Joint Ocean Ice Study (JOIS) 2009
Cruise Report

Photo: Jeffrey Charters

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* September 17 to October 15, 2009

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2009 involved the collaboration of Fisheries and Oceans Canada researchers with colleagues primarily from Japan and the U.S. This program forms an important Canadian contribution to international climate research program and is comprised of two ongoing programs: the Beaufort Gyre Exploration Project (BGEP), a collaboration with Woods Hole Oceanographic Institution scientists and the Pan-Arctic Climate Investigation (PACI), a collaboration with Japan Agency for Marine-Earth Science and Technology (JAMSTEC) scientists. In 2009 JOIS also included ancillary programs carried out by researchers from: the Ocean University of China; the International Arctic Research Center in Fairbanks Alaska; Tokyo University, Japan; Kitami Institute of Technology (KIT), Japan; the Korea Polar Research Institute (KOPRI); and the University of Washington. In addition, two Korean journalists were on board from the Educational Broadcasting System (EBS) to document these research programs for television.

Research questions sought to understand the impacts of global change on the physical environment and corresponding biological responses by tracking and linking decadal scale perturbations in the Arctic atmosphere (e.g. Arctic Oscillation and Beaufort Gyre) to interannual basin-scale changes in freshwater content, water mass properties, water mass distribution, ocean circulation and biota distribution. In particular to:

- Understand the impacts of global change on sea ice and other fresh water products by utilizing a suite of stable isotopes and geochemical markers to quantify freshwater components and investigate water mass pathways.
- Investigate physical processes such as ice formation and gas exchange, turbulence and heat transfer, thermohaline intrusions, ventilation, boundary currents, and geothermal heating**.**
- Investigate distribution of phytoplankton and zooplankton.

2. CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S St-Laurent* began September 17th and finished October 15th, 2009. The research was conducted in the Canada Basin from the Beaufort Shelf in the south to north to 80°N by a research team of 29 people. Full depth CTD casts with water samples were conducted, measuring biological, geochemical and physical properties of the seawater. The deployment of expendable temperature and salinity probes increased the spatial resolution of CTD measurements. Moorings and ice-buoys were serviced and deployed in the deep basin for daily time-series. Underway ice observations were taken and on-ice surveys conducted. Zooplankton net tows, phytoplankton and bacteria measurements were collected to examine distributions of the lower trophic level. Upper ocean turbulence was measured using a turbulence profiler; light attenuation was measured with PRR profiles; and underway measurements were made of the surface water. Daily dispatches were posted to the web and the Korean media team took footage of the science operations to make documentaries for both international and Korean viewing.

The goals of the JOIS program, led by Fiona McLaughlin of Fisheries & Oceans Canada (DFO), were met during the successful four-week program. This year, because of the late season ship schedule, science operations were less efficient and significant difficulties were encountered due to cold weather, the limited hours of daylight, and a number of storms. In addition the transfer of a crew member and the requirement to obtain fuel markedly decreased the number of days available for science (>2 days). With open water along our western section, transit times were faster than planned which allowed us to make up time however this was at the cost of putting a strain on and tiring both the science and ship's crew. Of the seven originally planned stations, two were obtained by repositioning other stations, and the other five were from an area specified as 'if time allows' and one ITP that had stopped working was recovered to the north of the proposed cruise track.

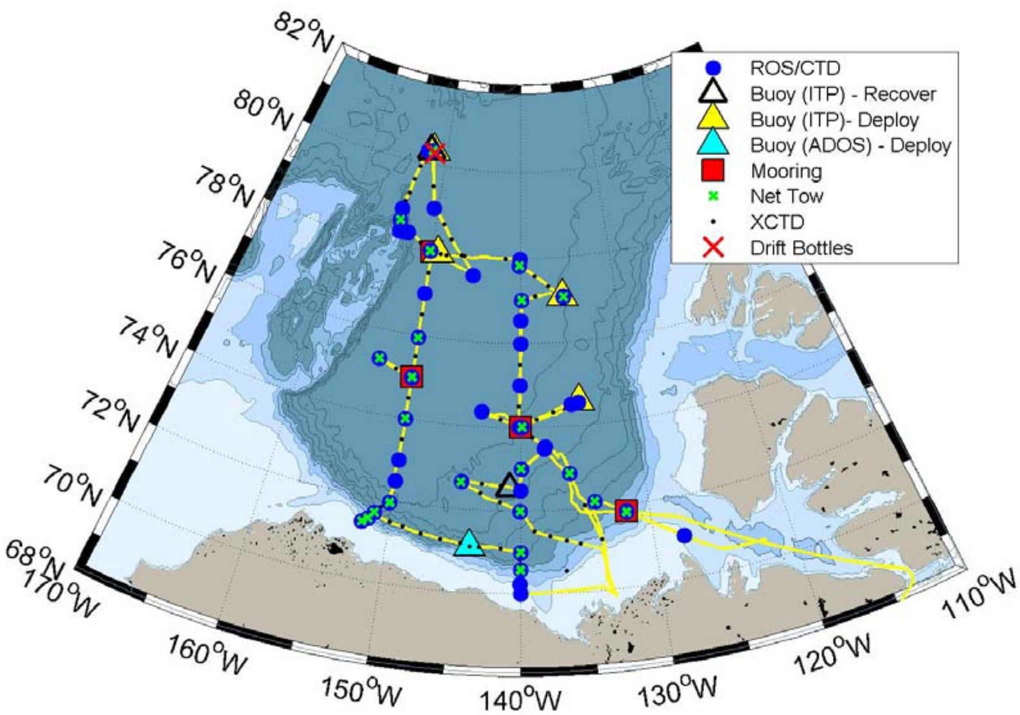


Figure 1.The JOIS-2009 cruise track showing the location of science stations.

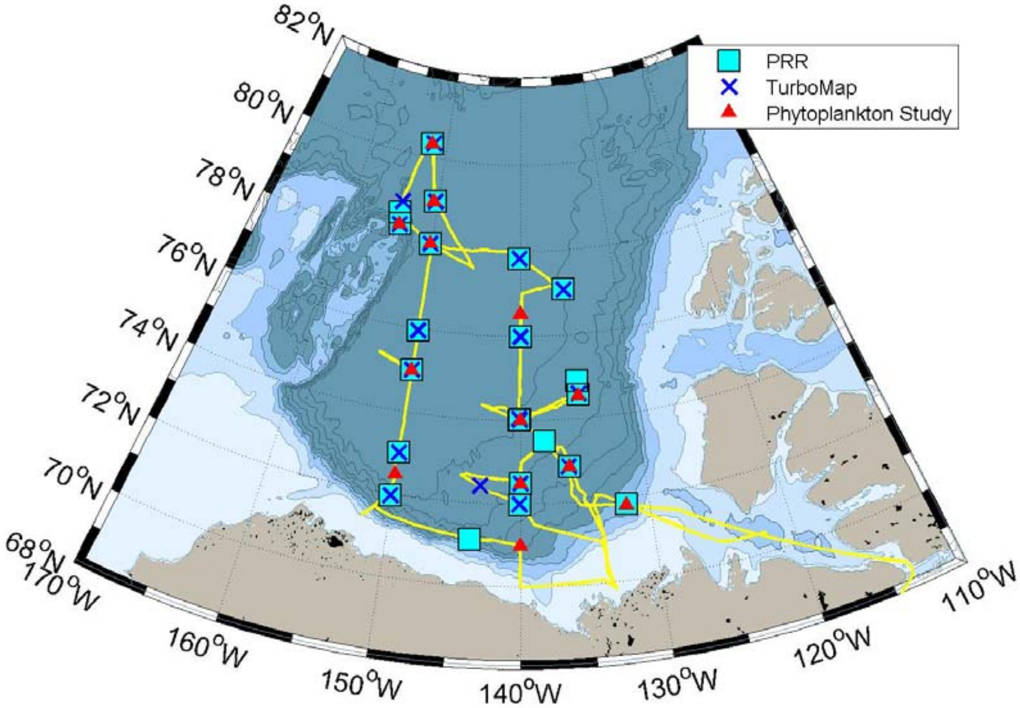


Figure 2. Locations of the PRR and TurboMap profiles and the phytoplankton productivity sites.

3. PROGRAM COMPONENTS

Distance Covered: 8500km (Kugluktuk to Kugluktuk)

Measurements:

- At CTD/Rosette Stations:
  - 53 CTD/Rosette Casts at 43 Stations (DFO) with 1123 water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (IOS, UBC, BIO and KOPRI).
    - At all stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC, at surface only), Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a.
    - At selected stations: Ammonium, DIC (full profile), $DI^{13}C$ and Phytoplankton for Productivity Study.
  - 1 Foredeck Niskin Cast (DFO)
  - Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts (DFO)
  - 63 Vertical Net Casts at 24 select Rosette stations typically to 100m with occasional casts up to 1000m deep (DFO)

- 18 Turbulence Profiler Casts using a TurboMap (Tokyo University)
  - 23 Light Attenuation Profiler Casts using a PRR. (OUC)
  - 13 Measurements for a carbon uptake experiment (primary productivity) including use of outside water baths at sea-surface temperature (KOPRI)
- 56 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth (JAMSTEC, Tokyo University, WHOI)
- Mooring and buoy operations
  - 4 Mooring Recoveries (3 deep basin (WHOI), 1 slope mooring (IARC))
  - 4 Mooring Deployments (3 deep basin (WHOI) and 1 slope mooring (IARC))
  - 4 Ice Buoy Deployments
    - 3 sites with an Ice Tethered Profiler (ITP, WHOI)
    - 1 multi-buoy site with an ITP (WHOI), Ice Mass Balance Buoy (CRREL), and O-buoy (CRREL)
  - 1 Open Water Buoy Deployment (UW)
- Ice Observations
  - Ice Observations (IARC)
    - Hourly visual observations from bridge and automated fixed-camera photos.
    - Opportunistic aerial observations during helicopter flights
    - On-ice observations of ice-depth transects and ice-cores
  - Ice Observations (KIT)
    - Underway measurements of ice thickness from passive microwave sensor, an electromagnetic inductive sensor (EM-31), and a fixed camera.
    - On-ice observations of snow composition.
  - Ice Observations (UBC)
    - Ice cores collected from the ice and from zodiac and water sampled from directly under the ice for carbon isotope samples to study carbon cycling.
- Underway collection of meteorological, depth, near-surface seawater, and navigation data with 152 water samples collected from the underway seawater loop for: Salinity, Oxygen, Nutrients, Barium, ^{18}O, $DI^{13}C$, DIC/Alkalinity, Particulate Organic Carbon (POC), and CDOM. (DFO,UBC)
- Drift Bottles deployed at 1 site (DFO)
- Daily dispatches to the web (WHOI)
- Media filming 2 documentaries (EBS)

Other:

- Passenger transfer to Tuktoyaktuk (CG crew member)
- Fuel (2000m^3 litres) loaded by barge near Tuktoyaktuk, the first attempt on Sept 21 was not possible due to weather, then fuelling occurred on Sept 25 and took more than 24 hours.

4. PROGRAM COMPONENT DESCRIPTIONS

Descriptions of the programs are given below with event locations listed in the appendix. Please contact program principle investigators for complete reports.

4.1 **Rosette/CTD Casts:** Fiona McLaughlin (IOS) PI, Mike Dempsey

The primary CTD system used on board was a Seabird SBE9+ CTD s/n 0756, configured with a 24- position SBE-32 pylon with 10L Niskin bottles fitted with internal stainless steel springs in an ice-strengthened rosette frame. The data were collected real-time using the SBE 11+ deck unit and computer running Seasave V7 acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, two oxygen sensors, fluorometer, transmissometer, CDOM fluorometer and altimeter. In addition, an ISUS nitrate sensor was used on select casts shallower than 1100 m. A surface PAR sensor was installed for Cast 11. These sensors have 0-5v analogue output which is included in the CTD data string.

Figure 3. The 24-bottle rosette with the SBE9+ CTD is deployed by Mike Dempsey.

A second CTD, SBE19 s/n 2688, was used for a few casts from zodiac and ship. The internally recording SBE19 CTD is configured with pumped temperature and conductivity. During one use, 1.7 and 5L Niskins were attached to the foredeck winch wire to trip bottles with better flushing than from the rosette.

On all rosette casts we sampled Salinity, Dissolved Oxygen, Nitrate (NO3), Silicate (SiO4), Phosphate (PO4), Chlorophyll-a (filtered at 0.7 µm with chlorophyll-a and phaeopigment values for each), Colored Dissolved Organic Matter (CDOM), Alkalinity, surface Dissolved Inorganic Carbon (DIC), ^{18}O, Barium, and Bacteria. On selected casts we sampled Ammonium, full profile DIC, and DI^{13}C.

Figure 4. Sampling in the Rosette Lab (photo Jeffrey Charters).

During a typical rosette cast: The transmissometer and CDOM sensor windows were sprayed with deionised water and wiped with a DI water-soaked lens cloth prior to each deployment. The package was lowered to 5m to cool the system to ambient sea water temperature, remove bubbles from the sensor's plumbing and equilibrate the oxygen sensor. The pumps turned on automatically after the conductivity cell sensed salinity greater than 16 PSU for a period of 1 minute and then system was soaked for 3 minutes. The package was then brought up to just below the surface to begin a clean cast, and lowered to within 8-10m of the bottom at 60m/min. Niskin bottles were closed during the upcast without a stop. The instrumented sheave (Brook Ocean Technology) read out to the winch operator, CTD operator and bridge, allowing all three to monitor cable out, wire angle and CTD depth.

Figure 5. Bringing the full rosette in the sampling room.

In the upper 400m, the sample depths were chosen to match a set of salinity values. During the downcast, the depths of the salinity values were noted so that on the upcast the bottle could be closed at the pre-determined depths.

Data/Performance notes:

The SBE9+ CTD overall performance was very good.

The primary oxygen sensor, a SBE-43, performed well. There were shifts in the readings requiring calibration but no issues with the membrane. A secondary oxygen sensor, the newly developed JFE-Alec Rinko III oxygen sensor, was put on for trial. Performance from preliminary data looks good although there is a continuous drift in the reading between each station.

There were initially problems with cross-talk between the CDOM sensor and the ISUS nitrate sensor that shared a cable and differential input connector on the CTD. Both the CDOM data and the ISUS data were compromised during the casts where the ISUS was installed until the problem was resolved after cast 39.

Due to the colder temperatures (0 to -20C) resulting from the timing of this years cruise:

Figure 6. The 'de-icer' attached to the CTD wire.

Problems were encountered with icing up of the Brooke Ocean technology (BOT) block. A pneumatic air blower (the "de-icer") was clipped onto the wire to dry the wire as it came in. Results were very good and after a few deployments, the installation required only an extra couple of minutes for each cast. At the completion of the cruise it was noted however that all 4 fairlead rollers had seized at some time and had been grooved by the wire and will require replacement before next cruise.

Effort was made to reduce the time of the Rosette on deck to prevent freezing of the sensor. The Rosette lab's doors would remain closed until the bridge gave permission to start the cast. The Rosette was then brought out and lowered into the water as quickly as possible. This step was repeated in reverse at the end of the cast. During one cast, Cast 45, the plumbing to the secondary temperature, conductivity and fluorometer was blocked, presumably with ice either formed while the CTD was on deck or in the surface waters. This resulted in fixed values for the upper 50m until the ice melted and flow was resumed. A suggestion for future casts is to check for dual sensor agreement during the initial surface soak and lower into warmer water (ex. 40m or into Atlantic Water at 400m) if there appears to be frozen plumbing or a frozen sensor before raising back to the surface.

With the increased hours of darkness, working lights were found an installed to improve visibility of the CTD operation. A suggestion for future cruises is to have a light mounted on the rail on the deck above to illuminate the working deck and to have a light mounted on outboard, aft, corner of the rosette lab, illuminating the water surface.

The 53 CTD/Rosette cast location are listed in the appendix

Sampling took place immediately after each cast in the heated rosette room. The order of sampling was fixed, based on sampling water most susceptible to gas exchange or temporal changes first. Dissolved Oxygen, Nutrients, Salinity, and Ammonium were analysed on board. All other samples were prepared as required and stored for analysis on shore.

Figure 7. Glenn Cooper analysing salinity. (photo Nina Nemcek)

Figure 8. Linda White runs the nutrients.

Figure 9. Oxygen analyses conducted by Nina Nemcek.

4.2 Side-of-ship ADCP (Svien Vagle PI)

Figure 10. ADCP being lowered to 5m during rosette cast.

In conjunction with the CTD/Rosette Casts, an RDI acoustic doppler current profiler (ADCP) measuring currents in the upper waters and two backscatter transducers looking for layers of zooplankton were lowered over the side. The package was lowered by crane from the boatdeck to approximately 5m beneath the surface and left in place until the completion of the CTD cast. The ship's heading and location, recorded using the SCS data collection system, , provides ADCP orientation information so the velocity of surface currents can be determined.

4.3 Zooplankton Vertical Net Haul

Kelly Young and Lori Waters, P.I. John Nelson(DFO)

Figure 11. The 4-net 'Bongo' used on the JOIS program. Photo by Alex Kain.

A total of 63 bongo net hauls were completed at 25 stations. Bongos were harnessed and deployed in the same manner as the 2008-30 JOIS cruise. Standard, duplicate tows to 100m were sampled at all stations except one where weather and time restraints limited the deployment to one 100m tow (MK-3). In addition to the routine tows, additional tows to depths of 200, 500 and 1000m were conducted at select stations (Table 1). Samples were preserved following the method in 2008-30, with the following additions for the deep tows:

Cast 1 (100m):

- 236 µm into buffered formalin (10%)

- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

Cast 2 (100m):

- 236 µm 95% ethanol
- 150 µm frozen in whirl-pak at -80°C
- both 53 µm combined 95% ethanol

Deep Casts (200, 500 & 1000m):

- 236 µm 95% ethanol
- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

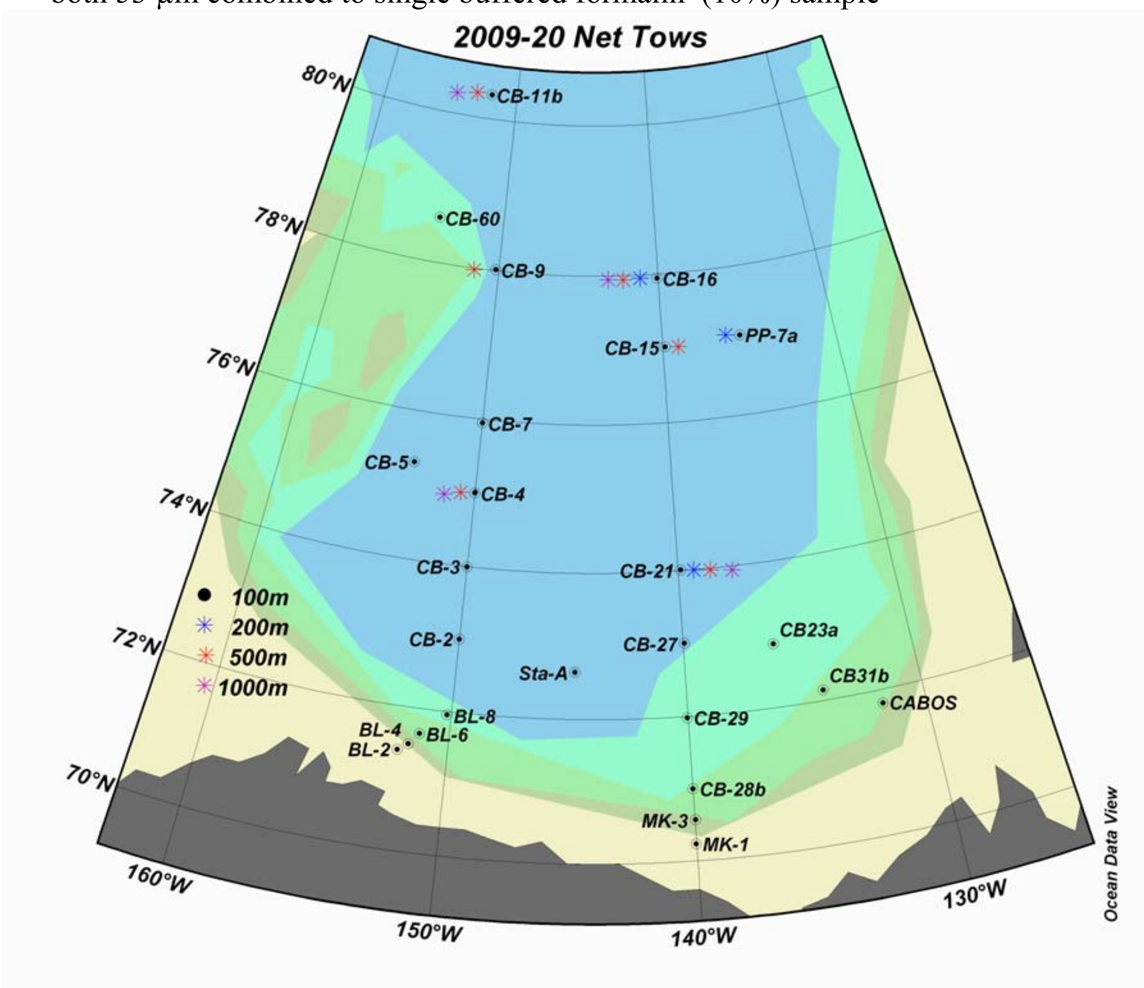


Figure 12. Map of zooplankton net tows for cruise 2009-20

Problems with the flowmeters were a common occurrence during this cruise, as the MF-315 flowmeters had a tendency for freezing up in the Arctic conditions.

The gears would also jam occasionally, and adjacent numbers would roll over out of sequence. To prevent the flowmeters from freezing between casts, they were removed immediately following the cast and brought inside the lab to defrost, and replaced immediately before the next cast. Occasional freezing up still occurred, especially for the multi-tow casts (deep tows) or on very chilly, windy days. Since similar problems were encountered last year, a TSK flowmeter was also used on one side of the large bongo frame. The TSK worked well in the cold; however errors occurred from the occasional misreading of the dial. This type of error would be reduced with experience and by having multiple people reading the dial to check for consistency.

An attempt was made to calibrate the flowmeters onboard near the end of the trip (at CB-12, 12-Oct-09). The nets were removed from the bongo frame, and the flowmeters attached. The frame was then lowered to 100m and raised to the surface in the same manner as a standard tow. Ideally the ascent rate should be constant at $1\ m\ s^{-1}$, and multiple tows and depths conducted; however only 2 tows to 100m were completed due to time constraints. The flowmeter values varied greatly between the two tows, making calibration difficult. The calibration coefficient was calculated using only the first of the calibration tows, as the other values did not agree well with expected trends for a 100m tow (Table 2). The calibration coefficients in Table 2 should be used with caution, if at all, until a complete sequence of calibration tows can be done (preferably 10-100m, plus a set of depths ranging from 50-1000). The net efficiency was then summarized for each type of net used (Table 3).

Table 2. Flowmeter calibration coefficients obtained from one 100m tow during 2009-20

Flowmeter	frame	Revs m^{-3}	coeff
TSK 2767	large	27.51	0.036
MF-315 #1	small	92.78	0.011
MF-315 #2	small	94.28	0.011
MF-315 #3	large	20.50	0.049

Table 3. Net efficiency for each net used during 2009-20. These are preliminary values, and should not be used with confidence until a complete set of calibration tows can be done.

Flowmeter	Mesh (μm)	Depth (m)	Average Net Efficiency (%)	σ (%)
MF-315 #3	236	100	65.2	10.9
TSK 2767	150	100	81.7	11.1
#1 & 2	53	100	75.7	24.1

The weight and weight-line of the bongos were adjusted this cruise to make it easier to deploy and retrieve the nets. The weight-line needs to be long enough so the weight does not interfere with the cod ends and the nets can hang freely, while short enough so the cod-end guidelines are not too long to get tangled during the tow. The solution was to slightly shorten the weight-line and attach the 2-53μm nets to the top of the weight, and attach the 236 and 150μm (which are longer than the smaller nets) to the bottom of the weight.

One of the 53□m mesh nets was damaged on 27-Sept-09 (MK-3) and removed from the frame for repair. It was thought at the time that there were no replacements available so only one 53□m was used until the net was repaired on 1-Oct-09 (CB-9). However, it was discovered at the end of cruise that there are 2 more 53□m nets available, and can be used for next year with the 2 older 53□m nets available as spares.

The fire hose froze several times during this cruise, which was sometimes solved by ships engineering, and by the deck crew storing the hoses in a warm container. When the fire hose was not available, the net was “dipped” to rinse by slowly raising the bongos clear of the surface, lowering them slowly back down until the frame was just above the surface, and then raising them slowly again. This method may not have worked well on the particularly cold and windy nights as the mesh would freeze as soon as they cleared the water.

4.4 Turbulence Profiles

PI Koji Shimada (Tokyo University))

Turbulence measurements were made using a TurboMAP instrument (http://www.alecchina.com/html/turbulence.htm) to evaluate mixing in the upper ocean (i.e. heat flux from Pacific water layer to surface mixed layer and its dependency on small scale ice motions and latitude). Casts were conducted at CTD stations when opportunity allowed, typically to 500m. The TurboMap data is recorded real time via a conducting cable. The TurboMap free falls at approximately 1m/s collecting measurements. It is then brought back to the surface by a rail mounted winch. The winch was initially set up on the stern rail and the HYAB crane was used to lift the TurboMap for deployment and recovery. The operation was moved to the foredeck, aft of the area used for mooring operations, mid-way through the cruise for instrument safety and ship handling concerns. The TurboMap was then deployed and recovered via the large foredeck crane. Because the crane required a crane operator, the casts were limited to day-work hours.

Figure 14. The TurboMAP

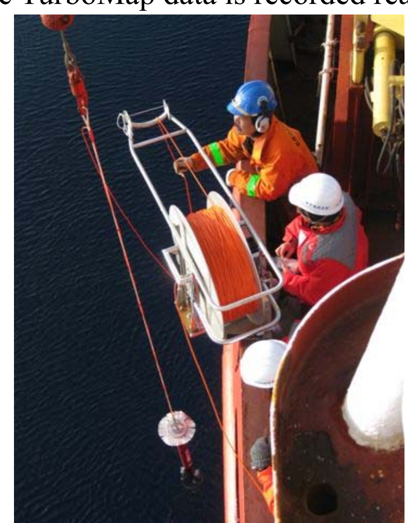


Figure 13. The winch and cable for the Turbomap

19 turbulence profiles were collected with a range between 150 and 580m deep.

4.5 Optical Observations (Light Attenuation Profiles)

Jinping Zhao P.I. and Weibo Wang, OUC

1. Introduction

Dr. Jinping Zhao, professor of physical oceanography, and Weibo Wang, graduate student from Ocean University of China participated on the cruise to conduct optical observations. Optical observation includes the units, PRR-800 for underwater profiling and PRR-810 for surface observation simultaneously. They are a multispectral system to measure the change of sunlight in sea water. Optical measurements are conducted in daytime. During the cruise, about 23 optical profiles were conducted successfully.
The optical data is beneficial to understand the solar heating in the upper layer of the ocean and correlated to the climate system. The optical data has also good linkage with biological activities. The signals of different wavelengths include the information from various biomasses.

2. Optical instruments

The instruments used for optical observation are high resolution Profiling Reflectance and Radiometer (PRR) made by Biospherical Instruments Inc. (BSI, USA). The system includes both an underwater profiler PRR800 and a surface unit PRR810, which collect signals simultaneously. Both instruments are all multispectral ones with very high resolution and sensitivity, enough to detect the light in deeper water. The parameters for the system are as follows.

PRR-800

Optical features:

Wavelenths:313,380,412,443,490,510,520,532,555,565,589,625,665,683,710,765,780 and 875nm

Bandwidth: 10nm FWHM

Sensors:

Upwelling radiance, downwelling irradiance, dual axis inclinometer, detector array temperature, PRT water temperature, and pressure/depth

Irradiance array

Typical Saturation: 10^5 $\mu Wcm^{-2}nm^{-1}$

Noise Equivalent Irradiance: $10\ ^5\mu Wcm^{-2}nm^{-1}$

Radiance array

Typical Saturation: 10^{-3} $Wcm^{-2}nm^{-1}$ sr^{-1}

Noise Equivalent Irradiance: 10^{-12} $Wcm^{-2}nm^{-1}$ sr^{-1}

PRR-810

Optical features:

Wavelenths:313,380,412,443,490,510,520,532,555,565,589,625,665,683,710,765,780 and 875nm

Bandwidth: 10nm FWHM

Sensors:

Downwelling irradiance and detector array temperature

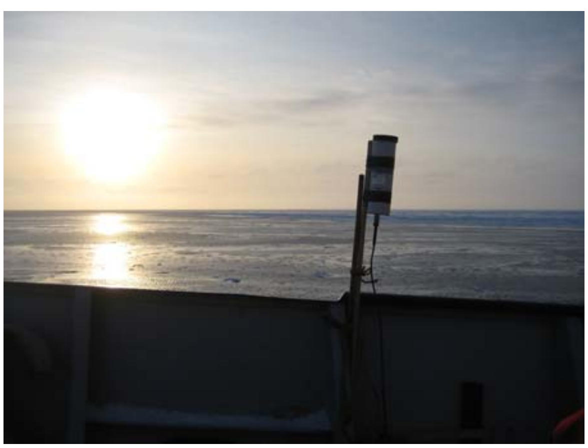
PRR-800/810 is a cable linked system to collect data directly by a computer during the deployment. A unit is adopted to link PRR-800, PRR-810 and computer to control the data acquirement.

2.3 MCTD

A Compact-CTD (MCTD) made by ALEC Electronics Co. Ltd (Japan) is mounted on the same frame with PRR800 for deployment. MCTD is used to measure depth, temperature, salinity, chlorophyll, and turbidity, simultaneously and records data internally. The technical parameters for MCTD are listed in Table 1.

Table 1 Technical parameters for MCTD

Sensor	Range	Resolution	Accuracy
Depth	0 600m	0.01m	0.3 FS
Temperature	-5 40℃	0.001℃	±0.01℃
Conductivity	0 60mS/cm	0.001 mS/cm	±0.02mS/cm
Chlorophyll	0 400ppb	0.01ppb	±1 or ±0.1ppb
Turbidity	0 1000FTU	0.03FTU	±2% or ±0.3FTU



Above left is the surface unit PRR-810, fixed on the side of starboard of the ship to minimize reflection from the ship. Above right is the PRR-800 (right) and MCTD (left), mounted on a frame specially designed to keep the instruments balance din water and not to shade the PRR-800.

2.3 Deployment of underwater system

The underwater system is deployed by the winch on the starboard. The members of crew helped to operate the winch and kept the communication with the bridge.

The system was linked to the steel rope wrapped on the winch. The rope passed the A-frame to the water. The instrument system was deployed by the rope, while the cable linking the instrument and computer are deployed together with the underwater system. A-frame was operated by crew members.

To increase the vertical stability of the underwater unit, 5 kg of steel blocks are attached to the balance the system, which reduced the tilt less than 7 degree even in the worst sea condition.

The data collection unit and computer were put on a box to real-time monitor the depth of the underwater instruments and the data quality. A dark value was recorded for optical system before the deployment. When it reached bellow the sea surface, the instrument is kept is the water for half minutes to balance the temperature. After then, it is lifted up the surface than going down again for profiling. The profiling usually took 15 minutes with the deployment speed less than 0.5 m/s.

The sampling frequency of PRR800/810 is 5Hz, a record per 0.2 second. The sampling interval time for MCTD is 0.1second.

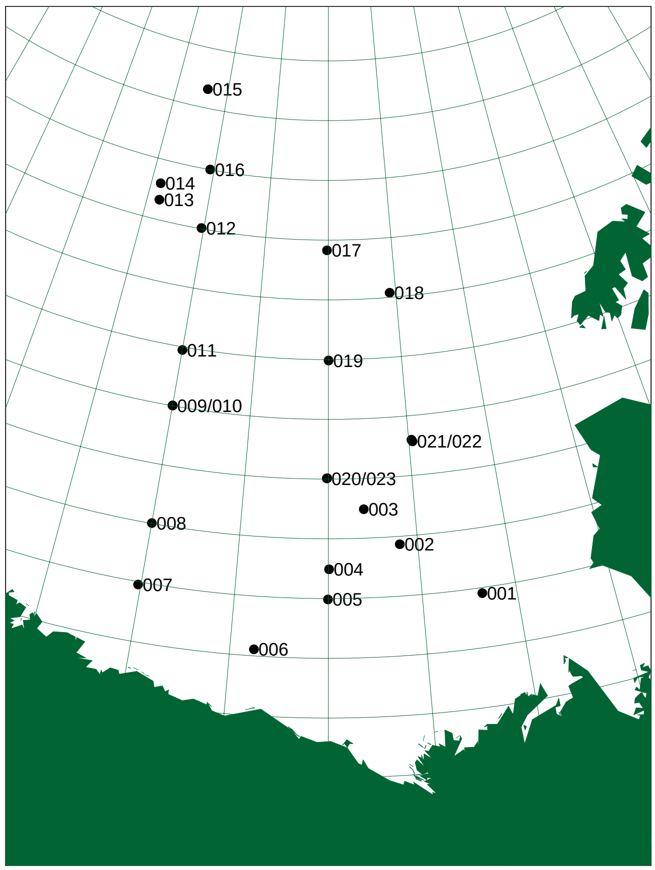
3. Measurements

3.1 Profiling

The optical unit and MCTD were deployed all the time from the A-frame in the foredeck with the winch. The daytime in this cruise is much shorter, so no optical observations in the most stations.

In the cloudy days, the sky became dark. The radiations in those days were quite low. Sometimes the directions of light and wind were different, we have to deploy in the shadow of the ship. In this case, the radiation was only 1/5 of the normal.

All the data we used is the original data, which file names as listed in Table 2, together with other information of each station. However, the original data is exported from Access files, which is recorded by the instrument system. The names of Access files for each station are listed in the record form.



Stations for optical observation in cruise JOIS2009

Table 2 Information of stations for optical observations

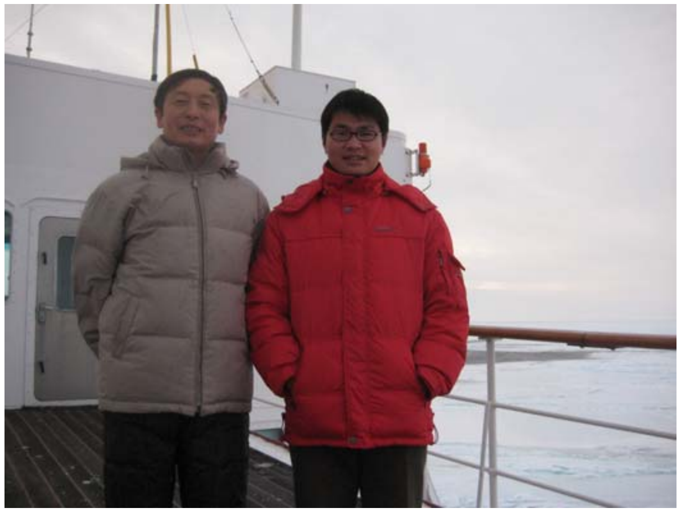
No	Name	Date	UTC	Location	Depth	800	810	CTD
001	CABOS	09-20	19:20	71 54.49'N 131 49.46'W	**114**	●	●	●
002	CB23a	09-22	16:11	72 52.13'N 136 00.15'W	**120**	●	●	●

003	CB22	09-22	01:41	73 29.10'N 137 56.77'W	**104**	●	●	●
004	MK7	09-23	17:08	72 29.41'N 139 57.69'W	**110**	●	●	●
005	CB29	09-24	22:24	71 59.13'N 140 01.29'W	**120**	●	●	●
006	006	09-27	18:08	71 06.59'N 143 46.47'W	**100**	●	●	●
007	BL8	09-28	17:15	71 57.17'N 150 08.74'W	**107**	●	●	●
008	CB2	09-28	01:29	73 00.37'N 149 59.64'W	**105**	●	●	●
009	CB4	09-29	23:46	75 00.28'N 149 59.61'W	**97**	●	●	●
010	CB4	09-29	02:13	75 00.28'N 149 59.61'W	**128**	●	●	●
011	CB7	09-30	02:40	75 56.91'N 149 59.62'W	**118**	●	●	●
012	CB9	10-01	01:55	78 00.80'N 150 11.13'W	**111**	●	●	●
013	CB10A	10-02	17:29	78 19.85'N 154 00.27'W	**122**	●	●	●
014	CB60	10-02	21:54	78 36.15'N 154 13.63'W	**111**	●	●	●
015	ITP8	10-03	20:49	80 18.89'N 151 59.96'W	**120**	●	●	●
016	CB11	10-04	18:21	79 00.22'N 150 20.54'W	**113**	●	●	●
017	CB16	10-06	22:31	77 49.77'N 140 06.45'W	**117**	●	●	●
018	PP7	10-07	20:35	77 04.74'N 135 27.20'W	**118**	●	○	●
019	CB17	10-08	23:13	75 59.12'N 139 58.93'W	**125**	●	○	○
020	CB21	10-09	20:23	74 00.70'N 140 05.60'W	**70**	●	●	●
021	CB40A	10-10	18:00	74 34.09'N 134 46.46'W	**117**	●	●	●
022	CB40B	10-10	22:44	74 35.78'N 134 49.61'W	**124**	●	●	●
023	CB21	10-11	22:34	74 00.88'N 140 03.72'W	**124**	●	●	●

Index:
● Data are obtained
○ Instrument did not work
Depth means the Maximum depth we deployed.
The time is UTC, but date is in ship time.
The features of the observation environment, sea ice condition, and weather factors are recorded in the forms as attached.

3.2 Data processing

Data are processed after deployment. All data are treated to following subtopics:
- Profile of attenuation coefficient for each wavelength
- Attenuation depth
- Optical thickness
- Photosynthetically Available Radiation，PAR
- Other analysis coupling the optical data and CTD data



4.6 Carbon Uptake Experiment

Carbon and nitrogen productions of phytoplankton and their species compositions and physiological characteristics in the Canada Basin (CCGS Louis S St-Laurent)

Mi Sun Yun, Korea Polar Research Institute (KOPRI)

Objectives:

1. To quantify primary production (carbon and nitrogen uptakes) of phytoplankton using a stable isotope
2. To define and compare effects of light and nutrient on the primary production of phytoplankton in the chl a maximum layer
3. To identify phytoplankton species compositions
4. To measure physiological characteristics of phytoplankton and estimate primary production using PAM (Pulse Amplitude Modulated) fluorescence
5. To compare primary production with different method (Carbon and PAM method)

Methods

1. To quantify carbon and nitrogen uptake of phytoplankton at different locations, productivity experiments were executed by incubating phytoplankton in the incubators on the top-deck for 3-4 hours after stable isotopes (^{13}C, $^{15}NO_3$, and $^{15}NH_4$) into each bottle were inoculated. Total **11** carbon and nitrogen uptakes experiments (Table 1) were completed. Seawaters (using 500ml bottles with different screen depending on depth) were collected from Niskin at 6 different light depths (100, 50, 30, 12, 5, and 1%). After the incubation, all productivity sample waters were filtered on GF/F (ø = 25 mm) filters and dried in the 60^{o}C oven. For laboratory isotope analysis, these samples will be sent to University of Alaska Fairbanks after this cruise.

Along with the carbon and nitrogen uptakes experiments, **13** light enrichment experiments and **10** nutrient enrichment experiments (Table 1) were conducted from 1% light depth to define and compare effects of light and nutrient on the primary production of phytoplankton in the chl a maximum layer.


2. To identify species composition of phytoplankton, water samples were taken from 100, 30, and 1 % of light depth at every productivity station. Based on the HPMA slide method, the total **39** samples were fixed for identifying species compositions of phytoplankton later at the laboratory in KOPRI.

3. To measure chlorophyll fluorescence using Phyto-PAM (Walz, Effecltrich, Germany), water samples (50ml) were taken from 100, 30, and 1 % of light depth at every productivity station. The total **39** samples were measured for analysis of physiological characteristics of phytoplankton. Physiological condition could be assessed by measuring the effective quantum yield of PSII (Φ_{PSII}) which measures the proportion of the light absorbed by chlorophyll associated with PSII used in photochemistry. Photosynthetic activities were assessed using rapid-light curves (RLCs), where samples were exposed to nine incremental steps of irradiance (20 s per step) ranging from 0 to 764 μmol photons·m^{-2}·s^{-1}. Photosynthetic parameters will be derived by fitting to the model of Platt et al. (1980). These parameters will be compared with parameters by carbon method.

4. **2** ice algae were taken at the bottom 3cm of ice core in the different stations (ITP 3, 4: One is new-year ice. Another is multi-year ice). These samples were fixed for identifying species compositions of ice algae. Two samples can be compared with difference of species compositions.

Table 1. Sampling list

St.	Primary Production				Species Composition	PAM Measurement
	Carbon Production	Nitrogen Production	Effect of Light Enrichment	Effect of Nutrient Enrichment		
CABOS	√	√	√	√	√	√
CB-23a	√	√	√		√	√
MK-7	√	√	√		√	√
CB-28b					√	√
CB-2a	√	√	√	√	√	√
CB-4	√	√	√	√	√	√
CB-9	√	√	√	√	√	√
CB-10a	√	√	√	√	√	√
CB-11b	√	√	√	√	√	√
CB-11			√		√	√
CB-15/17	√	√	√	√	√	√
CB-40b	√	√	√	√	√	√
CB-21	√	√	√√	√√	√	√

4.7 XCTD Profiles

PIs: Itoh (JAMSTEC), Shimada (Tokyo University), Proshutinsky (WHOI))

XCTD (expendable conductivity, temperature and depth profiler, Tsurumi-Seiki Co., Ltd.) probes provided by JAMSTEC, WHOI and Tokyo University were deployed from the ship's stern with temperature, salinity and depth data acquired by computer located in the stern (AVGAS) hold. The casts took approximately 5 minutes for the released probe to reach its final depth of 1100m. In open water, depending on the probe type, the ship may have slowed to 12 knots for deployment but in heavy ice the ship had to stop. Typically 1 XCTDs was deployed between CTD casts to increase the spatial resolution.

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD are as follows;

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]

Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

During this cruise, 55 XCTDs were successfully launched, and 1 failed. 2 of the working XCTDs had shortened profiles (400m and 900m respectively) presumably due to broken wires..

The deployment locations for the XCTD, XBT and XCP are listed in the appendix.

4.8 BGOS Field Operations as part of JOIS 2009

Rick Krishfield, Kris Newhall, Jim Dunn, and Brian Hogue; P.I Andrey Proshutinsky(WHOI)

As part of the Beaufort Gyre Observing System (BGOS; http://www.whoi.edu/ beaufortgyre), three bottom-tethered moorings deployed in 2008 were recovered, data were retrieved from the instruments, refurbished, and redeployed at the same locations in September and October 2009 from the *CCGS Louis S. St. Laurent* during the JOIS 2009 Expedition. In addition, four Ice-Tethered Profiler (ITP; http://www.whoi.edu/itp) buoys were deployed, one in combination with an Ice Mass Balance (IMB) and O-Buoy, and two ITPs were recovered.

Summary of BGOS 2008 field operations.

Mooring Designation	Depth (m)	2008 Location	2009 Recovery	2009 Deployment	2009 Location
BGOS-A	3825	75° 0.057'N 150° 0.283'W	29-Sep 17:30 UTC	30-Sep 21:47 UTC	75° 0.002'N 150° 0.005'W
BGOS-B	3821	78° 0.084'N 150° 4.438'W	1-Oct 21:02 UTC	5-Oct 22:56 UTC	78° 0.081'N 149° 59.949'W
BGOS-D	3511	73° 59.992'N 139° 59.710'W	11-Oct 18:28 UTC	12-Oct 21:49 UTC	73° 59.744'N 139° 59.698'W
ITP21			23-Sep 23:30		72° 33.4'N 140° 49.7'W
ITP8			3-Oct 17:00		80° 18.8’ N 152° 6.4’ W
ITP32				4-Oct 2:30	80° 19.4'N 151° 45.7'W
ITP33				7-Oct	77° 59.7'N

		0:02	149° 14.5'W
ITP35/IMB/O-Buoy		8-Oct	77° 4.5'N
		1:00	135° 25.8'W
ITP34		10-Oct	74° 35.0'N
		21:00	134° 45.5'W

Moorings:

The centerpiece of the BGOS program are the moorings which have been maintained at 3 or 4 locations since 2003. The moorings are designed to acquire long term time series of the physical properties of the ocean for the freshwater and other studies described on the BG webpage. To keep the moorings safe from the overhead icepack (where ridges can extend down to 30 m or more), the top floats are positioned approximately 45 m below the surface. The instrumentation on the moorings include an Upward Looking Sonar mounted in the top flotation sphere for measuring the draft (or thickness) of the sea ice above the moorings, a vertical profiling CTD and velocity instrument which samples the water column from 55 to 2000 m twice every two days, sediment traps for collecting vertical fluxes of particles, and a Bottom Pressure Recorder mounted on the anchor of the mooring which determines variations in height of the sea surface with a resolution better than 1 mm. Unfortunately, due to funding limitations, the sediment traps were not redeployed this year.

The moorings are deployed anchor first, rather than top float first (as is typical in lower latitudes), because of the presence of the ice pack. This requires the use of a dual capstan winch system to safely handle the heavy loads. Typically it takes around 5 hours to deploy the 3800 m long system.

Recovering the moorings in pack ice is extremely tricky, so that the top float does not surface under an icefloe, where we cannot access it. However, in this case, we do have backup floatation at the bottom of the mooring, which we can also recover the moorings from. First the locations of the moorings have to be pinpointed by triangulating acoustically on the releases at the bottom of the mooring. Then the Captain of the icebreaker creates a pond in the ice over the mooring, and acoustic release commands are sent to the release instruments just above anchor, which let go of the anchor, so that the floatation on the mooring can bring the system to the surface. Then the floatation, wire rope, and instruments are hauled back on board. Data is dumped from the scientific instruments, batteries, sensors, and other hardware are replaced as necessary, and then the systems are subsequently redeployed for another year.

So far, 6 years of data have been acquired by our mooring systems, which document the state of the ocean and ice cover in the BG. The seasonal and interannual variability of the ice draft, ocean temperature, salinity and velocity, and sea surface height in the deep Canada Basin are being documented and analyzed to discern the changes in the heat and freshwater budgets. Trends in the data show an increase in freshwater in the upper ocean in the 2000s, some of which can be accounted for by the observed decrease in ice thickness. However, the results indicate that budget is not balanced, so other mechanisms must also be at work.

Buoys:

Because the moorings only extend up to about 50 m from the ice surface, we use automated ice-tethered buoys to sample the upper ocean and sea ice. On this cruise, we deployed 4 Ice-Tethered Profiler buoys (or ITPs), and assisted with the deployments of one US Army CRREL Ice-Mass Balance buoy, and an O-Buoy. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).

The ITPs obtain profiles of seawater temperature and salinity from 7 to 760 m twice each day and broadcast that information back by satellite telephone. The flux buoys measure the fluxes of heat, salt, and momentum at the ice ocean interface, and the ice mass balance buoys measure the variations in ice and snow thickness, and obtain surface meteorological data. Most of these data are made available in near-real time on the different project websites.

The acquired CTD profile data from ITPs document interesting spatial variations in the major water masses of the Canada Basin, show the double-diffusive thermohaline staircase that lies above the warm, salty Atlantic Layer, measure seasonal surface mixed-layer deepening, and document several mesoscale eddies. The IBOs that we have deployed on this cruise are part of an international collaboration to distribute a wide array of systems across the Arctic as part of an Arctic Observing Network to provide valuable real-time data for operational needs, to support studies of ocean processes, and to initialize and validate numerical models.

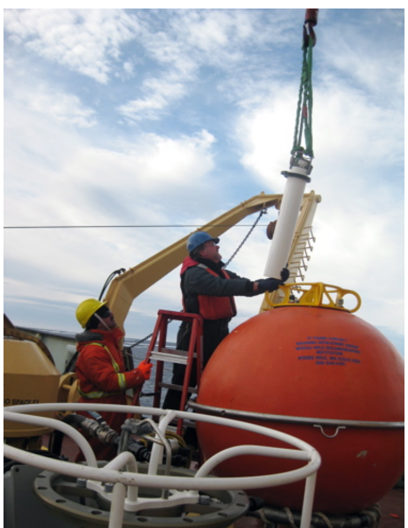


Figure 15.Installing the Upward Looking Sonar (photo Gertie Ward, acknowledgement to ARCUS PolarTREC)

Operations:

The mooring deployment and recovery operations were conducted from the foredeck using a dual capstan winch as described in WHOI Technical Report 2005-05 (Kemp et al., 2005). Before each recovery, an hour long precision acoustic survey was performed using an Edgetech 8011A release deck unit connected to the ship's transducer and MCal software in order to fix the anchor location to within ~10 m. The mooring top transponder (located beneath the sphere at about 45 m) was also interrogated to locate the top of the mooring. In addition, at every station the sphere was located by the ship's 400 khz fish finder. All top spheres successfully released into open water.

All of the mooring recovery and deployment operations were conducted without incident. The actual recovery operations varied from between 3 and 4.5 hours after release. The deployment operations normally entailed an hour of deck preparation once on site, followed by a 3 to 5.5 hour anchor first deployment. Extra instrumentation on mooring A (3 sediment traps) and mooring D (devices clamped to a deep segment of the wire) added time to the operations.

Complete year long data sets with good data were recovered from 2 out of 3 MMPs, every ULS, every BPR, and all 5 sediment traps. Unfortunately, the MMP on mooring A appears to have had a motor or cabling problem so that the instrument did not profile the water column, but was instead fixed at a single depth.

The ITP deployment operations were conducted with the aid of helicopter transport to and from each site according to procedures described in a WHOI Technical Report 2007-05 (Newhall et al., 2007). ITPs 32, 33, 34, and 35 were deployed on 3.0, 4.2, 2.8, and 2.6 m thick ice floes respectively. Not including the time to reconnaissance, drill and select the ice floes, the deployment operations took between 3 and 8 hours each (depending on the number of systems installed in each IBO) including transportation of gear and personnel each way to the site. Ice analyses were also performed by others in the science party, while the ITP deployment operations took place.

Since deployment, all of the ITPs have begun profiling and transmitting data. However, after the first full profile, ITP 35 appears to have a problem communicating with the surface package. A similar problem occurred with ITP 8 (deployed in 2007), which was recovered this cruise using helicopter support, and provided information on 470 more profiles that were taken while the profiler was unable to communicate with the surface package. This unit will be examined back in our laboratory to determine the cause of the failure. ITP 21 (deployed in 2008) was also recovered this year as it was no longer profiling. The cause for this failure was determined to be a broken tension spring

4.9 O-Buoy Deployment

Dan Carlson, UAF

The O-Buoy Project is a program to develop and deploy buoys in the Arctic to help study the atmosphere-surface chemistry and its seasonal and interannual variability in response to changing climate and ice cover. The buoy deployed on this cruise was the first buoy to be put out after an initial trial last winter in Alaska. The buoy is a self-powered, relays it data via satellite and consists of three sensors: 1) a MAX-DOAS BrO instrument, 2) an O3 detector, and 3) a CO2 analyzer. In addition, meteorological sensors and a web-camera were integrated into the system. The buoy was located on a multi-year ice floe with an ITP (WHOI) and IMBB (CRREL) to form an Ice Based Observatory site.

Please see the appendix or contact Dan Carlson (Dacarlson3@uaf.edu) for deployment details. *Reference "The Collaborative O-Buoy Project: Deployment of a Network of Arctic Ocean Chemical Sensors for the IPY and Beyond" from: http://www.arcus.org/search/catalog/280)*

Figure 17. O-buoy being flown to pre-made hole.

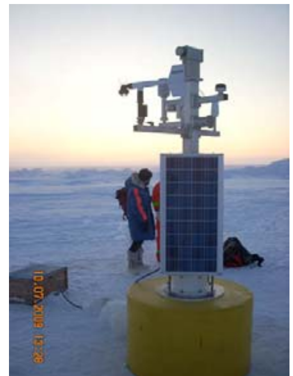


Figure 16. The installed O-buoy.

4.10CABOS Mooring Deployment Report

Igor Polyakov P.I. (IARC), Mike Dempsey

The Canadian Basin Observation System (CABOS) mooring has been deployed by on Institute of Ocean Sciences (IOS) Arctic cruises on behalf of the University of Alaska Fairbanks International Arctic Research Center since 2003 every year except 2007. The location of the mooring has varied due to ice conditions but has been continuously placed to monitor the flow of Atlantic water around the south east slope of the Canada Basin. The mooring is part of a string of moorings deployed by IARC to observe the movement of Atlantic water through the Arctic and measure the heat flux to upper waters. The Nansen/Amundsen Basin Observation System (NABOS) consists of a series of McLane Moored Profiler (MMP) and conventional moorings located around the self break of the Laptev Sea. The CABOS mooring, equipped with a MMP, provides complementary data for this array.

Table 1. 2009 Operations, CABOS mooring

Investigator	Recovery Depth (m)	Recovery Location	Recovery Time (UTC)	Deployment Depth (m)	Deployment Location	Deployment Time (UTC)
UAF/IARC I. Polyakov	1114	71° 49.702'N 131° 46.591'W	20 Sep, 2009 1716	1129 m	71° 49.708' N 131° 46.604' W	14 Oct., 2009 0142

Recovery occurred on September 20th in 8/10ths first year and new ice. The instruments were all downloaded and all had full data records. The MMP 11494 worked almost flawlessly for 424 of 426 days it was deployed. The deployment occurred October 14th in open water with a skin of new ice forming. The deployment went smoothly.

The recovery of the CABOS G 2008 mooring and deployment of the CABOS H 2009 moorings were 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 Kris Newhall, Jim Dunn and Rick Krishfield of WHOI for their help and the use of their Lebus dual capstan traction winch.

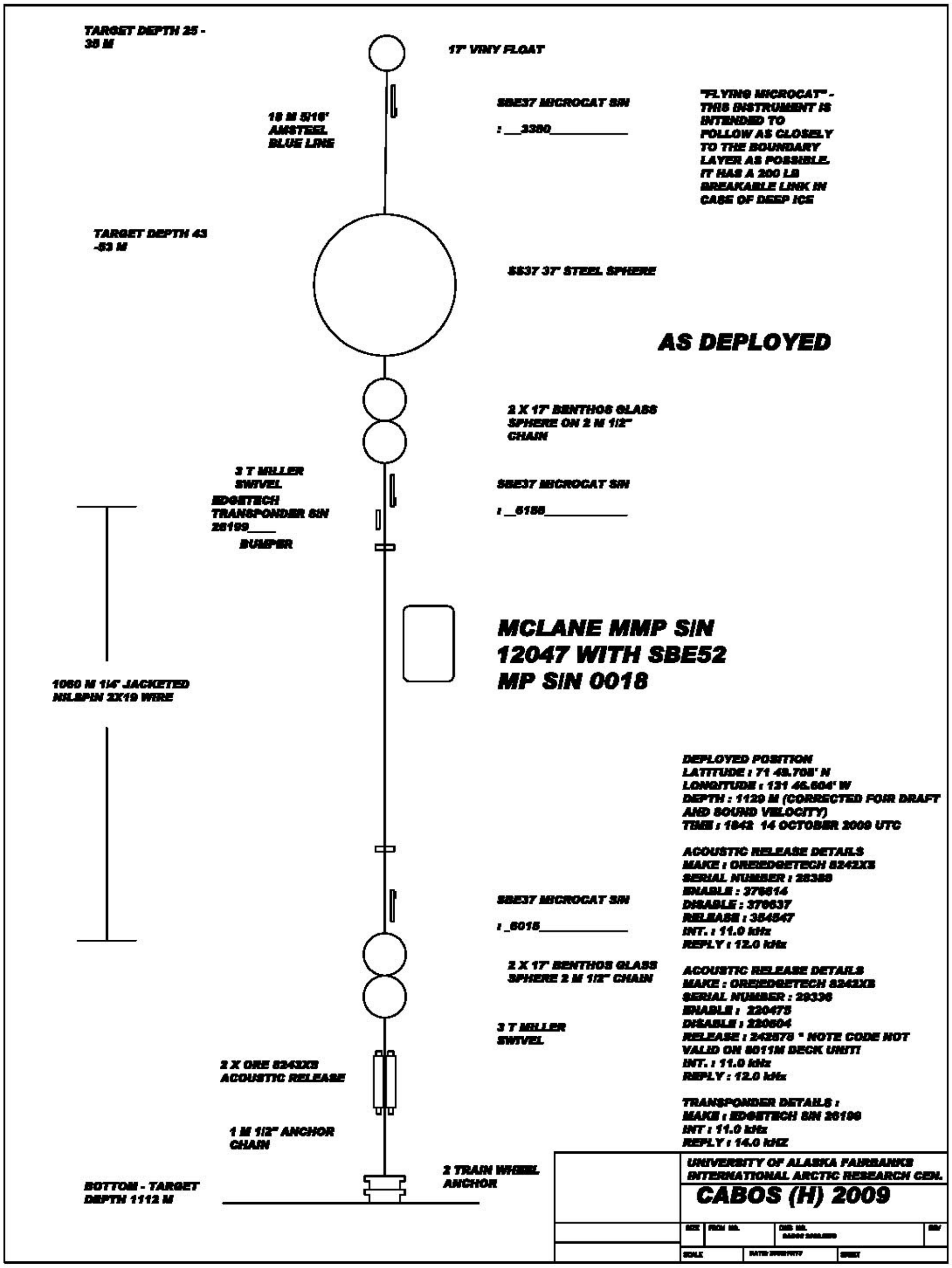


Figure 18. CABOS Mooring diagram as deployed in 2009.

4.11 Ice Observations

P.I. Jennifer Hutchings, Alice Orlich (IARC)
For the complete report with pictures please contact Jenny Hutchings.

Many thanks to Dan Carlson for assistance in collecting ice data. The Ice Pick, Rene Boisvert, provided independent ice observations against which we compared our observations. Mike Dempsey and Christina Brown helped in the collection of CTD data from the small CTD. We would especially like to thank captain McNeil and crew of the Louis S. St. Laurent for making these ice observations possible. This work is funded by JAMSTEC.

Ice observations recording during the Louis S. St. Laurent 2009-20 cruise will provide detailed information for the interpretation of satellite imagery of the ice pack. Our objective was to identify the major sea ice zones in the Beaufort Sea and determine the types and state of ice in these zones. The observations collected will be useful for investigating the evolution of the ice cover over the last four years when used in conjunction with satellite and buoy data. The ice camera we collected, in conjunction with visual ship and helicopter-based observations, will also be used to develop an autonomous camera based ice observation system.

The cruise occurred September 16 to October 15, providing a snapshot of ice conditions at the end of the 2009 melt season and a perspective of the start of freeze up throughout the Beaufort Sea. During the cruise we experienced early freeze-up conditions. Caution should be taken in comparing the 2009 to other years (2006-2008), as the 2009 cruise occurred a month later in the season than previous cruises and we experienced the beginning of the freeze season.

Observations from Bridge: Methodology

Hourly Observations

Every hour, while the ship was steaming and light conditions allowed, an observation of ice conditions was recorded. Each observation was made from the bridge, and photos were taken from the monkey island to document the pack ice observed. These are available on request from Jennifer Hutchings (http://research.iarc.uaf.edu/~jenny). This year we also extended our observation period into the night hours, as the majority of the ships travel occurred after dark. During night, ice type was estimated using ship spotlights and observing the ice overturned by the ship. RADAR was used to estimate concentration of ice types, and lead information. Observations were maintained along the ships track for sufficient time period every hour to observe the ice types apparent on the RADAR screen. Often at night it was necessary to estimate fractional type concentrations by visual observations, such as when multi-year or second-year ice was embedded in new ice.

5 Minute Observations

During the 2009 cruise we occasionally took ice concentration and type observations every 5 minutes for several hours at a time. We are interested in whether the hourly observations are representative of ice pack conditions, especially concentration, and especially in regions of 40-80% ice concentration where ice may be organized in bands or patches. We can also investigate how representative the ice camera view is of the entire ice pack. Where possible, we will use helicopter observations as ground truth against which we will compare satellite, 2 minute ice camera, 5 minute and hourly ship based observations.

Comments on Bridge Observing Methodology

As we did not have a continuous ice watch, the observations should not be used alone to estimate ice type coverage on scales smaller than 100km. The ship track and speed will introduce a bias into the type and thickness of ice overturned. Hence, although the sampling of thin and medium first year ice may be reasonable, thicker first year and multiyear ice will be under represented in thickness estimates. Poor visibility affects the area of ice observed, and could compound ship track bias in spatial coverage estimates.

It should also be noted that flat light conditions hinder the estimation of ridge height.

We found that the photographic record helped in consistency checking of the bridge ice observations. We placed two webcams on the monkey island to record ice automatically. However, due to poor resolution of the forward facing camera, we continued to take hourly photographs for our consistency checks. Most of the transits in 2009 occurred during night, and we do not have photographs for nighttime observations

Webcam Imagery

Two cameras were installed on the monkey island. Back on land, we will investigate whether the images from the cameras are useful for mapping ice types and concentration by an ice expert who does not attend the cruise. My inclination is that a lot of information is lost by the cameras, as they can not provide 360^o vision, and can not be focused on a variety of ice features as the human eye can.

Camera 1 pointed forward on the port side of the ship, and took an image every 2 minutes. This provided a wide field view of the ice pack the ship was heading into. This year we switched the forward facing camera to landscape format, as this provides a larger view of the ice pack. Please note the ice camera installation document has been updated to include the changes we made to the camera setup. The second camera was trained on the "ice thickness pole" to observed overturning ice. In order to get a representative sample of overturned ice, while underway this camera took pictures every 1 second. At night, after October 6 2009 a floodlight illuminated camera 2's scene during night transit. Prior to October 6^{th}, only daylight hours were recorded. Both cameras were linked into the ship's local area network (LAN), and images can be stored on any computer on this LAN that is running an FTP server. The NOAA server will be used in future for image storage. Anyone who is interested in these may contact Jenny.


Example of image from forward facing ice camera 1.

Example of an image from camera 2.

We have not processed the ice thickness data from this camera as it will take considerable time. However, once the data is processed it will give us a much more representative estimate of pack ice thickness than our visual observations from the bridge.

At night a floodlight was mounted on the 300 level deck (attached to the port side life boat emergency light). We had to stop the aperture on the camera all the way up at sundown, and return the aperture to a pinhole at sunup. Occasionally this was forgotten for a while, to the detriment of image quality.

We had a couple of small issues in setting up the camera system. First, the Netcam XL (forward facing camera) had experienced some corrosion and salt build up inside the camera case during the last year. This had resulted in reduced quality of image transfer. We cleaned the salt build up from the camera's circuit boards, fixing the problem. Second the netcam cameras do not have a small enough aperture for bright summer time pack ice photos. Hence we used this camera as camara2. We also experienced blowing snow and heavy snow storms during the cruise. This snow was blown into the camera housing. We fixed this problem with liberal application of rags. We would like to replace the netcam housing with weather tight housing in future.

Occasionally image quality drops out due to frost build up on the camera housing. We tried to remove this frost as often as possible, but often it build up over night affecting the early morning observations.

Aerial Ice Observations

At various times during the cruise we had the opportunity to observe the ice cover from helicopter on 4 flights. In flying conditions when visibility was good, and the helicopter could travel at an altitude of 2000 feet, these flights were very helpful in extrapolating ship based observations to the wider field. During flights, notes were taken of ice coverage, distribution of types and state of melt. Photographs were taken as a record of ice conditions.

Comments on ice type observations: A note of caution

During the majority of the cruise in the Beaufort Sea we were traveling through ice in small flat floes. These had a smattering of obvious multi-year floes with hummucking and ridges scattered between them. In these regions we were confused as to whether the predominant ice type was second year or very young multi-year ice. Some of the floes had uneven surfaces, suggesting they had experienced a previous melt season. However the majority of this ice type was remarkably flat. These ice floes were reminiscent of similar ice observed in the western Beaufort during 2007.

Unfortunately we did not acquire sufficient samples of the younger multi-year ice for salinity analysis. In order to type this ice it would have been useful to have several cores from it. We have coded a lot of ice this year as second year ice, as it is ice that survived summer 2009, but appears to be young enough to be last season's ice. It is possible that this ice could be 3rd or 4th year ice. It was characterized by less strength, and less resistance to ship travel, than the older clear blue ice we observed and coded as multi-year ice. In the ice station sites we did not encounter this ice so were unable to take core samples for aging.

Small CTD casts

We expect that the salinity and temperature data from the underway sea water loop will be interesting in following the evolution of freeze-up along the ships track. The water intake, and small sea chest, for the loop is located on the base of the ship at 9m depth. It is likely that the ship's heat could contaminate data collected from the underway system, especially while on station. It is also possible that rosette casts might have a bias in the upper mixed layer due to ship influence. To investigate this we performed casts with a small Seabird-19 CTD from a zodiac 200m from the ship. We also performed one cast from the ship's bow, during an interesting time in freeze-up.

We expect that salinity will rise and fall in concert with entering and leaving regions of new ice formation along the ship track. We hope the small CTD data collected will assist in validating the underway salinity data, and surface salinity from Rosette casts.

4.12 Ice Measurements

PIs: Kazutaka Tataeyama, Kitami Institute of Technology

Underway measurements

Underway measurements of ice thickness were made using a passive microwave system, an EM sensor and a forward looking camera. These data will be used to help interpret satellite images of sea ice which have the advantage of providing extensive area coverage but lack the groundtruthing of just what the images represent. The EM sensor was deployed from the foredeck's A-frame on the starboard side, collecting data while underway. The passive microwave sensor was mounted one deck higher also on the ship's starboard side looking out over the EM's measurement area and collected data continuously.

Figure 19. EM Sensor

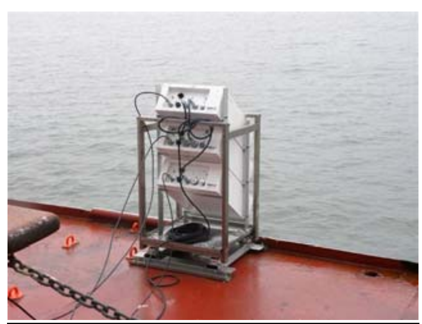


Figure 20. Passive Microwave

Ice station measurements

1. Snow properties survey

Snow depth, skin temperature, internal temperature, density, salinity, storategy (crystal type and size) were measured the in stations 2nd and 3rd. Sampling intervals are 1cm and 3cm for internal temperature and density/salinity, respectively. Snow strategy was recorded in each snow layers.

Those snow properties will be compared with PMR brightness temperatures in order to validate general microwave radiation transfer model for satellite remote sensing. Those data will be used for evaluation of snow and sea-ice conditions in the end of melting and the begging of freezing periods with ice core data.

2.EM transects

The ice team measured total snow and ice thickness distribution in the ice stations 2nd and 3rd to investigate representative sea-ice morphology by drilling and using EM. Apparent conductivities (mS/m) of the Vertical Magnetic Dipole (VMD) and Horizontal Magnetic Dipole (HMD) modes were collected every 2-4 m in order to synchronize ice core and drill-hole. For transformation from apparent conductivity to total snow and ice thickness, Standard 1-D model (Taeteyama et al., 2006) was used.

4.13 On-ice Measurements

Ice Chemistry: P.I. Fiona McLaughlin (DFO), Kristina Brown (UBC))
Ice Thickness and Cores: P.I. Jennifer Hutchings, Alice Orlich (IARC)
Ice and Snow Morphology: P.I. Kazutaka Tataeyama (Kitami)

A mix of ice cores, water samples, ice thickness transects and snow pits were conducted at four sites on an opportunity basis during the ITP buoy's recovery and deployments.

There were five main objectives for ice station work:

- To determine the mean level ice thickness and variability at point locations during the cruise;
- To collect ice cores for physical characterization of ice at the chemistry core sites
- To examine the chemistry of the ice and near-ice water by collecting ice cores and subsampling for δ^{13}C-DIC, δ^{13}C-POC, ^{18}O, alkalinity, salinity, chl a, and δ^{13}C-DOC analyses. To collect brine samples using a sack hole method for δ^{13}C-DIC, δ^{13}C-DOC, ^{18}O, alkalinity, & salinity analyses. To collect sample using a submersible pump for δ^{13}C-DIC, δ^{13}C-POC, ^{18}O, alkalinity, salinity, & chl a analyses
- To characterize the snow pack.

Table 1: Measurements and samples at each ice stations.

Ice Station	Date	Latitude (N)	Longitude (W)	# Cores	# thickness	Thickness transects	Snow Pits	Other Samples
1 (ITP 8)	3-Oct	80 19.4	151 45.7	1- TS 1 - Chem	0	0	No	Snow transect
2 (ITP33)	6-Oct	77 59.7	149 14.5	1 - TS	0	0	Yes	Water Samples

3 (ITP35)	7-Oct	77 04.5	135 25.8	2-TS 2-Chem 2- POC	7	2	Yes	EM-31
4 (ITP 34)	10-Oct	74 35.0	134 45.5	1 – TS 1 - POC	0	0	No	Water Samples

Participants
EM-31 & snow pits: Kazutaka Tateyama
Ice Coring: Kristina Brown (Chemistry) and Alice Orlich (Physical)
Drill and snow transects: Alice Orlich and Jenny Hutchings
Many thanks to Dan Carlson, Glenn, Lori and Misun for assistance on the ice.

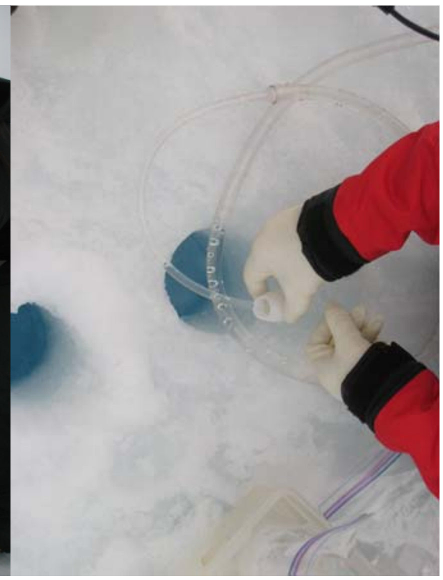
 

Figure 21 - Coring Operations (Mike Dempsey & Alice Orlich)

Figure 22 - Ice/Water Interface Pumping Operations (Nes Sutherland)

4.14 Underway Measurements
P.I. Svien Vagle DFO

Seawater Loop

The ship's seawater loop system draws seawater from below the ship's hull at 9m, to the main lab ("aft lab"). This system allows measurements to be made of the sea surface water without having to stop the ship for sampling. The water is as uncontaminated as possible coming directly from outside of the hull through stainless steel piping without recirculation in a sea-chest. The manifold is insulated to minimize condensation. The continuous flow was monitored throughout the cruise with periodic measurements of flowrate. Water properties were measured by both autonomous in-line sensors and by taking water samples.

Autonomous measurements made:

- SBE38: Temperature.
  Sensor was installed in-line, approximately 4m from pump at intake. This is the closest measurement to actual sea-temperature.
- SBE21 Seacat Thermosalinograph: Temperature and Conductivity, Fluorescence and CDOM
  5 second sample rate, run off the manifold in the main lab
  (Fiona McLaughlin, DFO)
- Blue Cooler: Total gas (Gas Tension Device), Oxygen (Optode).
  (Svein Vagle, DFO)

Independent of the seawater loop:

- SBE48: Hull Temperature
  This measurement is an approximation of seawater temperature, and is taken using a temperature sensor mounted on the ship's hull, inside, aft of the pump approximately 15m, starboard side.

Discreet Water Samples drawn for analyses on other instruments

- Oxygen, Salinity, Chlorophyll-a, CDOM, POC, DIC, ^{13}C-DIC, δ^{18}O, Ba, Nutrients

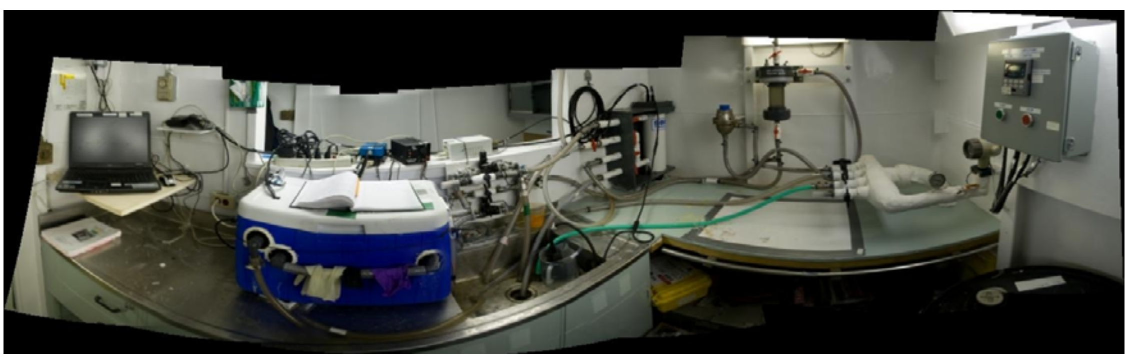


Figure 23. Seawater loop Lab including the Pump control, manifold, debubbler, flow control, TSG, COM and fluorometer in sink, blue cooler, and acquisition computer.

The data acquisition computer provided a means to pass ship's GPS for integration into sensor files, the SBE38 data from the engine room to the TSG instrument, and the TSG and SBE48 data back out to the ship's data collection system (SCS).

SCS Data Collection System

The ship uses the Shipboard Computer System (SCS) written by the National Oceanographic and Atmospheric Administration (NOAA), to collect and archive underway measurements. This system takes data arriving via the ship's network (LAN) in variable formats and time intervals and stores it in a uniform ASCII format that includes a time stamp. Data saved in this format can be easily accessed by other programs or displayed using the SCS software.

Data collected by SCS:

- Location from the ship's GPS (GPGGA and GPRMC sentences)
- Heading from the ship's gyro (HEHDT sentences)
- Depth sounding from the ship's Knudsen sounder (SDDBT sentences)
- Air temperature, apparent wind speed, apparent and relative wind direction, barometric pressure, relative humidity, and apparent wind gusts from the ship's AVOS weather data system (AVRTE sentences). SCS derives true wind speed.
- Sea surface temperature, conductivity, salinity and fluorescence from the ship's SBE 21 and SBE38 thermosalinograph
- Sea surface temperature from the SBE48 hull mounted temperature sensor
- SCS derives speed over ground and course over ground

The RAW files contain a day's worth of data, restarting around midnight. The ACO and LAB files continuously grow until they are moved out of the datalog/compress directory for archiving.

Performance of the SCS system was much improved this year with minimal communication errors requiring stopping and restarting of the system.

5. COMMENTS ON OPERATION

5.1 Ice conditions

We had a substantial amount of open water in our study area this year, primarily due to 2009 being another low ice extent year in the Arctic and partly due to the timing of the cruise during the summer ice minimum. The southern region and the 150W line north to 77N were mostly ice free and our return along the 140W between 76 and 74N was mostly through new ice. The thickest ice encountered along our track was in the multiyear ice in the south-east at CB-40 at 74.5N, 135W. In general, ice was not a constraint during our program. Instead it was a challenge to find ice thick enough to install the ice-buoys in the northern area. Delays were encountered and rescheduling was required because of strong winds and large swells in the open water.

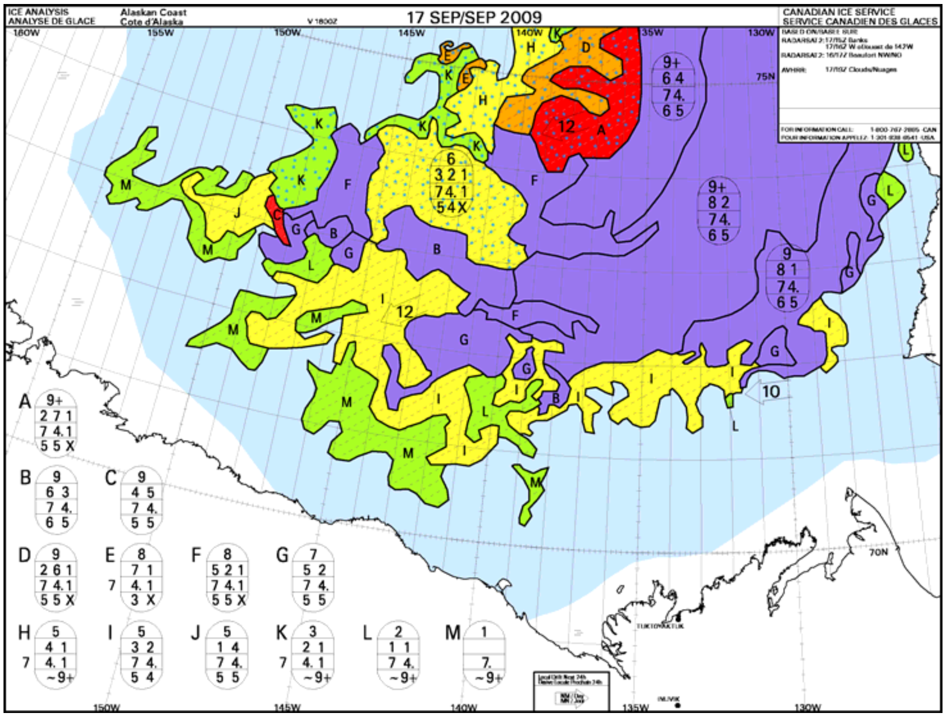


Figure 24. Ice concentration at the start of the program

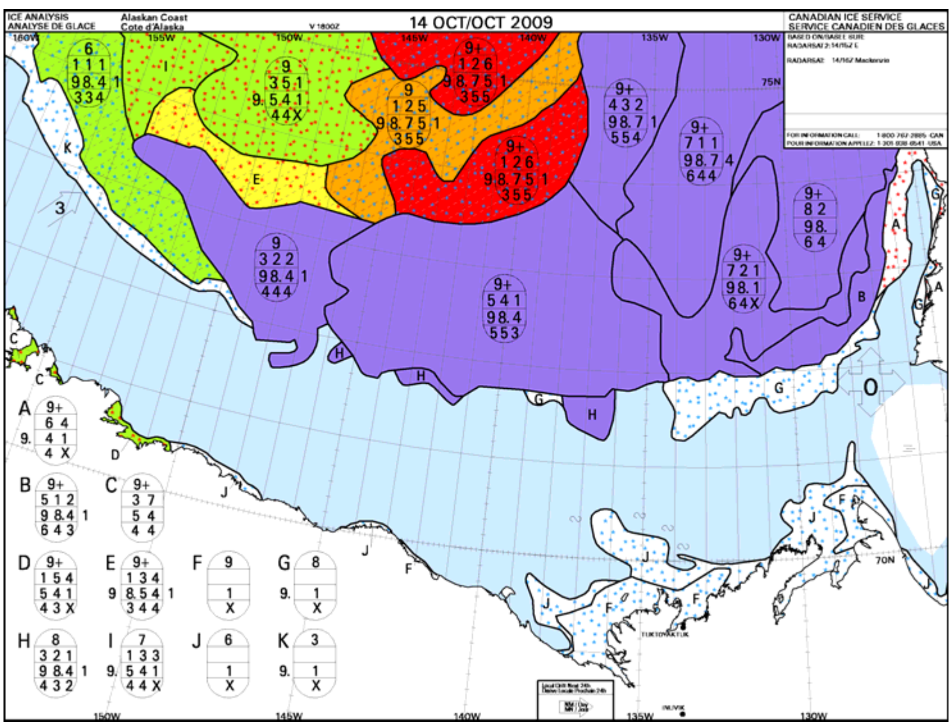


Figure 25. Ice concentration at the end of the program

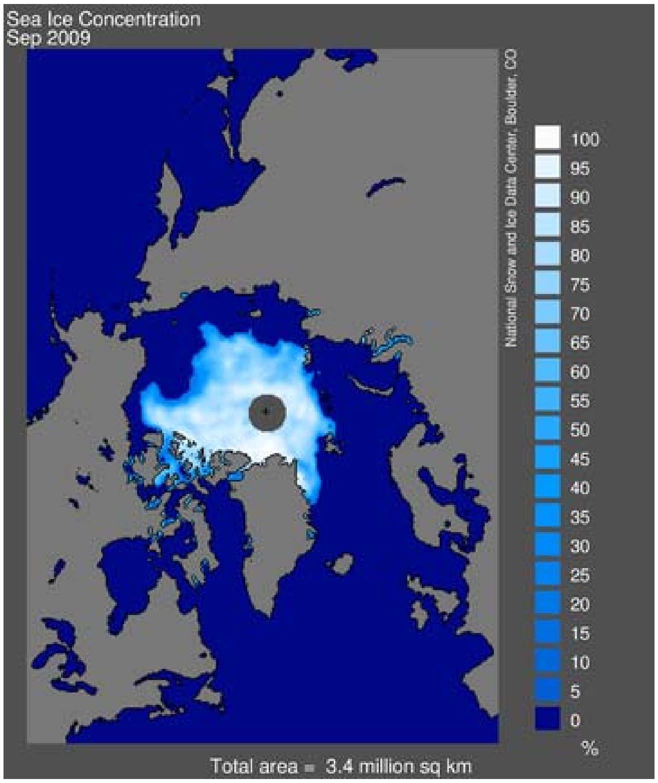


Figure 26. September Sea-Ice concentration in the Arctic.

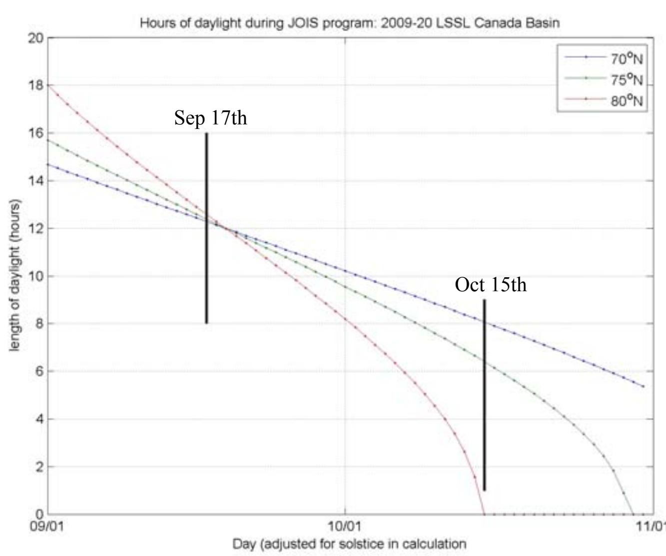


Figure 27. Hours of daylight dependant on latitude and day of year during the JOIS cruise.

5.2 Completion of planned activities

All primary objectives were met.

5.3 Ship improvements completed for 2009

We are very appreciative that all items identified last year for improvement were addressed. Through discussion and prioritising funds, decisions were made regarding what was feasible and could be improved. Some of the highlighted outcomes of last winter's efforts are listed below.

General Ship:

- Second breakout box was added to boardroom to provide access to both 'Ship' and 'Science' networks.

Science Operations:

- A-frames were completely re-serviced which was very important as our core science relies on the good working condition of the A-frames.
- The wooden deck outside rosette lab was repaired and improved by the addition of non-skid patched so that the transfer of the rosette in and out of the rosette lab was easier.
- Ship's time was set to Pacific Daylight Time during the cruise to shift the work-day hours closer to matching the hours of daylight and was much appreciated.
- Container labs were repainted.
- Science fridge in the fumehood container lab was repaired.
- Mylar blinds were added to windows in temperature controlled container lab.

Suggestions for 2010

A list of suggested improvements to and comments about the ship's equipment and lab spaces will be sent separately. In the event next year's cruise is conducted in late September and October it would be beneficial to have additional lighting of the work decks and the ability to keep plumbing (including water from fire-mains) and winches from freezing.

ACKNOWLEDGMENTS

The science team would like to thank the Coast Guard for their support, particularly Captain McNeill and the crew of the *CCGS Louis S. St-Laurent*. At sea, we were very grateful for everyone's top-notch performance and assistance with the program. We'd like to thank Rene Boisvert and the Canadian Ice Service for their assistance with ice images and weather information as well as Jim Myra, the helicopter pilot for his and the helicopter mechanic's valuable help with ice reconnaissance flights, support on the ice and transport. Importantly, we'd like to acknowledge DFO, NSF and JAMSTEC for their continued support of this program.

Figure 28. JOIS-2009 ***(photo Alex Kain)***

APPENDIX A: Participants

Table 1. Cruise Participants

Name	Role	Affiliation
Sarah Zimmermann	Chief Scientist	DFO-IOS
Mike Dempsey	Chief Technician, CTD Watch	DFO-IOS
Hugh Maclean	CTD Watch, Salinity	DFO-IOS
Edmand Fok	CTD Watch, Underway	DFO-IOS
Glenn Cooper	CTD Watch, Salinity, Bacteria	DFO-IOS
Jeffrey Charters	CTD Watch, Ammonimum	DFO-IOS
Miranda Corkum	CTD Watch	DFO-IOS
Lori Waters	CTD Watch	DFO-IOS
Kelly Young	CTD Watch, Zooplankton, Salinity	DFO-IOS
Linda White	Nutrient Analysis	DFO-IOS
Nina Nemcek	Oxygen Analysis	DFO-IOS
Kristina Brown	Carbon Cycling, Chemistry Spreadsheet, Ammonium	UBC
Rick Krishfield	WHOI Moorings and Buoys	WHOI, USA
Kris Newhall	WHOI Moorings and Buoys	WHOI, USA
Jim Dunn	WHOI Moorings and Buoys	WHOI, USA
Brian Hogue	WHOI Moorings and Buoys	WHOI, USA
Alex Kain	WHOI Web Dispatches	WHOI (Yale University), USA
Dan Carlson	O-Buoy	CRREL (UAF), USA
Koji Shimada	Turbomap, XCTD and Ice Observations	Tokyo University, Japan
Kohei Mizobata	Turbomap and XCTD	Tokyo University, Japan
Eri Yoshizawa	Turbomap and XCTD	Tokyo University, Japan
Kazutaka Tateyama	Ice Observations	KIT, Japan
Jinping Zhao	PRR Program	OUC, China
Weibo Wang	PRR Program	OUC, China
Jenny Hutchings	Ice Observations	IARC, US
Alice Orlich	Ice Observations	IARC, US
YUN Mi Sun	Phytoplankton Study	KOPRI, Korea
KIM Kwang-bum	Media for documentaries	ESB, Korea
KIM Yong	Media for documentaries	ESB, Korea

Table 2. Principal Investigators not on-board ship

Name	Affiliation
Fiona McLaughlin	DFO-IOS
Eddy Carmack	DFO-IOS
Michiyo Yamamoto-Kawai	DFO-IOS
John Nelson	DFO-IOS
Svein Vagle	DFO-IOS
Bill Williams	DFO-IOS
John Smith	DFO-BIO
Bill Li	DFO-BIO
Andrey Proshutinsky	WHOI
Motoyo Itoh	JAMSTEC
Shigeto Nishino	JAMSTEC
Chris Guay	Pacific Marine Sciences and Technology
Celin Gueguen	Trent University
Don Perovich	CRREL
Mike Steele	UW

Table 3. Affiliation Abbreviation

CRREL	Cold Regions Research Laboratory, New Hampshire
DFO	Department of Fisheries and Oceans, Canada
ESB	Educational Broadcasting System, Korea
IARC	International Arctic Research Center, Alaska
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
KIT	Kitami Institute of Technology, Japan
KOPRI	Korea Polar Research Institute, Korea
OUC	Ocean University China, China
UAF	University of Alaska Fairbanks, Alaska
UBC	University of British Columbia, BC
UW	University of Washington, Washington
WHOI	Woods Hole Oceanographic Institution, Massachusetts

APPENDIX B: Science Station Locations

Table 4. Station Locations

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORR ECTED BOTTOM DEPTH	MAX DEPT H	SAMPLE NUMBER S	COMMENTS
9/20/2009 0:06	AG-M	ROS	001	71.0316	127.7603	95	90.7	1-23	Test cast. CTD wire re-terminated prior to first cast of 2009-20.
9/20/2009 12:40	CABOS	ROS	002	71.8189	131.7956	1100	1000	24-46	
9/20/2009 13:20	CABOS	NET	Net 1	71.8139	131.7953	1140	100		First cast
9/20/2009 13:54	CABOS	NET	Net 2	71.8139	131.7953	1140	100		Fixed tear in net
9/20/2009 19:08	CABOS	ROS	003	71.8307	131.7787	1132	1108	47-70	ISUS removed
9/20/2009 19:21	CABOS	PRR	PRR-01	71.8308	131.7797	1400	114		First PRR cast.
9/21/2009 1:33	CB-31b	ROS	004	72.1486	134.1735	1944	1934	71-94	Stopped at 978 m to clear ice off block. Bubbler on continuously during cast.
9/21/2009 1:56	CB-31b	NET	Net 3	72.1445	134.1724		100		Flowmeter (MF-315) frozen.
9/21/2009 2:18	CB-31b	NET	Net 4	72.1445	134.1724		100		TSK appears to be working.
9/22/2009 4:05		XCTD	1	71.2348	133.8565				
9/22/2009 8:36		XCTD	2	72.0674	134.9599				
9/22/2009 16:11	CB-23a	PRR	PRR-02	72.8688	136.0025	>3000	120		Second PRR cast
9/22/2009 16:30	CB-23a	NET	Net 5	72.8701	135.9992	2783	100		Flowmeters (MF-315) frozen again.
9/22/2009 16:52	CB-23a	NET	Net 6	72.8701	135.9992	2783	100		
9/22/2009 17:13	CB-23a	ROS	005	72.8677	136.0063	2789	2718	95-118	
9/22/2009 19:43	CB-23(5)	TURB O	0	72.8620	136.0430		150		
9/23/2009 1:19	CB-22	ROS	006	73.4842	137.9522	3180	3132	119-142	CTD stopped on upcast to examine winch.
9/23/2009 1:41	CB-22	PRR	PRR-03	73.4850	137.9462	3200	104		
9/23/2009 10:11	CB-27	ROS	007	73.0024	139.9022	3265	3207	143-166	

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
9/23/2009 12:45	CB-27	NET	Net 7	73.0064	139.9417	3265	100		Firehose not working - no wash down BUT slowly dipped net 2x at surface to rinse (did NOT submerse).
9/23/2009 13:01	CB-27	NET	Net 8	73.0064	139.9417	3265	100		
9/23/2009 17:01	MK-07	ROS	008	72.4913	139.9523	3033	1000	167-190	Surface bucket sample taken (no niskin #24 - ISUS).
9/23/2009 17:08	MK-07	PRR	PRR-04	72.4902	139.9615	3025	110		
9/23/2009 18:28	MK-7(8)	TURBO	1	72.4883	139.9775		500		
9/24/2009 0:48		XCTD	3	72.5934	141.6049	3340			
9/24/2009 4:07		XCTD	4	72.6307	143.0965	3380			
9/24/2009 8:42	Sta-A	ROS	009	72.6582	144.7449	3505	3440	191-214	
9/24/2009 11:32	Sta-A	NET	Net 9	72.6463	144.8020	3500	100		
9/24/2009 11:41	Sta-A	NET	Net 10	72.6463	144.8020	3500	100		
9/24/2009 15:55		XCTD	5	72.4094	143.1807				
9/24/2009 16:04	XCTD-005	TURBO	2	72.4094	143.1807		500		
9/24/2009 19:32		XCTD	6	72.2006	141.6343				
9/24/2009 22:24	CB-29	PRR	PRR-05	71.9858	140.0215	2743	120		Back to light, sunny
9/24/2009 22:54	CB-29	ROS	010	71.9855	140.0184	2747 (K)	2687	215-238	Silty water discharge aft of rosette at 1900 m.
9/24/2009 23:32	CB-29	NET	Net 11	71.9836	140.0032	2746	100		Removing flow meters (except TSK) every time = works.
9/24/2009 23:48	CB-29	NET	Net 12	71.9825	140.0034	2747	100		
9/25/2009 1:04	CB-29(10)	TURBO	3	71.9806	140.0572		543		
9/25/2009 4:20		XCTD	7	71.5164	138.9132				
9/25/2009 6:02		XCTD	8	71.3726	137.7249	1756			
9/25/2009 7:53		XCTD	9	71.2572	136.5085	1436			
9/25/2009 9:07		XCTD	10	71.1593	135.5096	994			

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
9/27/2009 3:03	CB-28aa	ROS	011	69.9988	139.9824	60	47	239-242	
9/27/2009 4:38	MK-1	ROS	012	70.2328	140.0191	232	222	243-253	
9/27/2009 6:25		XCTD	11	70.4110	140.0054	532			
9/27/2009 7:17	MK-3	ROS	013	70.5723	139.9809	808	792	254-272	ISUS added to ROS
9/27/2009 9:18		XCTD	12	70.8234	140.0028	1859			
9/27/2009 10:20	CB-28b	ROS	014	70.9996	139.9959	2089	2069	273-296	ISUS off
9/27/2009 10:39	BL-6	NET	Net 16	70.9991	139.9973		100		53 um #2 not repaired yet, not on frame.
9/27/2009 10:55	BL-6	NET	Net 17	70.9989	139.9992		100		53 um #2 not repaired yet, not on frame.
9/27/2009 13:50		XCTD	13	71.0882	141.4687	N/A			
9/27/2009 16:11		XCTD	14	71.1093	143.0644	2212			
9/27/2009 18:08		PRR	PRR-06	71.1099	143.7745	2000	107		Midway to BL-6.
9/27/2009 18:34		XCTD	15	71.1096	143.7749	2023			
9/27/2009 19:40		XCTD	16	71.1861	144.5032	no sounder			
9/27/2009 20:45	MK-3	NET	Net 13	70.5725	139.9776	817	100		
9/27/2009 21:41		XCTD	17	71.2390	145.9997	2268			
9/27/2009 22:35	CB-28b	NET	Net 14	70.9991	139.9973	2069	100		
9/27/2009 23:36		XCTD	18	71.3277	147.5111	2325			
9/28/2009 1:26		XCTD	19	71.4352	148.9341	1827			
9/28/2009 2:43		XCTD	20	71.4892	149.9581	2020			
9/28/2009 4:55	BL-6	ROS	015	71.6576	151.2313	2022	2008	297-320	
9/28/2009 5:10	BL-6	NET	Net 15	71.6570	151.2298	2021	100		euphausiids in sample
9/28/2009 5:10	BL-6	NET	Net 18	71.6570	151.2298		100		Only one 53 um net still - will note when it returns.
9/28/2009 5:10	BL-6	NET	Net 19	71.6570	151.2298		100		
9/28/2009 8:21	BL-2	ROS	016	71.3960	152.0458	152	138	321-328	
9/28/2009 8:51	BL-2	NET	Net 20	71.3961	152.0499	152	100		
9/28/2009 9:10	BL-2	NET	Net 21	71.3961	152.0499	152	100		Big jelly in 236 um net.

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORR ECTED BOTTOM DEPTH	MAX DEPT H	SAMPLE NUMBER S	COMMENTS
9/28/2009 10:06		XCTD	21	71.4610	151.8008	506			
9/28/2009 10:53	BL-4	ROS	017	71.4926	151.6386	831	817	329-348	
9/28/2009 11:12	BL-4	NET	Net 22	71.4926	151.6410		100		
9/28/2009 11:27	BL-4	NET	Net 23	0.0000	0.0000		100		Big jelly in 236 um net.
9/28/2009 12:35		XCTD	22	71.5926	151.3748	1582			
9/28/2009 14:01		XCTD	23	71.8174	150.7786	2564			
9/28/2009 15:35	BL-8	ROS	018	71.9531	150.1701	2978	2980	349-372	
9/28/2009 15:42	BL-8	NET	Net 24	71.9532	150.1704		100		
9/28/2009 16:10	BL-8	NET	Net 25	71.9532	150.1704		100		
9/28/2009 17:15		PRR	PRR-07	71.9529	150.1457	2980	107		
9/28/2009 18:33	BL-8(18)	TURB O	4	71.9575	150.1255	3827	521		
9/28/2009 18:57		XCTD	0	70.5360	136.6323	500			
9/28/2009 21:02		XCTD	24	72.4931	150.0472	3691			
9/28/2009 21:22	CB-2a	ROS	019	72.4934	150.0462	3691	300	373-389	ISUS on.
9/29/2009 0:49	CB-2(20)	TURB O	5	73.0052	149.9955		584		
9/29/2009 1:26	CB-2	ROS	020	73.0058	149.9946	3720	3739	390-413	WHOI -> (mooring test release) x 3. Wait @ bottom.
9/29/2009 1:29	CB-2	PRR	PRR-08	73.0062	149.9940	3720	105		
9/29/2009 1:50	CB-2	NET	Net 26	0.0000	0.0000		100		
9/29/2009 2:00	CB-2	NET	Net 27	0.0000	0.0000		100		
9/29/2009 4:32	CB-4	ROS	022	74.9789	150.0048	3825	100	438-444	
9/29/2009 7:00		XCTD	25	73.4987	150.0172	3379			
9/29/2009 9:20	CB-4	ROS	023	75.0000	149.9994	3824	3816	445-468	
9/29/2009 10:00	CB-3	ROS	021	73.9981	150.0092	3793	3812	414-437	
9/29/2009 10:14	CB-3	NET	Net 28	73.9978	150.0097		100		2nd 53 um mesh net repaired, will be on net tows until further notice.
9/29/2009 10:29	CB-3	NET	Net 29	73.9978	150.0121		100		
9/29/2009 14:31		XCTD	26	74.4911	150.0045	3820			

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORR ECTED BOTTOM DEPTH	MAX DEPT H	SAMPLE NUMBER S	COMMENTS
9/29/2009 23:30		PRR	PRR-09	75.0047	149.9935		97		
9/30/2009 0:34	CB-4	NET	Net 35	74.9987	150.0042		1000		
9/30/2009 0:58	CB-4(25)	TURB O	6	75.0045	149.9913		529		
9/30/2009 1:13	CB-4	NET	Net 30	75.0050	149.9921	3826	100		
9/30/2009 1:43	CB-4	NET	Net 31	75.0054	149.9921	3825	500		Deep net cast. 50 um net ripped again, removed from bongos.
9/30/2009 1:55	CB-4	NET	Net 32	75.0050	149.9936	3824	100		
9/30/2009 2:13	CB-4	PRR	PRR-10	75.0048	149.9936		128		
9/30/2009 4:09		XCTD	27	75.1461	151.6186	3838			
9/30/2009 6:10	CB-5	ROS	024	75.3025	153.2765	3844	3852	469-492	
9/30/2009 6:27	CB-5	NET	Net 33	75.3040	153.2702		100		
9/30/2009 6:53	CB-5	NET	Net 34	75.3048	153.2678		100		
9/30/2009 13:48	CB-4	ROS	025	75.0014	150.0022	3825	1000	493-515	ISUS on
10/1/2009 0:08		XCTD	28	75.4953	149.9893	3827			
10/1/2009 2:17	CB-7(26)	TURB O	7	75.9503	149.9879		514		
10/1/2009 2:40	CB-7	PRR	PRR-11	75.9485	149.9937		118		
10/1/2009 2:45	CB-7	ROS	026	75.9500	149.9917	3827	3818	516-539	WHOI mooring release test x 3 (no wait on bottom - tested during downcast).
10/1/2009 3:13	CB-7	NET	Net 36	0.0000	0.0000	3827	100		Cast for Korean media only - not sampling (dumped into buckets).
10/1/2009 3:23	CB-7	NET	Net 37	75.9478	149.9947	3827	100		Hydrants/hoses all frozen on foredeck.
10/1/2009 3:33	CB-7	NET	Net 38	75.9475	149.9986	3827	100		
10/1/2009 7:30		XCTD	29	76.5012	150.0167	3827			
10/1/2009 10:14	CB-8	ROS	027	76.9997	150.0004	3825	3816	540-563	Rosette on deck for more than 5 minutes.
10/1/2009 14:44		XCTD	30	77.4997	150.0340	3823			

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORR ECTED BOTTOM DEPTH	MAX DEPT H	SAMPLE NUMBER S	COMMENTS
10/1/2009 17:16	CB-9	ROS	028	78.0190	150.1250	3825	1000	564-586	ISUS ON - noisier than previous casts.
10/2/2009 0:37	CB-9	NET	Net 39	78.0119	150.1887	4128	100		Fixed 50 um net - worked fine. Flow meters not working well by 3rd cast.
10/2/2009 0:44	CB-9	NET	Net 40	78.0115	150.1899	4132	500		
10/2/2009 1:18	CB-9	NET	Net 41	78.0101	150.1949	4130	100		
10/2/2009 1:46	CB-9(29)	TURB O	8	78.0151	150.1809		433		
10/2/2009 1:55	CB-9	PRR	PRR-12	78.0139	150.1830		111		
10/2/2009 2:27	CB-9	ROS	029	78.0125	150.1864	3825	3813	587-610	Delayed launch. Speed fluctuations at approx. 1200 m on downcast; winch asked to gear down.
10/2/2009 6:51		XCTD	31	78.1750	151.4223	3832			
10/2/2009 8:59		XCTD	32	78.3540	152.6151	3805			
10/2/2009 10:02	CB-10	ROS	030	78.3440	153.0207	2952	2965	611-634	
10/2/2009 13:29	CB-10a2	ROS	031	78.3419	153.5108	1725	1713	635-658	Station name in hdr file is incorrect - it should be 10a2 not 10a.
10/2/2009 16:16	CB-10a(31)	TURB O	9	78.3263	154.0306		531		
10/2/2009 17:29	CB-10a	PRR	PRR-13	78.3308	154.0046		122		
10/2/2009 17:32	CB-10a	ROS	032	78.3294	154.0088	1066	1000	659-681	ISUS ON; pushed ISUS to 1050 m. Noisy from start.
10/2/2009 20:59	CB-60	ROS	033	78.5938	154.2330	1984	1974	682-705	
10/2/2009 21:54	CB-60	PRR	PRR-14	78.6025	154.2271		111		
10/2/2009 22:20	CB-60	NET	Net 42	78.5964	154.2316	1931	100		Lots of ice in samples, -6.2 deg C, blowing snow, very windy.
10/2/2009 22:34	CB-60	NET	Net 43	78.5980	154.2303	1918	100		
10/3/2009 1:03	CB-	TURB	10	78.8607	154.2612		171		CTD

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
	61(34)	O							
10/3/2009 1:20	CB-61	ROS	034	78.8593	154.2647	3074	3095	706-729	De-iced block at 350 m, 775 m and 1170 m on downcast (not usually done this often).
10/3/2009 4:47		XCTD	33	79.0523	154.1886	3062			
10/3/2009 5:45		XCTD	34	#VALUE!	#VALUE!	-			Lost, only 0-28m
10/3/2009 6:52		XCTD	35	79.2549	153.8919	N/A			
10/3/2009 9:42		XCTD	36	79.5800	153.6243	3814			
10/3/2009 12:29		XCTD	37	79.9163	153.1988	3818			Lost communication before 880m
10/3/2009 15:54	CB-11b	ROS	035	80.2813	152.5693	3812	3796	730-753	Stopped at 100 m on upcast and downcast for cups.
10/3/2009 17:05	CB-11	ROS	037	79.0012	150.5252	3826	3808	763-787	Stop at 100 m downcast and upcast (cups).
10/3/2009 18:21	CB-11	PRR	PRR-16	79.0036	150.3424		113		
10/3/2009 20:49	CB-11b	PRR	PRR-15	80.3148	151.9961		120		
10/3/2009 20:51	CB-11b	ROS	036	80.3146	152.0084	3811	100	754-763	
10/3/2009 21:27	CB-11b	NET	Net 44	80.3150	151.9829	3811	100		
10/3/2009 21:40	CB-11b	NET	Net 45	80.3153	151.9769	3811	100		
10/3/2009 22:15	CB-11b	NET	Net 46	80.3167	151.9543	3811	500		
10/3/2009 22:54	CB-11b	NET	Net 47	80.3185	151.9317	3811	1000		
10/4/2009 1:27	CB-11b(36)	TURBO	11	80.3261	151.8104		180		Windy
10/4/2009 10:04		XCTD	38	79.5092	151.0816	3822			
10/4/2009 20:04	CB-11(37)	TURBO	12	79.0036	150.3373		490		Windy, CTD
10/4/2009 22:54		XCTD	39	78.6663	149.0643	3827			
10/5/2009 1:23		XCTD	40	78.3384	147.9435	3824			
10/5/2009 4:02		XCTD	41	78.0042	146.6135	3814			

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
10/5/2009 7:25	CB-12b	ROS	038	77.5628	145.1524	3799	3789	788-811	Add de-icer at 2982 m (stopped); stopped at 2456 m to check de-icer; stopped at 440 m to take de-icer off.
10/6/2009 0:55		XCTD	42	77.9675	148.3555	3820			
10/6/2009 4:51		XCTD	43	77.9806	148.9825	3803			
10/6/2009 7:45		XCTD	44	77.9946	146.3137	3795			
10/6/2009 10:29		XCTD	45	77.9915	141.6806	3775			
10/6/2009 15:19	CB-16	ROS	039-Fail	77.9776	140.0423	3753	1000	Failed	FAILED CAST - deck unit problem; stop at 46.80 m, possible electrical problem (0.5 A fuse blown).
10/6/2009 16:16	CB-16	NET	Net 52	77.8279	140.1073	3741	200		
10/6/2009 22:31	CB-16	PRR	PRR-17	77.8295	140.1075		117		
10/6/2009 23:01		TURBO	13	77.8290	140.1075		510		Carm wind
10/6/2009 23:14	CB-16	ROS	039	77.8282	140.1070	3741	3730	812-835	Rinko on V5 + V6; CDOM on V7 (NO ISUS).
10/7/2009 5:07		XCTD	46	77.5900	138.4949	3705			wire broken at 366m deep
10/7/2009 8:22		XCTD	47	77.3394	136.9975	3655			
10/7/2009 13:46	PP-7a	ROS	040	77.0663	135.4696	3577	3564	836-859	After ROS is at surface, took it back down to 10 m to take de-icer off.
10/7/2009 14:22	PP-7a	NET	Net 53	77.0669	135.4673	3564	100		
10/7/2009 14:39	PP-7a	NET	Net 54	77.0674	135.4690		100		
10/7/2009 14:56	PP-7a	NET	Net 55	77.0676	135.4681		200		
10/7/2009 16:03		TURBO	14	77.0687	135.4683		530		Carm wind, CTD
10/7/2009 20:35	PP-7a	PRR	PRR-18	77.0790	135.4534		117		
10/7/2009 21:22	PP-7a	ROS	041	77.0790	135.4528	3580	1000	860-882	ISUS on. Salt test at 185 m and 35 m - 30 second stops on upcast.

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
10/8/2009 0:29	CB-15	NET	Net 48	77.0170	139.8654	3727	500		no firehose (frozen) so nets rinsed by lowering and raising at the surface. Freezing conditions (minus10-15) and nets were freezing fast, so possible zooplankton were frozen to the mesh
10/8/2009 8:01		XCTD	48	77.1099	138.4076	3703			
10/8/2009 11:10	CB-15	ROS	042	77.0172	139.8806	3727	3718	883-906	
10/8/2009 11:53	CB-15	NET	Net 56	77.0171	139.8715	3727	100		
10/8/2009 12:08	CB-15	NET	Net 57	77.0171	139.8689		100		
10/8/2009 12:29	CB-15	NET	Net 58	77.0170	139.8654		500		
10/8/2009 17:36		XCTD	49	76.5397	139.9775	3690			
10/8/2009 19:26	CB-17_18	ROS	043	76.5387	139.9783	3690	100	907-916	
10/8/2009 22:42	CB17	TURBO	15	75.9857	139.9842	3694	530		Carm wind, CTD
10/8/2009 23:20	CB-17	PRR	PRR-19	75.9856	139.9820	3694	125		
10/8/2009 23:26	CB-17	ROS	044	75.9856	139.9822	3694	3684	917-940	
10/9/2009 4:22		XCTD	50	75.4928	140.0318	3886			
10/9/2009 7:32	CB-18	ROS	045	75.0043	140.0602	3632	3621	941-964	
10/9/2009 13:56		XCTD	51	74.5017	140.1727	3640			
10/9/2009 20:07	CB-21	ROS	046	74.0033	140.0859	3527	3510	965-988	Very windy; difficult to maintain good wire angle.
10/9/2009 20:30	CB-21	PRR	PRR-20	74.0081	140.0907				
10/9/2009 22:58		TURBO	16	74.0388	140.1128		150		Strong wind over 30Kt
10/10/2009 2:29		XCTD	52	74.1840	138.5623	3437			
10/10/2009 6:14		XCTD	53	74.3506	137.1150	3322			
10/10/2009 11:21	CB-40	ROS	047	74.5081	135.4601	3263	3248	989-1012	Windy

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORRECTED BOTTOM DEPTH	MAX DEPTH	SAMPLE NUMBERS	COMMENTS
10/10/2009 16:33	CB-40b	ROS	048	74.5522	134.8098	3267	1000	1013-1035	ISUS ON - internally recorded. Rinko DO on v4 (MD).
10/10/2009 18:00	CB40	PRR	PRR-21	74.5682	134.7744				
10/10/2009 21:54		TURBO	17	74.5895	134.7699		520		Windy, 10Kt, IT
10/10/2009 22:44	CB40	PRR	PRR-22	74.5964	134.8269				
10/11/2009 12:03	CB-21	ROS	049	74.0042	139.8699	3512	3497	1036-1059	
10/11/2009 12:47	CB-21	NET	Net 49	74.0055	139.8706	3512	100		nets washed with firehouse prior to tow
10/11/2009 12:47	CB-21	NET	Net 59	74.0055	139.8706	3500	100		
10/11/2009 13:02	CB-21	NET	Net 50	74.0053	139.8710	3512	100		
10/11/2009 13:02	CB-21	NET	Net 60	74.0053	139.8710		100		
10/11/2009 13:15	CB-21	NET	Net 61	74.0057	139.8717		500		
10/11/2009 14:06	CB-21	NET	Net 51	74.0072	139.8733	3512	200		winch froze up, no meter for depth reading so delayed start of to 10-15min, nets hung overboard while winch was defrosted. Nets kept out of water during this time
10/11/2009 14:06	CB-21	NET	Net 62	74.0072	139.8733		200		
2009/10/11 14:38	CB-21	NET	Net 63	74.0081	139.8740	3512	1000		
10/11/2009 22:34	CB21	PRR	PRR-23	74.0147	140.0620				
10/11/2009 22:44		TURBO	18	74.0137	140.0607		150		

DATE + TIME (UTC)	STATION	CAST TYPE	EVENT No.	Lat (N)	Lon (W)	UNCORR ECTED BOTTOM DEPTH	MAX DEPT H	SAMPLE NUMBER S	COMMENTS
10/12/2009 2:45		XCTD	54	74.1921	141.7288	3446			
10/12/2009 6:30	CB-6e	ROS	050	74.3575	143.4122	3706	3697	1060-1083	
10/12/2009 21:58	CB-21	ROS	051	73.9960	139.9938	3527	100	1084-1099	**Niskin #3 did not close** until rosette landed on the deck; possibly salt build-up around seal.
10/13/2009 0:17		XCTD	55	73.7533	138.9947	3383			
10/13/2009 2:49	CB-22	ROS	052	73.5235	137.9138	3188	3168	1100-1123	Barium samples not collected.
10/14/2009 2:08	CABOS	ROS	053	71.8278	131.7823	1123	1100	1124-1126	ISUS ON