CTD/Rosette	22:09	22:28	= 79° 15,21’ =144° 58,37’	= 79° 15,35’ =144° 58,53’	Cast 5

Station Number: KD1808 Data: 13/10/08 Time of beginning: 10:04
dd/mm/yy hh:mm (GMT)
Latitude: 79° 26,93’ N Longitude: 158° 21,54’ E Depth: 300 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	10:14	10:34	= 79° 27,0’ =158° 21,64’	= 79° 27,13’ =158° 21,77’	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	10:40	10:59	=79° 27,18’ =158° 21,81’	= 79° 27,32’ =158° 21,91’	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD1908 Data: 13/10/08 (dd/mm/yy) Time of beginning: 12:15 (hh:mm (GMT))

Latitude: 79° 35,36' N Longitude: 158° 46,73' E Depth: 750-840 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	12:20	12:57	= 79° 35,36' =158° 46,73'	= 79° 35,84' =158° 47,06'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 650, 700m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	13:13	13:57	=79° 35,98' =158° 47,22'	= 79° 36,56' =158° 48,11'	
5	Mooring recovering	------		--------		
6	Microstructure	12:50	13:05	= 79° 35,84' =158° 47,06'	= 79° 35,91' =158° 47,15'	

Station Number: KD2008 Data: 13/10/08 (dd/mm/yy) Time of beginning: 15:17 (hh:mm (GMT))

Latitude: 79° 45,71' N Longitude: 159° 20,09' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	15:17	16:11	= 79° 45,71' =159° 20,09'	= 79° 46,40' =159° 21,96'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD2108 Data: 13/10/08 Time of beginning: 03:53
dd/mm/yy hh:mm (GMT)
Latitude: 81° 16,3' N Longitude: 136° 29,7' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	17:55	18:47	= 79° 54,94' =159° 40,32'	= 79° 95,42' =159° 42,26'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------	--------	---------	
5	Mooring recovering	04:00	06:27	= 79° 45,91' =159° 23,95'	= 79° 46,13' =159° 32,88'	
6	Microstructure	------	------	------	------	

Station Number: KD2208 Data: 14/10/08 Time of beginning: 08:25
dd/mm/yy hh:mm (GMT)
Latitude: 80° 02,95' N Longitude: 160° 12,44' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	08:50	09:57	= 80° 02,93' =160° 13,94'	= 80° 02,45' =160° 18,1'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 700, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	10:12	11:00	=80° 02,3' =160° 18,69'	= 80° 01,57' =160° 20,62'	
5	Mooring recovering	------		--------		
6	Microstructure	------	------	------	------	

Station Number: KD2308 Data: 14/10/08 Time of beginning: 13:15
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 20,84' N Longitude: 161˚ 15,81' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	13:18	14:12	= 80˚ 20,84' =161˚ 15,81'	= 80˚ 20,47' =161˚ 14,53'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	14:29	15:22	=80˚ 20,37' =161˚ 14,26'	= 80˚ 20,14' =161˚ 14,00'	
5	Mooring recovering	------		--------		
6	Microstructure	13:59	14:35	=80˚ 20,56' =161˚ 14,82'	= 80˚ 20,31' =161˚ 14,13'	

Station Number: KD2408 Data: 14/10/08 Time of beginning: 17:15
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 33,78' N Longitude: 162˚ 11,96' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	17:24	18:19	= 80˚ 33,78' =162˚ 11,96'	= 80˚ 33,92' =162˚ 15,68'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD2508 Data: 16/10/08 Time of beginning: 08:06
dd/mm/yy hh:mm (GMT)
Latitude: 79˚ 44,65' N Longitude: 159˚ 02,79' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	Beginning	end	
1	CTD/Rosette	-------	------	--------	---------	Sampling levels:
2	XBT	-------	------	--------	---------	
3	Mooring deployment	08:10	-------	=79˚ 44,64' =159˚ 02,81'	---------	
4	Nets	-------	------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	------	--------	---------	

Station Number: KD2608 Data: 16/10/08 Time of beginning: 17:45
dd/mm/yy hh:mm (GMT)
Latitude: 79˚ 19,17' N Longitude: 157˚ 54,71' E Depth: 220 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	Beginning	end	
1	CTD/Rosette	17:49	18:06	= 79˚ 19,17' =157˚ 54,71'	= 79˚ 19,27' =157˚ 55,47'	Pressure sensor frozen
2	CTD/Rosette	18:48	19:05	= 79˚ 19,43' =157˚ 58,03'	= 79˚ 19,41' =157˚ 58,86'	Closed only 1 bathometer
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD2708 Data: 18/10/08 Time of beginning: 10:38
dd/mm/yy hh:mm (GMT)
Latitude: 78˚ 25,43' N Longitude: 125˚ 32,70' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		Begin.	end	beginning	end	
1	CTD/Rosette	10:43	11:45	= 78˚ 25,43' =125˚ 32,70'	= 78˚ 25,03' =125˚ 36,28'	Sampling levels: 5,10,25,50,75,100,150,200, 250,300,350,400,450,500, 550,600,650,700,750,800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	02:10	06:06	------	= 78˚ 25,83' =125˚ 29,29'	
4	Nets	11:48	12:41	=78˚ 25,01' =125˚ 36,39'	= 78˚ 24,60' =125˚ 38,96'	
5	Mooring recovering	------		--------		
6	Microstructure	-------	------	--------	---------	

Station Number: KD2808 Data: 18/10/08 Time of beginning: 14:48
dd/mm/yy hh:mm (GMT)
Latitude: 78° 09,92' N Longitude: 126° 00,77' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	14:48	15:40	= 78° 09,92' =126° 00,76'	= 78° 09,59' =126° 01,83'	Sampling levels: 5, 10, 25, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	15:51	16:46	=78° 09,53' =126° 02,03'	= 78° 09,30' =126° 03,06'	
5	Mooring recovering	------		--------		
6	Microstructure	14:57	15:54	=78° 09,86' =126° 00,96'	= 78° 09,51' =126° 02,10'	

Station Number: KD2908 Data: 18/10/08 Time of beginning: 18:51
dd/mm/yy hh:mm (GMT)
Latitude: 77° 50,14' N Longitude: 126° 00,68' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	18:56	19:47	= 77° 50,14' =126° 00,68'	= 77° 50,15' =126° 02,59'	Sampling levels: 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	20:03	20:55	=77° 50,15' =126° 03,31'	= 77° 50,17' =126° 03,33'	
5	Mooring recovering	------		--------		
6	Microstructure	18:54	20:00	=77° 50,14' =126° 00,68'	= 77° 50,54' =126° 00,90'	

Station Number: KD3008 Data: 18/10/08 Time of beginning: 22:55
dd/mm/yy hh:mm (GMT)
Latitude: 77˚ 30,10' N Longitude: 126˚ 00,29' E Depth: >2000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	beginning	end	
1	CTD/Rosette	22:57	23:54	= 77˚ 30,10' =126˚ 00,29'	= 77˚ 29,86' =126˚ 04,71'	Sampling levels:
2	CTD/Rosette	01:07	01:43	= 77˚ 29,35' =126˚ 10,16'	= 77˚ 29,04' =126˚ 12,40'	Down for 600 m
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	00:00	00:55	=77˚ 29,83' =126˚ 05,16'	= 77˚ 29,45' =126˚ 09,30'	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD3108 Data: 19/10/08 Time of beginning: 03:35
dd/mm/yy hh:mm (GMT)
Latitude: 77˚ 10,38' N Longitude: 126˚ 02,81' E Depth: 900 m Ice: 9

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	03:42	04:34	= 77˚ 10,38' =126˚ 02,81'	= 77˚ 09,95' =126˚ 06,48'	No samples
2	CTD/Rosette	05:53	06:42	= 77˚ 09,42' =126˚ 11,91'	= 77˚ 09,16' =126˚ 15,15'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800 m
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	04:40	05:17	=77˚ 09,89' =126˚ 07,11'	= 77˚ 09,64' =126˚ 09,51'	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD3208 Data: 19/10/08 Time of beginning: 08:37
dd/mm/yy hh:mm (GMT)
Latitude: 77˚ 04,26' N Longitude: 126˚ 04,87' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	08:41	08:57	= 77˚ 04,43' =126˚ 10,46'	= 77˚ 04,41' =126˚ 11,75'	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75,100, 125, 150, 175, 200m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	07:53	08:15	=77˚ 04,27' =126˚ 04,8'	= 77˚ 04,32' =126˚ 07,46'	
5	Mooring recov.	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD3308 Data: 21/10/08 Time of beginning: 00:00
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 44,93' N Longitude: 103˚ 29,98' E Depth: 1500 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	06:15	07:09	= 80˚ 45,00' =103˚ 33,18'	= 80˚ 45,01' =103˚ 34,39'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	07:34	08:31	=80˚ 45,02' =103˚ 34,87'	= 80˚ 45,08' =103˚ 35,68'	
5	Mooring recovering	00:05	06:01	=80˚ 44,93' =103˚ 29,98'	= 80˚ 44,99' =103˚ 32,87'	triangulation
6	Microstructure	07:03	07:39	=80˚ 45,01' =103˚ 34,25'	= 80˚ 45,02' =103˚ 34,97'	

Station Number: KD3408 Data: 21/10/08 Time of beginning: 10:54
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 53,26' N Longitude: 104˚ 37,79' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	11:02	11:53	= 80˚ 53,28' =104˚ 33,84'	= 80˚ 53,51' =104˚ 35,03'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	12:29	13:19	=80˚ 53,65' =104˚ 35,89'	= 80˚ 53,84' =104˚ 37,14'	
5	Mooring recovering	------		--------		
6	Microstructure	11:50	12:28	=80˚ 53,49' =104˚ 34,96'	= 80˚ 53,65' =104˚ 35,89'	

Station Number: KD3508 Data: 21/10/08 (dd/mm/yy) Time of beginning: 16:18 (hh:mm (GMT))

Latitude: 81˚ 00,78' N Longitude: 105˚ 20,42' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	16:23	17:18	= 81˚ 00,78' =105˚ 20,42'	= 81˚ 00,86' =105˚ 21,30'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	17:44	18:35	= 81˚ 00,9' =105˚ 21,64'	= 81˚ 01,05' =105˚ 21,62'	
5	Mooring recovering	------		--------		
6	Microstructure	16:59	17:40	=81˚ 00,83' =105˚ 20,91'	= 81˚ 00,9' =105˚ 21,64'	

Station Number: KD3608 Data: 21/10/08 (dd/mm/yy) Time of beginning: 20:00 (hh:mm (GMT))

Latitude: 81˚ 05,62' N Longitude: 106˚ 16,09' E Depth: >1000 m Ice: 9-10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	20:11	21:07	= 81˚ 05,63' =106˚ 16,09'	= 81˚ 05,82' =106˚ 16,40'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	21:29	22:27	=81˚ 05,91' =106˚ 16,42'	= 81˚ 06,12' =106˚ 16,50'	
5	Mooring recovering	------		--------		
6	Microstructure	21:05	21:20	=81˚ 05,83' =106˚ 16,45'	= 81˚ 05,88' =106˚ 16,40'	

Station Number: KD3808 Data: 22/10/08 Time of beginning: 09:20
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 40,68' N Longitude: 103˚ 00,95' E Depth: 620 m Ice: 9

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	09:40	10:11	= 80˚ 40,68' =103˚ 00,95'	= 80˚ 40,68' =103˚ 01,33'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 575 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	11:15	11:41	=80˚ 40,68' =103˚ 02,02'	= 80˚ 40,69' =103˚ 02,37'	
5	Mooring recovering	------		--------		
6	Microstructure	10:15	10:51	=80˚ 40,68' =103˚ 01,45'	= 80˚ 40,68' =103˚ 01,85'	

Station Number: KD3908 Data: 22/10/08 Time of beginning: 13:50
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 36,51' N Longitude: 103˚ 31,44' E Depth: 340 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	13:50	14:12	= 80˚ 36,52' =102˚ 31,44'	= 80˚ 36,49' =102˚ 31,68'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	14:19	14:40	= 80˚ 36,48' =102˚ 31,73'	= 80˚ 36,47' =102˚ 32,06'	
5	Mooring recovering	------		--------		
6	Microstructure	14:42	15:22	=80˚ 36,47' =102˚ 32,06'	= 80˚ 36,48' =102˚ 32,54'	

Station Number: KD4008 Data: 22/10/08 Time of beginning: 16:36
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 31,71' N Longitude: 102˚ 01,86' E Depth: 284 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	16:36	16:53	= 80˚ 31,71' =102˚ 01,86'	= 80˚ 31,7' =102˚ 02,00'	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	17:05	17:24	=80˚ 31,69' =102˚ 02,26'	= 80˚ 31,75' =102˚ 02,66'	
5	Mooring recovering	------		--------		
6	Microstructure	16:50	17:05	=80˚ 31,70' =102˚ 01,99'	=80˚ 31,69' =102˚ 02,26'	

Station Number: KD4108 Data: 22/10/08 Time of beginning: 18:38
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 27,51' N Longitude: 101˚ 23,23' E Depth: 234 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	18:39	18:57	= 80˚ 27,51' =101˚ 23,23'	= 80˚ 27,47' =101˚ 23,60'	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75,100, 125, 150, 175, 200 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	19:24	19:41	=80˚ 27,49' =101˚ 24,20'	= 80˚ 27,50' =101˚ 24,49'	
5	Mooring recovering	------		--------		
6	Microstructure	19:05	19:23	=80˚ 27,47' =101˚ 23,76'	= 80˚ 27,67' =101˚ 24,05'	

Station Number: KD4208 Data: 22/10/08 Time of beginning: 20:50
dd/mm/yy hh:mm (GMT)
Latitude: 80˚ 23,07' N Longitude: 100˚ 57,61' E Depth: 181 m Ice: 9

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	20:52	21:11	= 80˚ 23,07' =100˚ 57,62'	= 80˚ 23,13' =100˚ 58,06'	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	21:38	21:51	=80˚ 23,24' =100˚ 58,40'	= 80˚ 23,29' =100˚ 58,48'	
5	Mooring recovering	01:00	03:57	=80˚ 21,84' =101˚ 27,99'	= 80˚ 21,94' =101˚ 25,88	Triangulation, cleaning, unsuccessful
6	Microstructure	20:55	21:30	=80˚ 23,13' =100˚ 58,06'	= 80˚ 23,24' =100˚ 58,40'	

Station Number: KD4408 Data: 25/10/08 Time of beginning: 21:00
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 39,75' N Longitude: 311˚ 05,63' E Depth:___m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	-------	------	--------	---------	Sampling levels
2	XBT	-------	------	--------	---------	
3	Mooring deployment	21:00	-------	------	--------	M7
4	Nets	-------	------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	------	--------	---------	

Station Number: KD4508 Data: 26/10/08 Time of beginning: 02:54
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 05,71' N Longitude: 31˚ 17,72' E Depth: ___>1000_____m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	03:09	04:05	= 81˚ 54,67' =31˚ 18,28'	= 81˚ 54,48' =31˚ 19,07'	Unsuccessful
2	CTD/Rosette	05:22	06:18	= 81˚ 54,28' =31˚ 19,91'	= 81˚ 54,12' =31˚ 20,42'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	06:23	07:19	=81˚ 54,11' =31˚ 20,49'	= 81˚ 53,95' =31˚ 21,25'	
5	Mooring recovering	------		--------		
6	Microstructure	04:06	04:50	=81˚ 54,48' =31˚ 18,98'	= 81˚ 54,29' =31˚ 19,87'	

Station Number: KD4608 Data: 26/10/08 Time of beginning: 08:40
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 39,81' N Longitude: 31˚ 08,14' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	Beginning	end	
1	CTD/Rosette	11:52	12:51	= 81˚ 39,97' =31˚ 17,55'	= 81˚ 39,66' =31˚ 19,46'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	13:23	14:13	=81˚ 39,50' =31˚ 20,57'	= 81˚ 39,24' =31˚ 22,31'	
5	Mooring recovering	08:49		=81˚ 39,81' =31˚ 08,18'	-------	
6	Microstructure	12:53	13:15	=81˚ 39,65' =31˚ 19,58'	= 81˚ 39,54' =31˚ 20,30'	

Station Number: KD4708 Data: 26/10/08 Time of beginning: 16:00
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 36,57' N Longitude: 31˚ 00,60' E Depth: >1800 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	16:00	16:58	= 81˚ 36,58' =31˚ 00,60'	= 81˚ 36,29' =31˚ 02,78'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	17:04	17:55	=81˚ 36,29' =31˚ 02,78'	= 81˚ 36,06' =31˚ 04,68'	
5	Mooring recovering	------		--------		
6	Microstructure	18:01	18:24	=81˚ 36,01' =31˚ 04,97'	= 81˚ 35,91' =31˚ 05,84'	

Station Number: KD4808 Data: 26/10/08 Time of beginning: 21:23
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 27,38' N Longitude: 30˚ 57,51' E Depth: 520 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	21:32	22:03	= 81˚ 27,38' =30˚ 57,52'	= 81˚ 27,22' =30˚ 59,20'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	22:20	22:48	=81˚ 27,17' =31˚ 00,20'	= 81˚ 26,90' =31˚ 04,98'	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD4908 Data: 27/10/08 Time of beginning: 00:57
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 24,55' N Longitude: 30˚ 58,24' E Depth: 330 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	01:05	01:20	= 81˚ 24,55' =30˚ 58,25'	= 81˚ 24,39' =30˚ 59,22'	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150, 175, 200 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	01:22	01:41	=81˚ 24,34' =30˚ 59,46'	= 81˚ 24,23' =31˚ 00,09'	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD5008 Data: 27/10/08 Time of beginning: 03:30
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 19,08’ N Longitude: 31˚ 01,93’ E Depth: ___190__m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	03:33	03:45	= 81˚ 19,08’ =31˚ 01,93’	= 81˚ 18,90’ =31˚ 02,34’	Sampling levels: 5, 10, 20, 25, 30, 40, 50, 75, 100, 125, 150, 175 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	03:45	04:08	=81˚ 18,90’ =31˚ 02,34’	= 81˚ 18,64’ =31˚ 02,75’	
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD5108 Data: 27/10/08 Time of beginning: 10:51
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 33,66’ N Longitude: 30˚ 49,95’ E Depth: ___>1000______m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	Beginning	end	
1	CTD/Rosette	11:08	12:03	= 81˚ 33,52’ =30˚ 50,18’	= 81˚ 33,42’ =30˚ 50,75’	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	-------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	12:18	12:44	=81˚ 32,91’ =30˚ 50,87’	= 81˚ 32,70’ =30˚ 51,66’	

Station Number: KD5208 Data: 27/10/08 Time of beginning: 15:54
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 29,73’ N Longitude: 30˚ 54,61’ E Depth: ___>1000______m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		begin	end	beginning	end	
1	CTD/Rosette	15:54	16:33	= 81˚ 29,73’ =30˚ 54,61’	= 81˚ 29,49’ =30˚ 53,98’	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	16:35	17:22	=81˚ 29,47’ =30˚ 53,84’		
5	Mooring recovering	------		--------		
6	Microstructure	-------	-------	--------	---------	

Station Number: KD5308 Data: 27/10/08 Time of beginning: 20:09
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 34,99' N Longitude: 30˚ 55,49' E Depth: >1000 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	20:09	20:59	= 81˚ 34,99' =30˚ 55,49'	= 81˚ 34,79' =30˚ 54,71'	Sampling levels: 5, 10, 25, 60, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 900, 1000 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	------	--------	---------	

Station Number: KD5408 Data: 27/10/08 Time of beginning: 22:25
dd/mm/yy hh:mm (GMT)
Latitude: 81˚ 31,74' N Longitude: 30˚ 51,39' E Depth: 900 m Ice: 10

#	Research Activity	Time, GMT		GPS Position		Comments
		beginning	end	beginning	end	
1	CTD/Rosette	22:29	23:05	= 81˚ 31,74' =30˚ 51,39'	= 81˚ 31,49' =30˚ 51,30'	Sampling levels: 100, 130, 150, 170, 220, 270, 320, 370, 415, 465, 512, 560, 612, 640 m
2	XBT	-------	------	--------	---------	
3	Mooring deployment	-------	-------	--------	---------	
4	Nets	-------	------	--------	---------	
5	Mooring recovering	------		--------		
6	Microstructure	-------	------	--------	---------	