Joint Ocean Ice Study (JOIS) 2011
Cruise Report

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* July 21 to August 18, 2011

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1. OVERVIEW

The 2011 Joint Ocean Ice Study (JOIS) involved the collaboration of Fisheries and Oceans Canada researchers with colleagues primarily from the U.S.A and Japan. This program forms an important Canadian contribution to international climate research programs and is primarily a collaboration with the Beaufort Gyre Exploration Project (BGEP) based at Woods Hole Oceanographic Institution. There are also strong links with Japanese scientists via the Pan-Arctic Climate Investigation (PACI), a collaboration with Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and with Tokyo University of Marine Science and Technology. In 2011 JOIS also included ancillary programs carried out by researchers from: the International Arctic Research Center (IARC) in Fairbanks Alaska; Kitami Institute of Technology (KIT), Japan; and University of Akron, Akron Ohio.

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 to interannual basin-scale changes in freshwater content, water mass properties, water mass distribution, ocean circulation and biota distribution in the Beaufort Gyre of the Canada Basin. 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 July 21st and finished August 18th, 2011. The research was conducted in the Canada Basin from the Beaufort Shelf in the south to 80°N by a research team of 28 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. Underway measurements were made of the surface water. Daily dispatches were posted to the web.

The goals of the JOIS program, led by Bill Williams of Fisheries & Oceans Canada (DFO), were met during the successful four-week program. Our science program was completed thanks to:

a) Efficiency and multitasking of the Captain and crew in their support of science.

b) Relatively light ice conditions leading to faster transit times.

c) Minimizing the science program prior to the cruise:

i) WHOI had a program to sample the southern end of the 150W line near Barrow Canyon from the USCGC Healy

ii) no additional projects that might require wire-time were brought on board.

iii) selecting the minimal geographic extent needed for the science stations.

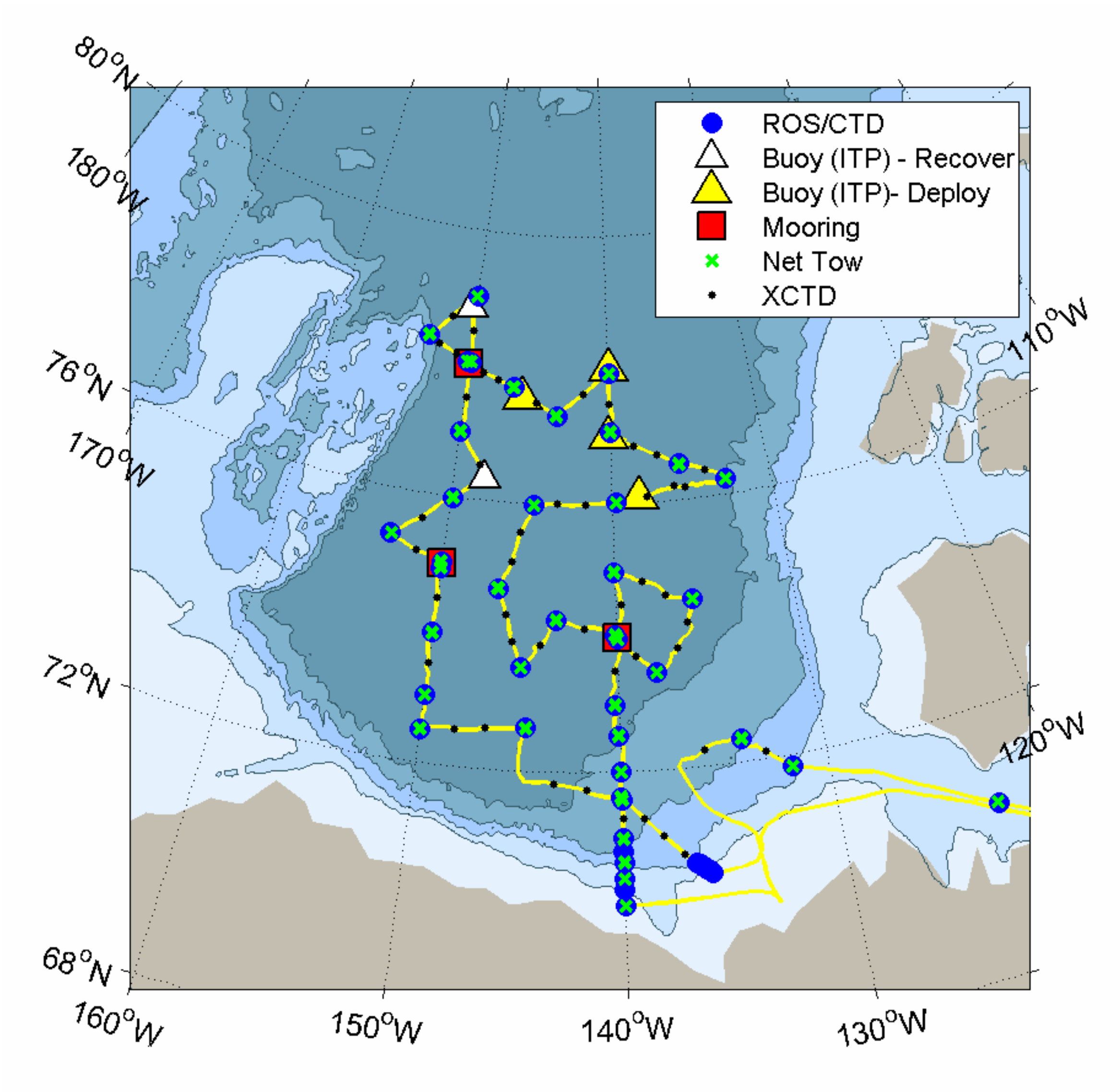


Figure 1.The JOIS-2011 cruise track showing the location of science stations.

- **PROGRAM COMPONENTS**

Measurements:

- At CTD/Rosette Stations:
  - 52 CTD/Rosette Casts at 48 Stations (DFO) with 997 water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (DFO, TrentU, TUMSAT, UAkron, WHOI).
    - At all stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), pH, Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a,
    - At selected stations: Ammonium, DIC (full profile), Argon and Oxygen isotope, DIC14, DOC14, D2O, Microzooplankton.
  - Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts (DFO)
  - 78 Vertical Net Casts at 37 select Rosette stations typically to 100m with occasional casts up to 500m deep (DFO)
- 49 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth (JAMSTEC, WHOI , Tokyo University,)
- Mooring and buoy operations
  - 3 Mooring Recoveries (3 deep basin (WHOI))
  - 3 Mooring Deployments (3 deep basin (WHOI))
  - At 2 mooring sites in-situ pumps were used to collect particulate organic carbon (POC) to compare with moored sediment traps
  - 3 Ice-Based Observatories (IBO, WHOI)

    the first consisting of :

    1 Ice Tethered Profiler (ITP, WHOI)
    1 Ice Mass Balance Buoy (IMBB, CRREL)
    1 O-buoy (Bigelow, UAF)

    the second:

    1 Ice Tethered Profiler (ITP, WHOI)
    1 Ice Mass Balance Buoy (IMBB, CRREL)
    1 Arctic Ocean Flux buoy (AOFB, NPS)
    3 Ice Beacons (Yale)
    1 Uptempo Buoy (UW)
    4 GPS Buoys at corners of 5nm square around IBO site (IARC)

    the third:

    1 Ice Tethered Profiler (ITP, WHOI)
    1 Seasonal Ice Mass Balance Buoy (SIMBB, CRREL)
    1 Uptempo Buoy (UW)
  - 1 Ice Tethered Profilers deployed on its own (ITP, WHOI)
  - 2 Ice Tethered Profiler recoveries (ITP, WHOI)
  - CABOS mooring recovery (IARC)
- Ice Observations
  - Ice Observations (UAF/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 and ice-depth transects.
- Underway collection of meteorological, depth, near-surface seawater, and navigation data with 94 water samples collected from the underway seawater loop for: Salinity, Oxygen, CDOM, and chlorophyll (DFO,TrentU). In addition, water was filtered through C-18 cartridges to concentrate dissolved lignins for radiocarbon dating to distinguish soil and melting permafrost sources of terrestrial organic matter.
- Daily dispatches to the web (WHOI)

Other:

- Fuel detour made to near Tuktoyaktuk but due to weather, fuelling was cancelled.

3. COMMENTS ON OPERATION

3.1 Ice conditions

We had a substantial amount of open water and/or weak and thin first and second year ice in our study area again this year. The first and second year ice was heavily melt-ponded (see cover photo) though melting of sea ice was somewhat slowed during much of our expedition due to persistent fog that blocked incoming solar radiation (see www.nsidc.org). The fog was very likely due to the open water provided by the melt ponds. There is a feedback here.

The thickest multiyear ice was generally to the east of 140W near the northwestern border of the Canadian Arctic Archipelago. We encountered some of this ice when heading east from BGOS site C and D toward Banks Island. 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 of the Iced Based Observatories in the northern area.

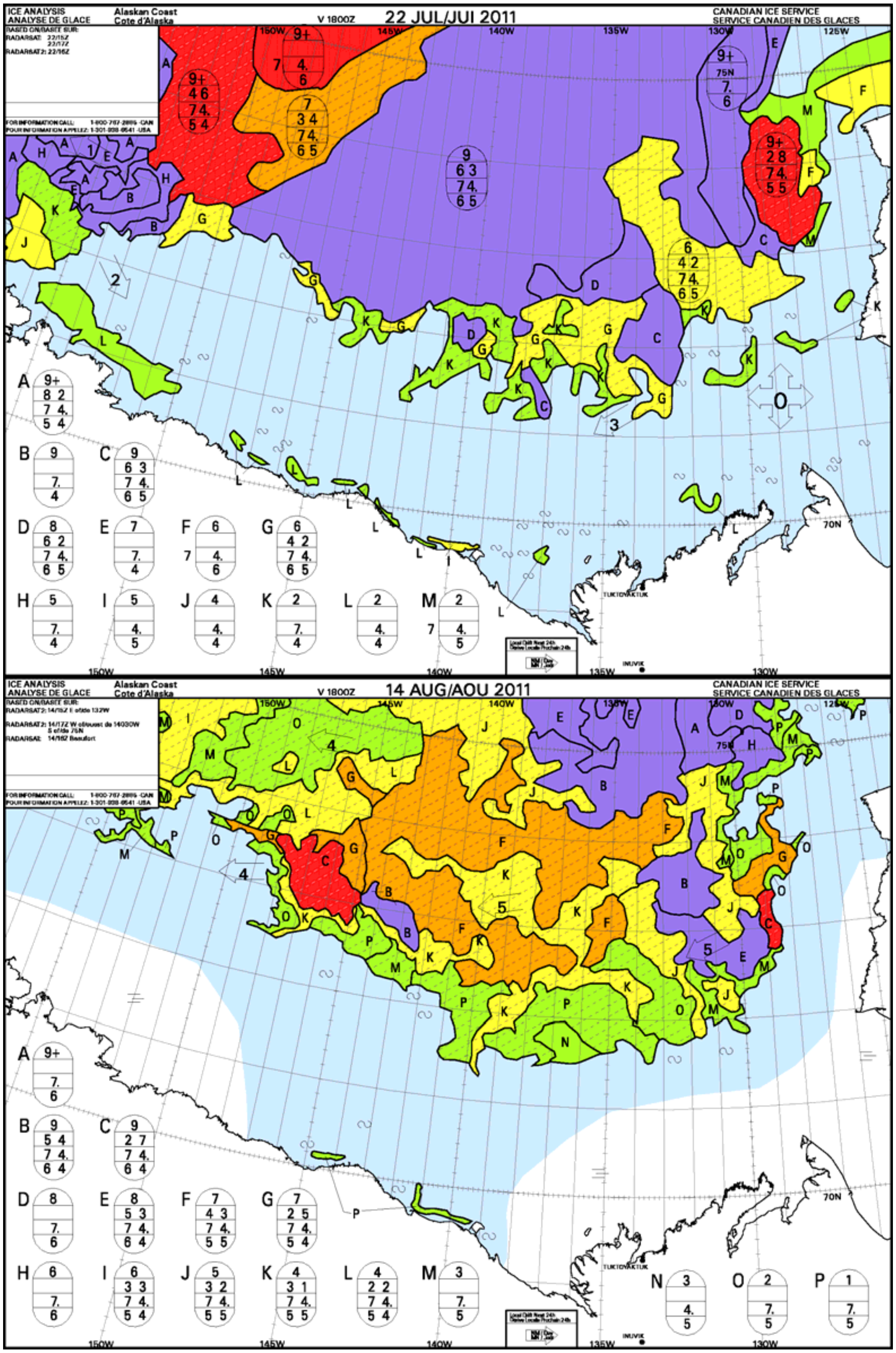


Figure 2: Canadian Ice Service ice concentration charts from the beginning and end of the cruise for the southern part of the JOIS cruise track.

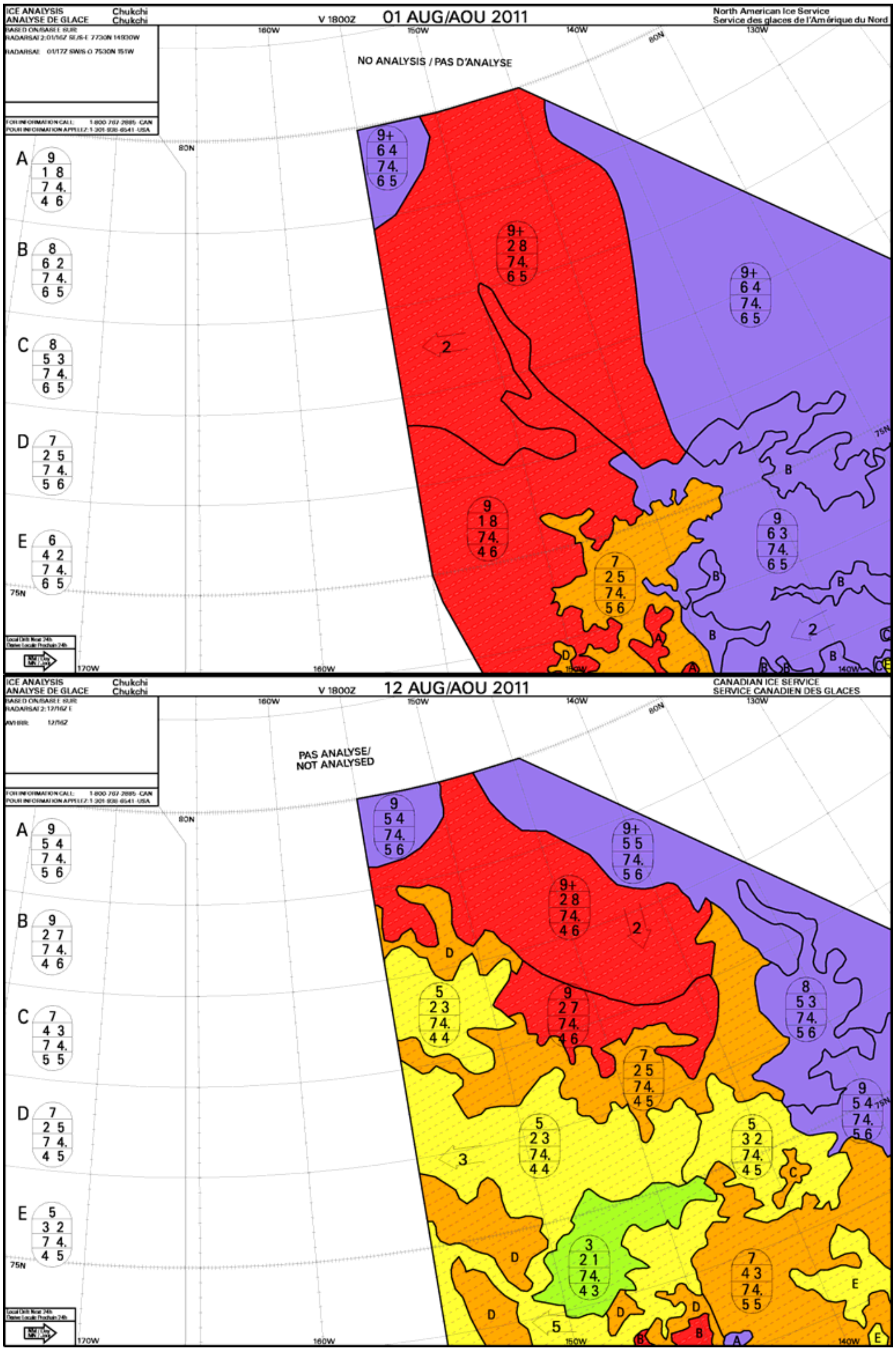


Figure 3: Canadian Ice Service ice concentration charts for August 1 and August 12 for the northern part of the JOIS cruise track.

3.2 Completion of planned activities

All primary objectives were met.

3.3 Ship improvements completed for 2011

We are very appreciative of the items identified last year for improvement that were addressed such as assistance with replacement of the Hawboldt winch's shell and wire (7000m of new .322" CTD wire were installed on a new shell); assistance with removal, service and reinstallation of the seawater pump on the science seawater loop; and repair to the CTD launching deck and application of skidproof paint.

3.4 Suggestions for 2012

A list of suggested improvements to and comments about the ship's equipment and lab spaces will be sent separately.

4. ACKNOWLEDGMENTS

The science team would like to thank the Coast Guard for their support, particularly Captain Andrew 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. The engine department deserves special mention for their successful effort to address the unusual number of issues that arose during the cruise. We'd like to thank Roger Provost and the Canadian Ice Service for their assistance with ice images and weather information as well as Chris Swannell, the helicopter pilot for his and his team'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.

5. 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.

5.1 Rosette/CTD Casts:

PI: Bill Williams (DFO-IOS)
Mike Dempsey, Sarah Zimmermann (DFO-IOS)

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 V7.21d acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, dissolved oxygen sensor, fluorometer, transmissometer, CDOM fluorometer and altimeter. An ISUS nitrate sensor with depth limit of 1100m was used for the first few casts though instrument problems resulted in no data. A PAR sensor was used for casts less than 2000m deep. A surface PAR sensor was installed for all casts, but covered during casts without an underwater PAR. Note: continuous PAR data was collected for the whole cruise as part of the underway suite of sensors. All CTD sensors have 0-5v analogue output which is included in the CTD data string.

On all rosette casts we collected water samples for 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, Dissolved Inorganic Carbon (DIC), pH, ^{18}O, Barium and Bacteria. On selected casts we sampled Ammonium, full profile DIC, Argon and Oxygen isotopes, $DI^{14}C$, $DO^{14}C$, Deuterium, and water for plankton measurements and experiments (see Lavretyev and Putland's work below)

Prior to each deployment of the CTD/Rosette package the transmissometer and CDOM sensor windows were sprayed with deionised water and wiped with a DI water-soaked lens cloth to prevent sensor drift due to window fouling during the month-long cruise.

At the beginning of each CTD cast, the package was lowered to 10m to cool the system to ambient sea water temperature, remove bubbles from the sensor's plumbing and equilibrate the oxygen sensor. The pumps for the T/C/DO_2/Fluorometer ducts were manually turned on when the CTD/Rosette package was lowered into the water. The sensors were soaked for 3 minutes at 10m then the package was brought up to just below the surface to begin a clean cast. For the cast, the package was lowered at 30m/min down to 300m deep and then lowered to within 8-10m of the bottom at 60m/min. Niskin bottles were closed during the upcast 'on the fly' without slowing the ascent of the package, or when multiple bottle were tripped at the same depth the package would be stopped for 30seconds before closing the multiple bottles. In addition, four 'calibration' casts were taken where select bottles were closed using the 'yo-yo' method where the package was stopped 30 seconds, lowered 1m, raised 2m, lowered 1m, paused for 30 more seconds

then the bottle closed with the expectation that the water in the Niskin and around the CTD would be closely matched following this mechanical mixing. During a CTD/Rosette cast, the instrumented sheave (Brook Ocean Technology) read out data to the winch operator, CTD operator and bridge, allowing all three to monitor cable out, wire angle and CTD depth.
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.

Figure 7. Sampling the Rosette. ***Photo by M-L Timmermans***

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. The ISUS however did not work properly and needs servicing.

A few Niskin problems were encountered. Initially there were problems with bottles 13 and 17 not closing. Better guides for the wire were made by adding tape to the guard rail. The trigger was swapped out and a repaired bottle was used in place of 17, however the replacement's repair did not hold and needed to be replaced again. The type of problem that had been repaired, the o ring lip tends to crack and chip with use, had been repaired using plumbers' epoxy however in seawater the epoxy is too soft and peeled off the PVC lip. Since there are 8 bottles with similar chips, it would be worthwhile trying another fix. Welding in a strip of PVC then shaping it is a possible option. There were also 5 casts where it appeared that Niskins 15 to 18 were sampling water 25 m deeper than the recorded bottle closure depth. Possible causes could be improper flushing due to tilting of the rosette. In air, it was noted that Niskin 8 is the low spot and the rosette is out of trim 2-3 degrees.

Repairs were made to the Hawbolt CTD winch and the CTD wire replace prior to the cruise. The bearings were serviced and were no longer an issue. The ~4300 m 0.316" single conducted wire was wound off and saved on 7000 m of new Rochester 0.322", 3 conductor CTD cable was wound on. Electrically the wire performed flawlessly, but there were continuing problems with spooling of the wire at the forward shoulder requiring manual assistance. The diamond screw may be offset to the aft shoulder and may need to be re-centred a small amount, perhaps as little as ¼" forward (towards bow of ship).

The 52 CTD/Rosette cast locations are listed in the ***Appendix B.***

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, Alkalinity, DIC, pH and Ammonium were analysed on board. All other samples were prepared as required and stored for analysis on shore.

5.2 Side-of-ship ADCP

Mike Dempsey (DFO-IOS)
PI: Svein Vagle (DFO-IOS)

Figure 2. ADCP being lowered to 5m during rosette cast. *Photo by Sarah Zimmermann*

In conjunction with the CTD/Rosette Casts, an RDI acoustic doppler current profiler (ADCP) measuring currents in the upper waters looking for layers of zooplankton were lowered over the side. During previous JOIS cruises, a 50kHz and 200kHz backscatter transducers have typically been mounted on the ADCP frame, however due to electronic problems they were not installed this year. 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.

A few casts were missed (between stations CB12 and PP6) due to a damaged underwater connector. During CB12 (ADCP 108), the system was tugged by ice which exacerbated a problem with the connector. A field fix was made and the ADCP used again a few stations later. No real data quality assessment was made at sea. The checks for data quality were very basic. For the ADCP, during acquisition, it was ensured that the ADCP went through its start up and was receiving GPS and Gyro. Once acquiring data, a quick check was made that the good returns seemed consistent and that all beams were showing a return.

Please see list of csat locations in ***Appendix B***

5.3 XCTD Profiles

PIs: Kohei Mizobata, Koji Shimada, (TUMSAT), Andrey Proshutinsky (WHOI), Motoyo Itoh (JAMSTEC)

XCTD (expendable conductivity, temperature and depth profiler from manufacturer Tsurumi-Seiki Co., Ltd. or Sippican) probes provided by WHOI, Tokyo University of Marine Science and Technology and JAMSTEC were deployed from the ship's stern to acquire vertical profiles of temperature and conductivity. Both computer and data converter, MK-150 (Tsurumi-Seiki Co., Ltd.) were located in the stern (AVGAS) hold. The data converter, MK-150 (Tsurumi-Seiki Co., Ltd.) was used for data acquisition and data-conversion from original binary to 1-m averaged ascii data. Depth was calculated using time and falling rate. Salinity, density and sound speed were automatically calculated after XCTD deployment was finished.

The casts took approximately 5 minutes or 10 minutes for the released probe to reach its final depth of 1100m. Two types of probes were used, XCTD-1 and XCTD-3 which can be deployed as the ship steams 2knt and 15knt respectively. In heavy ice the ship is stopped for deployment to prevent the probe's wire from being broken by the ice, thus XCTD-1 probes were used preferentially in the heavy ice areas where the ship would be stopped.

Figure 1: XCTD probe deployment from the ship's stern and XCTD data converter MK-150.

The locations of XCTD deployment were determined 1) to increase the spatial resolution of CTD data and 2) to make all cross-section data comparable to other years, deploying at certain isobaths or spacing. Typically 1 probe was deployed between CTD casts which were 45 to 60nm apart.

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)

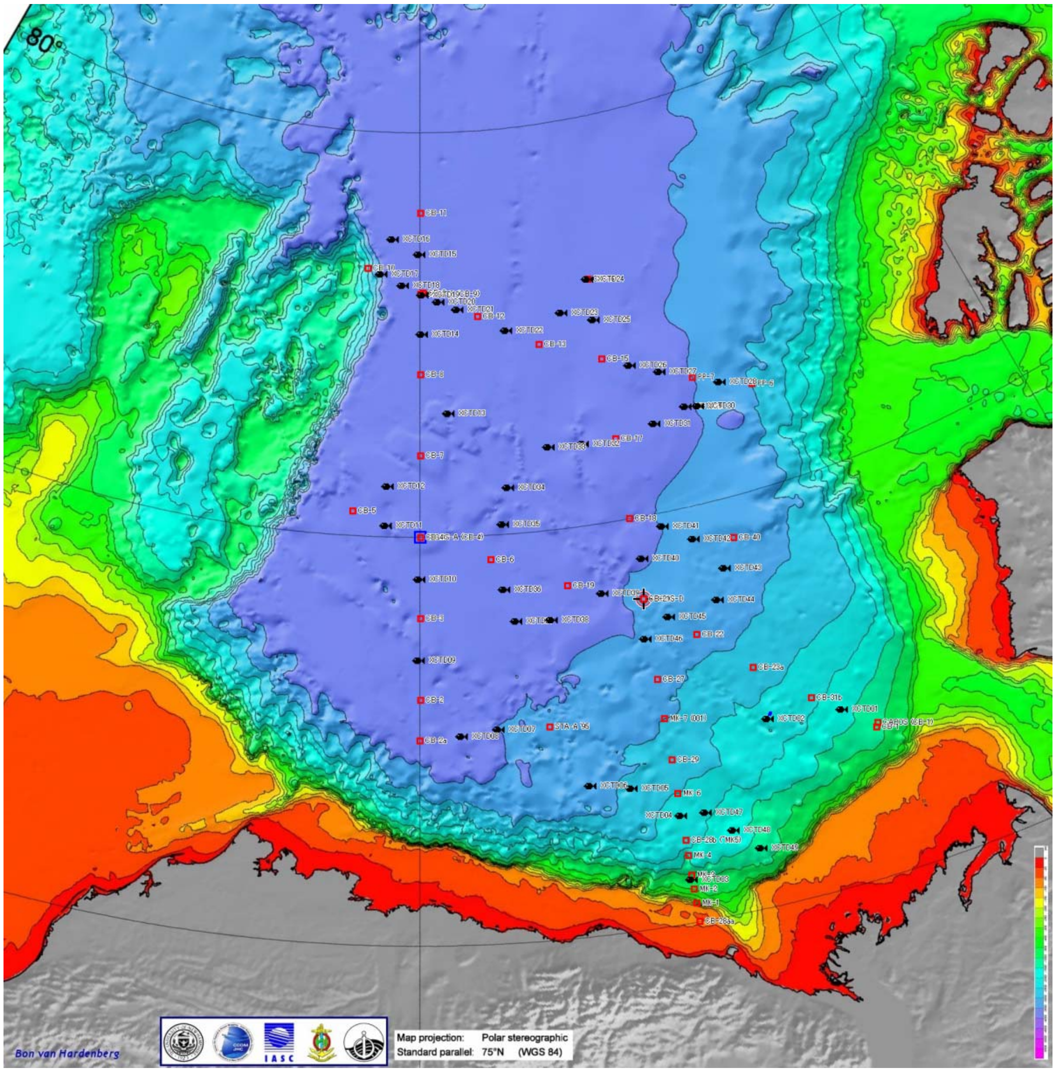


Figure 2: The location of CTD (red square) and XCTD (black "fish" mark) stations of the JOIS2011 cruise in the Canada Basin.

During this cruise, 49 XCTDs were successfully launched with no failures however cast #21 had a shortened profile of 1059m instead of 1100m presumably due to the wire breaking on the ice. Several XCTD casts were added seeking eddy structure near CB-9 (78N 150W). After each deployment, binary raw data was immediately converted to 1-m interval data. To make it comparable to CTD data, temperature data was converted using a following equation,

t=temp*1.00024 : [ITS68-->ITS90];

Please see list of launch locations in ***Appendix B***

Calibration of the salinity data will be done after the CTD data have been calibrated. Although the calibration is needed, preliminary results of the "high-resolution" combined dataset of CTD and XCTD exhibit the interesting features, such as eddies. Figure 3 shows a subsurface eddy with stretching Pacific Winter Water (PWW) layer and relatively warm Pacific Summer Water (around 0 degree C). The subsurface PWW eddies were also captured by CTD casts along 150^{o} W during this year's cruise (not shown) and have been evident in the Canada Basin since, at least 2010. Each eddy was captured by a only single CTD or XCTD cast, suggesting a spatial scale defined by the Rossby radius of deformation. A fine resolution CTD observation would be needed to capture them.

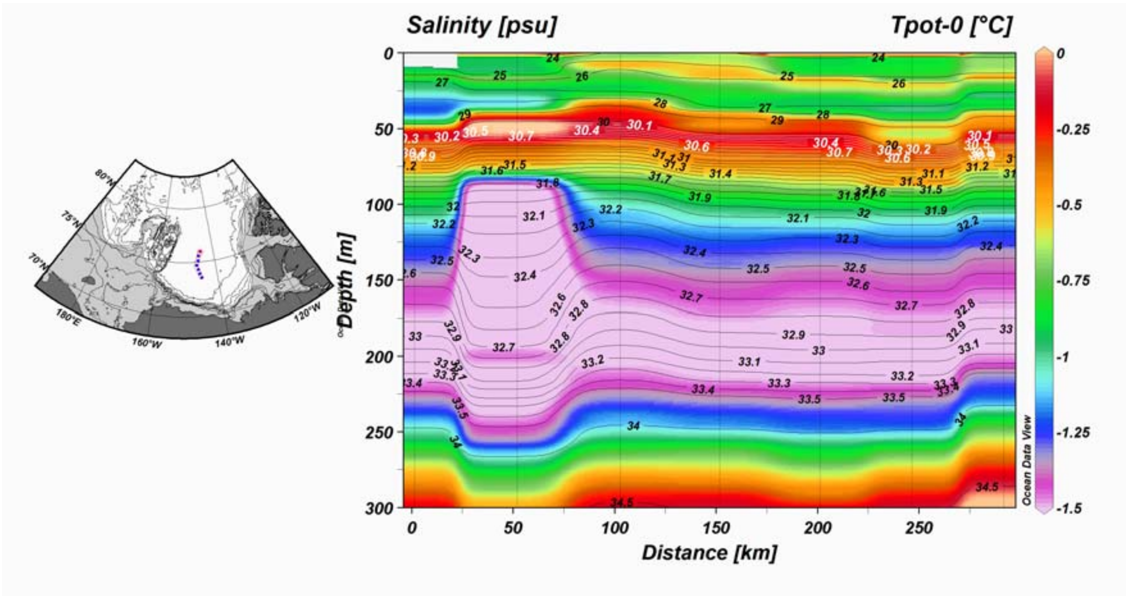


Figure 3: A cross-section of potential temperature and salinity from new stations CBC to CBS based on CTD and XCTD datasets. Eddy-like feature with warm Pacific Summer Water at 50m water depth was captured by XCTD (Cast # 34) at about 50 km away from Station CBC.

5.4 Zooplankton Vertical Net Haul.

Kelly Young (DFO-IOS)
PI: John Nelson(DFO-IOS)
Day Watch: Babtiste Marcare (Trent) Mike Dempsey (DFO-IOS)
Night Watch: Hugh Maclean (DFO-IOS), Kohei Mizobata (TUMSAT), Hiroki Shibata (KIT)

Summary

A total of 86 bongo net hauls were completed at 37 stations. Bongos were harnessed and deployed in the same manner as the 2010-07 JOIS cruise. Standard, duplicate tows to 100m were sampled at all stations except where weather and time restraints limited the deployment to one 100m tow (CB-11, CB-28aa, MK-2). Two stations were repeated a few days apart (CB-21 and MK-6). At select stations, tows to 500m and live tows to 100 or 200m (closed cod ends, see *New additions* below) were conducted in addition to the routine tows (Table 1). Samples were preserved as follows:

Cast 1 (100m):

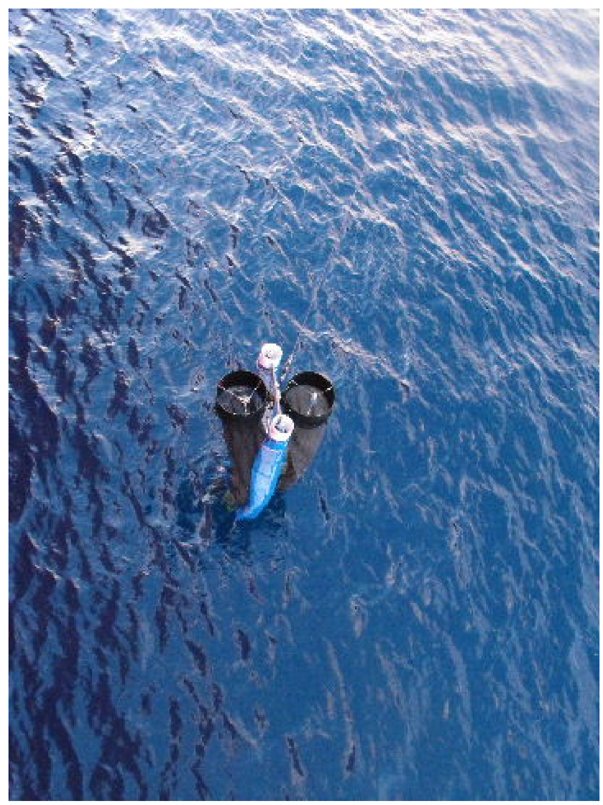
- 236 µm into buffered formalin (10%)

- 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 (500m):
- 236 µm 95% ethanol
- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

Live Cast (100 or 200m)
- after copepods needed for grazing experiment were removed, remaining sample (all mesh sizes) was preserved in one jar with 95% ethanol



Please see table of casts in Appendix B

New Additions

Live casts for mesozooplankton grazing experiments (P. Lavrentyev and J. Putnam, U. Akron)

Additional tows were conducted at 8 stations (see Table 1, 'all' mesh size) to collect live copepods for grazing experiments. Tows were to 100-200m deep to ensure enough copepods were collected for each experiment. The net was deployed as usual except the 150 and 236 m mesh cod ends were replaced with closed cod ends (mesh windows taped over). Upon retrieval, the net was brought on deck with no wash down, and the cod ends gently emptied into two buckets that were partially filled with water from the sea loop and sitting on ice. The net was then hung up and hosed down with no cod ends to ensure no transfer of plankton to the next station.

Immediately after collection, individual copepods were collected using gentle suction (a turkey baster worked well) and transferred into clean glass bowls filled with seawater from the loop. The bowls were kept on ice and covered with tinfoil. The condition, stage and id of individuals were checked using a dissecting microscope. The female stage of two species were targeted: *Calanus hyperboreus* and *C. glacialis*. There were enough *C. hyperboreus* females collected in a 100m tow (only 6 individuals were needed); however, a 200m tow was needed at some stations to ensure there were enough *C. glacialis* females (20 individuals per experiment). Once all individuals were collected, they were placed in the cold room until needed for the experiment. The remaining sample was combined into one jar and preserved with 95% ethanol.

Suggestions for next year

- It would be very useful to have a small RBR depth meter to attach to the bongos (as in 2010). Occasionally the flowmeters will jam or give an unreliable reading, and it is not clear how accurate the winch cable-out meter is. Since depth is an important part of calculating abundance and biomass (needed to calculate the volume sampled by the nets), an RBR would allow a more accurate reading to be obtained, and also provide a backup in case the flowmeters malfunction.

- It would be helpful if a container would be available on the foredeck for wet work (either a sink or just a drain) that has adequate ventilation so all the sample processing (including preservation with formalin and ethanol) could take place on the foredeck.

- If tows are conducted in very cold weather, an ice chummy for the forward winch cable may help prevent the meter block from freezing up.

- Spare cod ends for the 53 m nets are needed (there are currently only 4 total, and all are used for one station).

- Spare nets are needed for the 53 m nets.

- A new weight line should be made, or the current weight line should be adjusted to remove knots in the line that the cod ends catch on.

5.5 Underway Measurements

Sarah Zimmermann, Mike Dempsey, Edmand Fok
PIs: Svein Vagle (DFO-IOS), Celine Gueguen (Trent University)

Overview

This report describes measurements taken at frequent regular intervals throughout the cruise. These measurements include:

- From the seawater loop system: salinity, temperature (inlet and lab), fluorescence, CDOM, gas tension, and oxygen saturation.
- Hull temperature
- Ice Camera
- SCS system used to log
    a. From the Novatel GPS: all NMEA strings (GPRMC, GPGGA, HEHDT, among others) as well as position, time, speed and total distance
    b. AVOS weather observations of: air temperature, humidity, wind speed, barometric pressure
    c. Sounder reported depth and applied soundspeed
- Photosynthetically Active Radiation (PAR)

Seawater Loop

The ship's seawater loop system draws seawater from below the ship's hull at 9m using a 3" Moyno Progressive Cavity pump Model #2L6SSQ3SAA to the TSG lab, a small room just off 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 unaltered as possible coming directly from outside of the hull through stainless steel piping without recirculation in a sea-chest. The manifold in the TSG has been insulated to minimize condensation. Flow rate is controlled to the lab by a Honeywell electronic system which has a data feed from a pressure sensor in the lab, and on one arm of the manifold, by a Kates mechanical flow rate controller. This arm also has a vortex debubbler so that the water provided to the TSG and other instruments is as bubble free as possible.

Autonomous measurements were made using:

- SBE38: Temperature s/n 0319, calibration date 6 Jan 2011.
  Sensor was installed in-line, approximately 4m from pump at intake. This is the closest measurement to actual sea-temperature.
  SBE21 Seacat Thermosalinograph s/n 3297, calibration 11 Jan 2011:
  Temperature and Conductivity, Fluorescence (WET Labs WETStar fluorometer

s/n WS3S-376P, calibration date 1998) and CDOM (WET Labs CDOM s/n WSCD-1281). The Fluorometer and CDOM sensors were plumbed together off of a different manifold output than the debubbler output used the Temperature and Conductivity. GPS was provided to the SBE-21 data stream using the NMEA from PC option rather than the interface box
5 second sample rate

- Blue Cooler: Total gas (Gas Tension Device) 40s sampling, Oxygen.
  5 second sample rate, fed by water that has gone through the debubbler
  (Svein Vagle, DFO)

Flow rate

The Honeywell controller typically read 13.8 PSI and 24% output.
Flowrate to the various was measured periodically through the cruise.

Manifold to:	Average (l/min)	Minimum (l/min)	Maximum (l/min)
Temperature and Conductivity	9.8	8.0	12.0
Blue Cooler	3.7	2.0	4.8
Fluorometer and CDOM	9.7	8.6	10.9

Part of the system, but not attached to the seawater loop:

- SBE48 (S/N 480022, calibration 9 Jan 2011): Temperature was also measured through the hull using a temperature sensor mounted on the ship's hull, inside, aft of the pump approximately 15m, starboard side. Sampling rate is once per minute

Discreet Water Samples:

- Salinity, Chlorophyll-a, Dissolved Oxygen, and CDOM to be used to calibrate the underway sensors.
- Water was filtered for POC samples. See Daniel Montlucon's report below.

Figure 1. Seawater loop system providing uncontaminated seawater from 9m depth to the science lab for underway measurements. No "Black Box" was used this year, and a laptop replaces the desktop PC, otherwise the setup was similar to this photo from 2008.

Figure 2. Pump for seawater loop at intake in engine room.

Some of the instruments were self-contained; others were connected to a single data storage computer. The data storage computer provided a means to pass ship's GPS for integration into sensor files, to pass the SBE38 data from the engine room to the TSG instrument, and to pass the TSG and SBE48 data to the ship's data collection system (SCS).

Problems

The Moyno pump was removed and serviced prior to this year's cruise and worked well for the cruise. It was necessary to hand crank the pump to start at the beginning of the cruise though this was thought to be due to the newly reassembled pump to be 'tight' and that it would loosen up with wear. Snow covered ice continues to be a difficult environment for the pump. The strainers clog and low flow or bubble filled flow comes through to the TSG lab. Noise in the CDOM and fluorometer data, likely caused by excessive bubbles, is a good indicator that all TSG data are suspect due to poor flow.

Filtering water samples for chlorophyll took much too long for many of the samples collected from the seawater loop. Compared to the 5m Niskin from the rosette where 1L of seawater takes about 20 minutes to filter, the same volume was taking up to, or over, an hour to filter, potentially breaking apart the chlorophyll containing cells. There seemed to be a correlation between loop seawater from ice covered areas taking longer to filter than seawater from open water areas.

Ice Cameras

Ice Cameras mounted on above the bridge took pictures every 5 to 30minutes depending on ice conditions. Two cameras were installed, one looking forward, the other looking aft along the side of the ship to observe upturned ice. See the complete report on this system by Alice Orlich.

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.

The SCS system on a shipboard computer called the "NOAA server" collects:

- Location, speed over ground and course over ground as well as information about the quality of GPS fixes 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 (see note on true wind speed below).

- Sea surface temperature, conductivity, salinity, CDOM and fluorescence from the ship's SBE 21 thermosalinograph and ancillary instruments
- Sea surface temperature from the SBE48 hull mounted temperature sensor

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

We experienced few problems this year with the system losing data. Major gaps in the TSG records are due to the system needing to be turned off in certain ice conditions, sometimes for periods of over 24 hours. The SBE48 Hull temperature data were collected to a log file though the integration into the SCS system did not work properly.

Knudsen Sounder

Data string SDDBT: New this year, both the sounder depth and the sound speed used to calculate the depth are being recorded. The soundspeed was only changed intermittently so for accurate depth the soundspeed should be assessed per CTD cast and applied as needed to the depth value (ie back out the travel time from the soundspeed used and reapply new soundspeed to the travel time to obtain accurate depth).

Photosynthetically Active Radiation (PAR)

The continuous logging Biospherical Scalar PAR Reference Sensor, QSR2100, sn10350, calibration date 2/27/2007, was mounted above the helicopter hanger, with an unobstructed view over approximately 300deg. The blocked area is due to the ship's crane and smoke stack which are approximately 50' forward of the sensor. Data was sampled at 1/5second intervals.

5.6 POC Study

Daniel Montlucon (ETH Zürich)
PI: Tim Eglinton (W.H.O.I. / ETH Zürich)

The main purpose of this work is to collect Particulate Organic Carbon (POC) in the Canada Basin for studies of carbon fluxes from either across-shelf transport processes or surface production. See ***Appendix B*** for location and type of sampling performed.

- Sediment traps samples (traps on the WHOI moorings) are used to look at seasonal variability in POC fluxes while the in-situ pumps (pumped at WHOI mooring sites A and B) will provide information on the POC chemical and isotopic (C13,C14, deuterium) composition at varying depths.

- C14 DOC and C14 DIC water samples (from the CTD/Rosette) are used to look at the radiocarbon age of the DOC pool in the different water masses.

- Samples collected for water deuterium analysis will be used in conjunction with
compound-specific (i.e.analysis on suites of single compounds) deuterium analysis done on POC samples. Full cast sampling (from the CTD/Rosette) for deuterium and ^{18}O will be used to look at the water deuterium/^{18}O signatures in different water masses

- Filtered water (from the surface seawater loop) passed through C-18 cartridges to concentrate dissolved lignins will be eluted and analysed for radiocarbon to look at the age of this terrestrial pool of organic matter and assess the respective contribution from soil (younger carbon) or melting permafrost (older carbon).

- Surface water was filtered for POC to provide chemical and isotopic information on the surface POC pool and to complement the in-situ POC pump casts. In addition discrete water samples were collected along the ship track for water deuterium analysis

5.7 BGOS Field Operations

Rick Krishfield, John Kemp, Steve Lambert, and Jeff Pietro (WHOI),
Mary-Louise Timmermans (Yale University)
PI: Andrey Proshutinsky, John Toole (WHOI)

As part of the Beaufort Gyre Observing System (BGOS; www.whoi.edu/beaufortgyre), three bottom-tethered moorings deployed in 2010 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in July-August 2011 from the *CCGS Louis S. St. Laurent* during the JOIS 2011 Expedition. In addition, four Ice-Tethered Profiler (ITP; www.whoi.edu/itp) buoys were deployed, one in combination with an Ice Mass Balance (IMBB) and atmospheric chemistry O-Buoy, one with an Arctic Ocean Flux Buoy (AOFB), IMBB, 3 Ice Beacons, and an Uptempo buoy, and a third with a Seasonal IMBB (SIMBB) and Uptempo buoy. One ITP was also completely recovered (number 42) and second partially recovered (number 33 was missing profiler).

Summary of BGOS 2011 field operations.

Mooring Designation	Depth (m)	2010 Location	2011 Recovery	2011 Deployment	2011 Location

BGOS-A	3825	75° 0.055'N 149° 58.744 'W	29-Jul 15:49 UTC	30-Jul 22:18 UTC	74° 59.913'N 149° 59.800'W
BGOS-B	3824	77° 59.313'N 149° 58.198'W	1-Aug 19:48 UTC	3-Aug 21:04 UTC	77° 59.3'N 149° 58.2'W
BGOS-D	3505	73° 59.945'N 139° 59.004'W	11-Aug 18:19 UTC	13-Aug 20:00 UTC	73° 59.87'N 139° 58.98'W
ITP42			31-Jul 23:22		76° 20'N 148° 2'W
ITP33			2-Aug 19:07		78° 50'N 150° 20'W
ITP53				4-Aug 18:43	77° 34.2'N 145° 56.4'W
ITP52/IMBB/O-Buoy				5-Aug 21:50	78° 0.4'N 139° 55.5'W
ITP54/AOFB/IMBB/ Ice Beacons/Uptempo				6-Aug	77° 0.1’N
				23:03	140° 5.7’W
ITP55/SIMBB/Uptempo				8-Aug 23:00	76° 5.1'N 138° 16.9'W

Moorings:

The centerpiece of the BGOS program are the bottom-tethered moorings which have been maintained at 3 (sometimes 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. Previous years, the top floats were positioned approximately 45 m below the surface to avoid ice ridges, but this year the floats were brought up to 30 m due to thinner ice conditions and to increase the scope of the underwater instruments. 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, an Acoustic Doppler Current Profiler for measuring upper ocean velocities in 2 m bins, one (or two) vertical profiling CTD and velocity instruments which samples the water column from 50 to 2050 m (and 2010 to 3100 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.

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 systems.

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, 8 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, but Ekman (surface driven) forcing is also a significant contributor.

Buoys:

Because the moorings only extend up to about 30 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 Naval Postgraduate School Arctic-Ocean Flux Buoys, three US Army CRREL Ice-Mass Balance buoys, three Ice Beacons, two Uptempo, and an O-Buoy. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).

The centerpiece 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.

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 30 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 around 4 hours after release. The deployment operations normally entailed an hour of deck preparation once on site, followed by a 4 to 5 hour anchor first deployment.

Complete year long data sets with good data were recovered from 2 out of 3 MMPs, all ULSs, all ADCPs, every BPR, and all but one of the temperature and salinity loggers. In addition both sediment traps collected samples for the duration of the deployment.

The ITP recovery and 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). Two ITPs were recovered this cruise, numbers 42 and 33, while two other systems that were slated for recovery had drifted too far west from the cruise track to allow recovery. The profiler on ITP 42 operated for only part of the year since being deployed on JOIS 2010, apparently due to a bad battery pack, while the profiler on ITP 33 stopped sending data after 1000 profiles. Hence, the recovery of ITP 42 was a salvage operation, while the recovery of ITP 33 could have returned another 500 profiles stored within the underwater instrument. ITP 42 was recovered intact, but unfortunately the wire had parted on ITP 33 (presumably dragged on shallow bathymetry), so that profiler was lost. The recovery operations were conducted from the ship after breaking the units out of the floes that they contained by running them over.

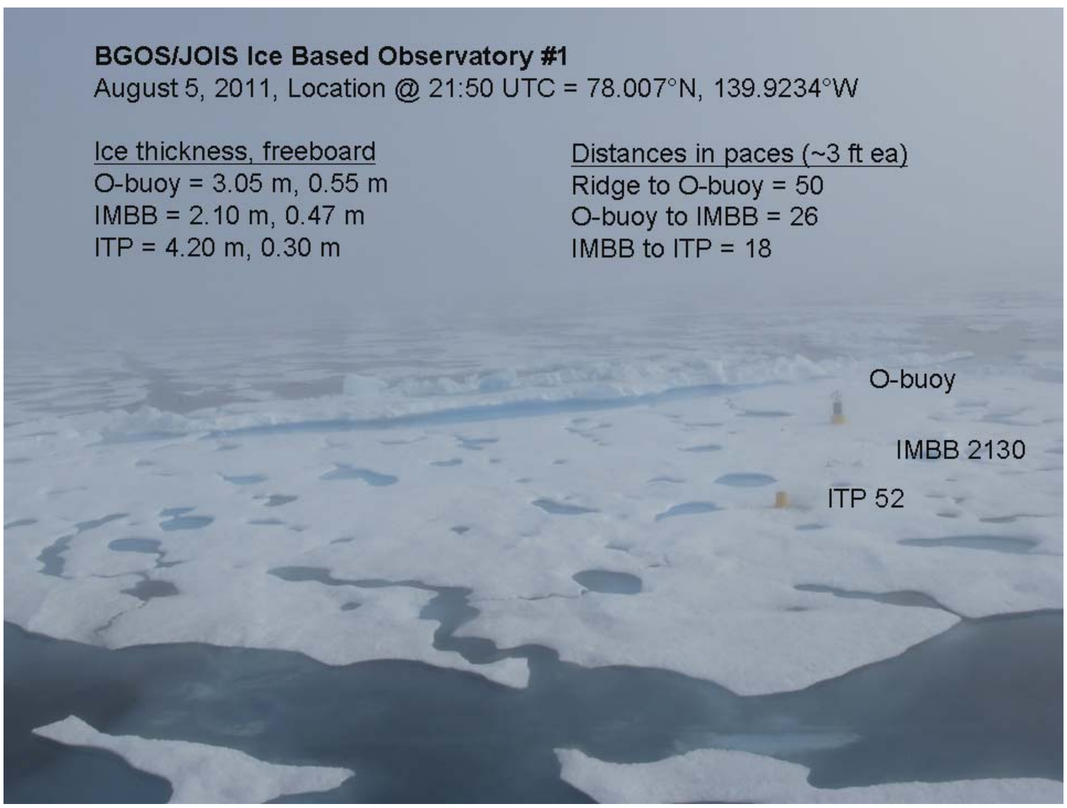
ITPs 52 (with full biosuite sensors) 53, 54 (with additional microcat instrument on the wire), and 55 (with profiler from ITP 42 which was recovered earlier) were deployed on 4.2, 3.8, 2.2, and 3.2 m thick ice floes respectively. Only ITP 53 was deployed alone, all other systems were deployed as part of IBOs. 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. Photos of the IBOs as deployed with some initial information are presented below. Ice analyses were also performed by others in the science party, while the ITP deployment operations took place.

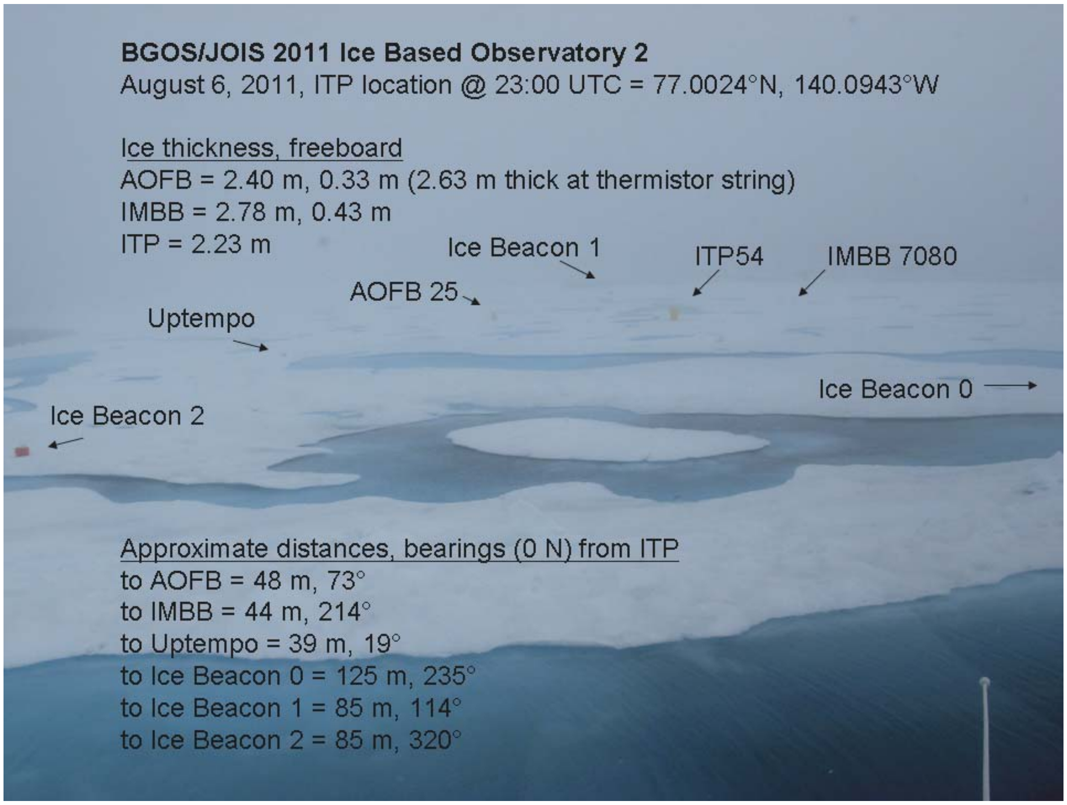
Since deployment, all of the ITPs have begun profiling and transmitting data. Only the ITP 54, which is configured with a new version Inductive Modem Module (IMM) is having some intermittent problems communicating profiles up the wire.

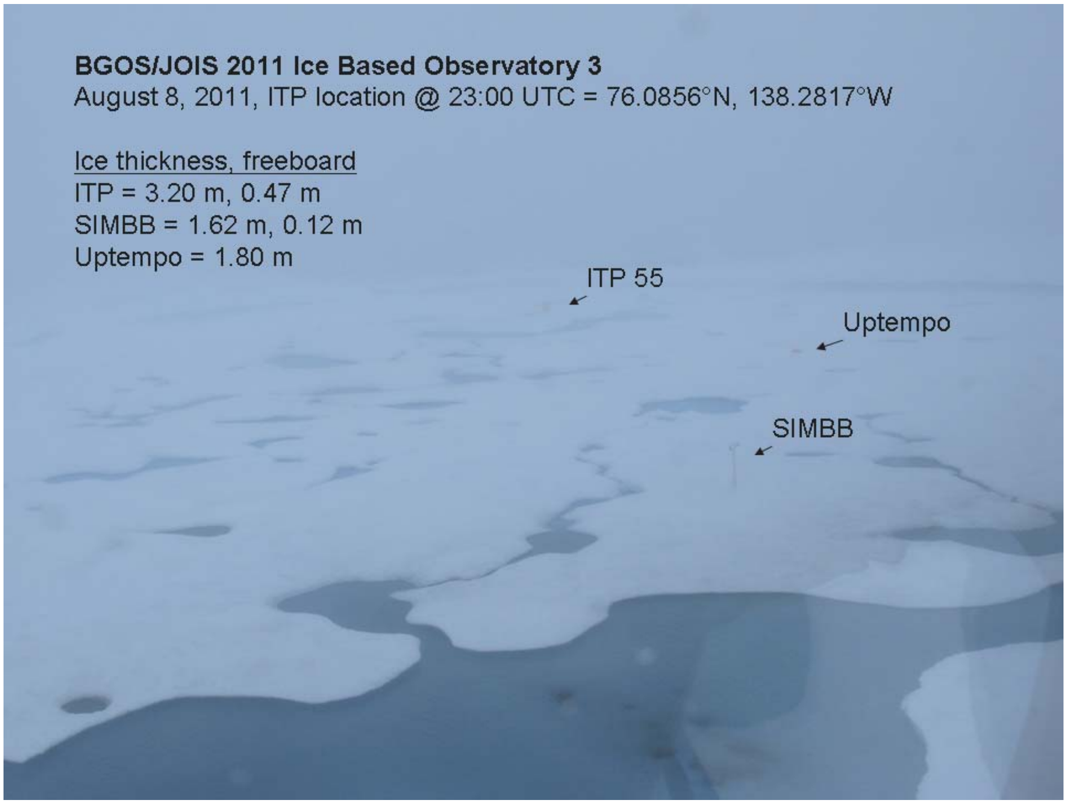
Other:

In addition to handling the sediment trap samples, Daniel Montlucon performed pumping stations at two of the mooring stations (A & B), but did not have sufficient time to pump at mooring D due to our early departure to Tuktoyaktuk to refuel (which did not occur).

Twenty-six dispatches documenting all aspects of the expedition were posted in near real time on the WHOI website at: www.whoi.edu/beaufortgyre/2011-dispatches.




BGOS/JOIS 2011 Ice Based Observatory 2
August 6, 2011, ITP location @ 23:00 UTC = 77.0024°N, 140.0943°W
Ice thickness, freeboard
AOFB = 2.40 m, 0.33 m (2.63 m thick at thermistor string)
IMBB = 2.78 m, 0.43 m
ITP = 2.23 m
Ice Beacon 1
ITP54
IMBB 7080
AOFB 25
Uptempo
Ice Beacon 0
Ice Beacon 2
Approximate distances, bearings (0 N) from ITP
to AOFB = 48 m, 73°
to IMBB = 44 m, 214°
to Uptempo = 39 m, 19°
to Ice Beacon 0 = 125 m, 235°
to Ice Beacon 1 = 85 m, 114°
to Ice Beacon 2 = 85 m, 320°


BGOS/JOIS 2011 Ice Based Observatory 3
August 8, 2011, ITP location @ 23:00 UTC = 76.0856°N, 138.2817°W
Ice thickness, freeboard
ITP = 3.20 m, 0.47 m
SIMBB = 1.62 m, 0.12 m
Uptempo = 1.80 m
ITP 55
Uptempo
SIMBB

5.8 O-buoy Deployment

Carlton Rauschenberg, Bigelow Laboratory for Ocean Sciences
John W. Halfacre, Purdue University
PI's: Patricia Matrai, Paul Shepson, Bill Simpson, Don Perovich, Francisco Chavez

Reference: www.o-buoy.org

The O-buoy Project

The O-buoy Project is an NSF funded research project involving the collaboration of Bigelow Laboratory, Purdue University, University of Alaska – Fairbanks, the U.S. Army Cold Regions Research and Engineering Laboratory, Environment Canada, Monterey Bay Aquarium Research Institute, SRI and CH2M HILL Polar Services. The O-buoy is an autonomous, mulit-instrument, sea-ice tethered buoy with the ability to measure surface level ozone, carbon dioxide, bromine oxide, meteorological conditions, and its own location using a GPS device. The goal of the project is to deploy a large network of O-buoys across the Arctic to further our understanding of current Arctic ozone and carbon dioxide chemistry, both important greenhouse gases, and to help us predict how that chemistry might change as the Arctic environment changes.

Ozone has been observed to precipitously decrease from background levels of ~30 ppbv to near zero levels during the Arctic spring time when the sun rises. It is believed that bromine plays the major role in Arctic ozone depletion chemistry, and bromine oxide (a product of the reaction between bromine radical and ozone) provides evidence of ozone destruction. Long term ozone, bromine oxide, and meteorological measurements over the ocean will help us understand the conditions that initiate, contribute to, and terminate ozone depletion events.

Deployment Summary

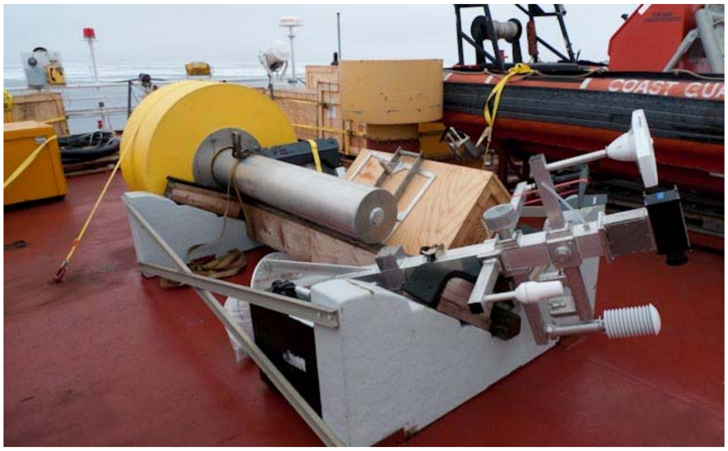
When Carlton and I first got on the *Louis*, we thought it would be a good idea to find our stuff. Aside from our tools and cold weather gear, all of our equipment (tube + mast + parts box, flotation collar, solar panel box) was found on the upper deck above the ship's hanger. The O-buoy essentially consists of three sections: the tube, the mast, and the solar panels. The tube is fairly long and pretty heavy, so we decided the best option would be to prop it on a conveniently placed, empty boat cradle. The tube, however, was inconveniently placed in its box, so we had to get it out using the ship's crane.

Next, we assembled the mast. We mounted the mast on saw horses near the main tube so we could easily make connections into the instrument panel. Assembly of the mast consisted of attaching the DOAS scanhead (used to take in sunlight to measure BrO), the wind instrument, GPS instrument, and the Iridium satellite communications device. The instrument cables / tubing that ran through the mast were connected to the instrument panel, and the mast was subsequently bolted onto the tube. The buoy was now assembled enough such that it could be tested.

We turned on the buoy by plugging in the power chord on the exterior of the mast. We then connected a laptop to the communications port and logged into the O-buoy's supervisory computer. We then verified that the buoy was both powered and that the instruments seemed to be operating as they should. Now that the buoy was powered, a last bit of instrument work on our end was calibrating the ozone instrument.

We left the buoy powered for a period of two days so that it could transmit data using the Iridium device, thus allowing proper instrument function to be checked remotely by each instrument's corresponding team. Once we received verification that the instruments were functioning satisfactorily, we powered down the buoy, unbolted the mast, and disconnected the instrument connections from the instrument panel. Because of the fragility of the DOAS scan head, we disconnected it and kept it with us to be reattached on deployment day.

The next step was to mount the flotation collar. This required moving the heavy base of the buoy from the inside of the boat cradle to the outside, such that we would be able to lift it up and slide the collar on. Once accomplished, we bolted the collar to the tube, bolted the solar panel mounting plate into the collar, and covered the instrument panel on the tube and the instrument connections in the mast to protect them from moisture. We turned the buoy around again and secured the mast, tube, and flotation collar to the boat cradle. Finally, we screwed the mounting screws for the solar panels into the mounting plate and attached lead weights to the base of the buoy. We were now ready to deploy.



Finally, on August 5, 2011, it was time to deploy. After our 16" hole had been drilled in the ice, the tube and flotation collar were airlifted by helicopter and placed in the hole. When the mast arrived, the DOAS scan head was reconnected to the top of the mast, and the mast was then bolted on top of the tube. We then mounted the solar panels. The final step was to turn it on. We verified that the instrument was powered using our handy laptop, and checked with the different O-buoy teams to verify if instruments were still functioning properly. As of this writing all sensors are operational.

Other Sampling
Carlton Rauchenberg

Copepod samples were collected for two separate projects. The first will compare the lipid content of Arctic copepods with copedpods in the Gulf of Maine. The second project will focus on how the decreasing sea ice effects copepod lipid/amino acid production. This project will be most informative if samples can be collected for a minimum of five years to see if a trend is visible.

Copepod samples were collected at stations:

- CABOS
- Station A
- CB4
- CB9
- CB13

- CB15
- CB17
- CB6

The samples were collected in the net and sorted by Kelly and put into the -80 freezer for storage until the ship returns to St. Johns were they will be shipped overnight to Bigelow Laboratory for Ocean Sciences.

Microgel and total organic carbon (TOC) samples were collected from ice core D on the 6^{th} of August, 2011. The purpose for collecting microgels is three fold. The first is to compare with samples collected from I/B Oden in 2008. The second is to help elucidate the contribution of marine microgels to the arctic dissolved organic carbon (DOC) pool. Finally, it would be very useful to continue this analysis for the next five years to see if a trend presents itself as a function of sea cover. The total organic carbon (TOC) samples were collected in order to convert the gels to % carbon.

For each 10cm section of the ice core 50 ml was collected for TOC and another 50 ml was collected for microgels. The microgel samples were fixed with 1% sodium azide for a final concentration of 0.02%. The microgel samples are stored in the refrigerator. The TOC samples were frozen in the -80 freezer. All samples will be shipped back to Bigelow Laboratory for Ocean Sciences. A cooler will be mailed to the ship once it has returned containing frozen ice packs so samples can be returned.

5.9 CABOS Mooring Recovery

Mike Dempsey (DFO-IOS)
PI: Igor Proshutinsky, International Arctic Research Center

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 and conventional moorings located around the self break of the Laptev Sea. The CABOS mooring provides complementary data for this array.

Table 1. 2011 Operations, CABOS mooring

Investigator	Recovery Depth (m)	Recovery Location	Recovery Time (UTC)	Deployment Depth (m)	Deployment Location	Deployment Time (UTC)
UAF/IARC				1129 m	71° 49.708' N	14 October 2009 0142
I. Polyakov					131° 46.604' W	
UAF/IARC	1129	71° 49.708'N	23 July, 2011 1905			
I. Polyakov		131° 46.554'W				

The instruments were all downloaded and all had full data records. The MMP 12047 unfortunately had a problem after 58 profiles (116 days). It appears from the records that a problem was encountered with the drive motor and the profiler remained at the bottom of the wire for the rest of the deployment.

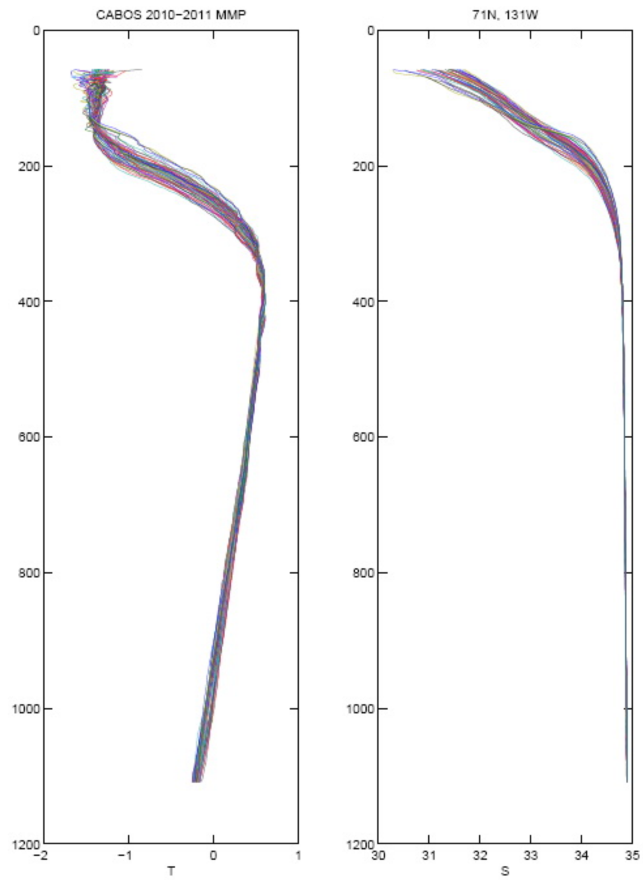
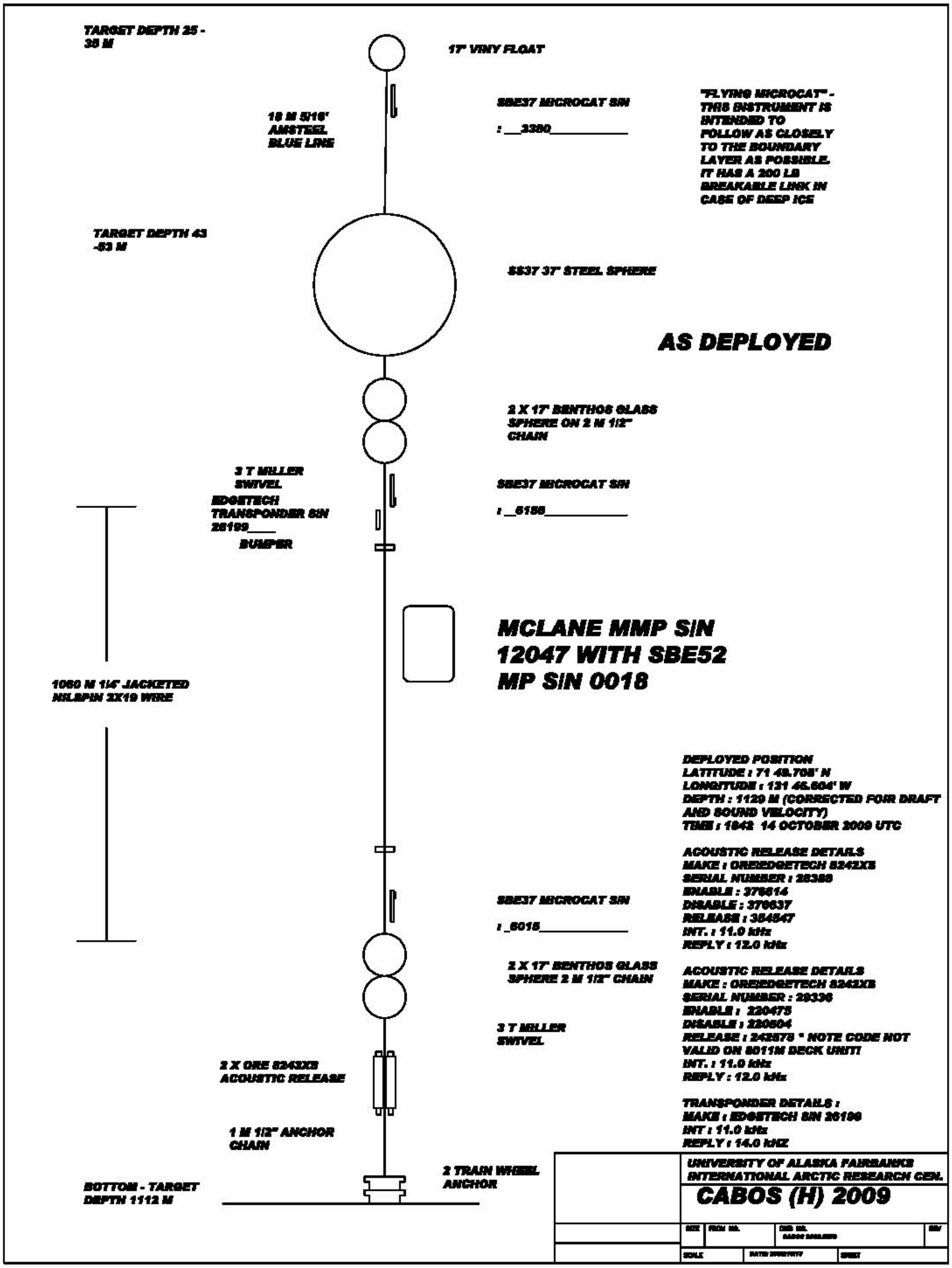


Figure 1. Raw Temperature and Salinity vs. Depth plots for the whole deployment

Over 64,000 samples were collected on each of the 3 Microcats on the CABOS mooring. A quick glance at the data shows no open water winter storm events evidenced by pull down of the mooring as was seen in 2008. The topmost Microcat on the single Viny float, did not change depth more than a few metres through out the 20 month deployment.


TARGET DEPTH 25 - 35 M
17" VINY FLOAT
SBE37 MICROCAT S/N : __3380__________
18 M 5/16" AMSTEEL BLUE LINE
"FLYING MICROCAT" - THIS INSTRUMENT IS INTENDED TO FOLLOW AS CLOSELY TO THE BOUNDARY LAYER AS POSSIBLE. IT HAS A 200 LB BREAKABLE LINK IN CASE OF DEEP ICE
TARGET DEPTH 43 -53 M
SS37 37" STEEL SPHERE
AS DEPLOYED
2 X 17" BENTHOS GLASS SPHERE ON 2 M 1/2" CHAIN
3 T MILLER SWIVEL
EDGETECH TRANSPONDER S/N 26199____
BUMPER
SBE37 MICROCAT S/N : _6188__________
MCLANE MMP S/N 12047 WITH SBE52 MP S/N 0018
1060 M 1/4" JACKETED NILSPIN 3X19 WIRE
DEPLOYED POSITION
LATITUDE : 71 49.708' N
LONGITUDE : 131 46.604' W
DEPTH : 1129 M (CORRECTED FOIR DRAFT AND SOUND VELOCITY)
TIME : 1842 14 OCTOBER 2009 UTC
ACOUSTIC RELEASE DETAILS
MAKE : ORE/EDGETECH 8242XS
SERIAL NUMBER : 28380
ENABLE : 376614
DISABLE : 376637
RELEASE : 354547
INT. : 11.0 kHz
REPLY : 12.0 kHz
SBE37 MICROCAT S/N : _6018__________
2 X 17" BENTHOS GLASS SPHERE 2 M 1/2" CHAIN
ACOUSTIC RELEASE DETAILS
MAKE : ORE/EDGETECH 8242XS
SERIAL NUMBER : 29336
ENABLE : 220475
DISABLE : 220504
RELEASE : 242578 * NOTE CODE NOT VALID ON 8011M DECK UNIT!
INT. : 11.0 kHz
REPLY : 12.0 kHz
3 T MILLER SWIVEL
2 X ORE 8242XS ACOUSTIC RELEASE
TRANSPONDER DETAILS :
MAKE : EDGETECH S/N 26199
INT : 11.0 kHz
REPLY : 14.0 kHZ
1 M 1/2" ANCHOR CHAIN
2 TRAIN WHEEL ANCHOR
BOTTOM - TARGET DEPTH 1112 M
UNIVERSITY OF ALASKA FAIRBANKS
INTERNATIONAL ARCTIC RESEARCH CEN.
CABOS (H) 2009

The recovery of the CABOS H 2009 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. The professional assistance of the captain, officers and crew was excellent as always. Many thanks also to John Kemp, Jeff Pietro, Steve Lambert and Rick Krishfield of WHOI for their help and the use of their Lebus dual capstan traction winch. Also many thanks to Rick Krishfield for using WHOI's Matlab analysis tools for the MMP data to provide the quick snapshot of the raw data and MMP performance.

5.10 Microbial Food Web Component

PI: Peter Lavrentyev (University of Akron)
Jennifer Putland (University of Akron)
With participation of Kelly Young (DFO-IOS)

The following table shows our sampling effort during the JOIS 2011 expedition. The stations, date, time, and sampling depth are indicated along with the grazing experiments if any.

From each collected sample we have collected subsamples for enumeration of microzooplankton (2% acidic Lugol's iodine), micro- (2% acidic Lugol's iodine) and nanophytoplankton (1% formalin) and picoplankton (1% photosynthetic and heterotrophic, formalin followed by liquid N2 freezing, and chlorophyll a (filtered onto 0.2 um nylon filters and frozen at -80oC). At selected sites/depths we have also collected plankton DNA by filtering ca. 1.6L of seawater through a 0.2-um Millipore filter capsule. The collected samples will be analyzed using inverted and epifluorescence microscopy, flow-cytometry, image analysis software, and pyrosequencing (18SSrDNA). These methods should allow us to obtain information on the composition, abundance, and carbon-based biomass of the microbial plankton mentioned above.

At selected sites we have also conducted 11 dilution experiments to estimate phytoplankton and bacteria growth and grazing mortality rates and taxon-specific growth rates. In addition, we have conducted 8 mesozooplankton grazing experiment with two predominant Arctic copepod species, *Calanus hyperboreus* and *C. glacialis* (four experiment with each species). In all experiment adult female copepods were used. All experiments were done in triplicate bottles mounted on a plankton wheel in a deck temperature controlled incubator. The same set of microbial samples was collected from each experimental bottle at T_0 and T_{24} in each experiment.

Altogether, we have collected 1,027 plankton samples from CTD casts and incubation experiments. All copepods used in the experiments were recaptured and frozen in buffer solution for the subsequent gut content analysis using molecular methods.

Key for Table:
"mzp" is Microzooplankton Grazing Experiment
"meso" is Mesozooplankton Grazing Experiment "meso"
"DCM" is Deep Chlorophyll Maximum

Station	***Date, Local Time***	***Profile Samples (m)***	***Grazing Exps***
AG5	22 July, 0300	5, 43, 105, 300, 600	none
CABOS	23 July, 1930	5, 138, 380, 1000	mzp @60m (DCM)
"Tuk"	25 July, 1100	Surface (bucket)	none
CB28aa	26 July, 0215	5, 18, 50	mzp @5m
MK2	26 July, 0700	20, 70, 372, 498	none
MK4	26 July,	5, 58, 119, 370, 1611	none
MK6	26 July, 2200	5, 54, 151, 400, 2376	none
Stn A	27 July, 1300	5, 167, 433, 3150	mzp+meso @ 69m (DCM)
CB-2a	27 July, 2215	5, 75, 133, 400, 3524	none
CB-3	28 July, 1900	5, 72, 181, 450, 3620	none
CB-4	29 July, 1520	5, 67	mzp+meso @ 67m (DCM)
CB-5	31 July, 0130	5,60, 200, 480,3630	none
CB-7	31 July, 1230	5, 54	mzp @ 54m (DCM)
CB-8	01 Aug, 0300	5, 56, 201, 482, 3627	none
CB-9	01 Aug, 1930	5, 50	mzp+meso @ 50m (DCM)
CB-11	02 Aug, 1830	5, 41, 177, 475, 3617	none
CB-9	03 Aug, 1930	51, 198, 465	none
CB-13	04 Aug, 2145	5, 56	mzp+meso @ 56 m (DCM)
CB-16	05 Aug, 2030	5, 60, 173, 426, 3540	none

Station	*Date, Local Time*	*Profile Samples (m)*	*Grazing Exps*
CB-15	06 Aug, 0700	5, 52	mzp+meso @ 59 m (DCM)
PP6	07 Aug, 2130	5, 54, 167, 425, 2905	none
CB-17	08 Aug, 2300	5, 65	mzp+meso @ 65m (DCM)
CBC	09 Aug, 1208	5, 57, 195, 459, 3585	none
CB-6	10 Aug, 1230	5, 65	mzp+meso @ 65 m (DCM)
CB-19	10 Aug, 2345	5, 62, 174, 475, 3495	none
CB-18	12 Aug, 1210	5, 67	mzp+meso @ 67 m (DCM)
CB-22	13 Aug, 1205	5, 62, 182, 445, 3000	none
CB-21	13 Aug, 1000	2,5,25,50,66,86,141, 187,241,458,1500, 3290	none
CB-29	14 Aug, 1030	5, 71, 128, 415, 2480	none

5.11 Ice Observations

PI: Kazutaka Tataeyama, Kitami Institute of Technology, Japan
With Kunio Shirasawa (HU) and Hiroki Shibata (KIT)

Measurements:

- Underway Ice thickness observations
  Underway measurements of ice thickness from an electromagnetic induction sensor, Passive microwave Radiometers(PMR), and fixed forward-looking cameras.
- Ice station measurements
  Drill-hole and EM Survey, Snow Pit Survey, Melt Pond Survey,

Underway measurements
Kazu Tateyama (KIT)
Kunio Shirasawa (HU)
Hiroki Shibata (KIT)

Underway measurements of ice thickness were made using, an Electromagnetic induction (EM) sensor, Passive Microwave Radiometers (PMR) 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 and thickness but lack the groundtruthing of just what the images represent. The EM sensor was deployed from the foredeck's crane on the port side, collecting data while underway. The passive microwave sensor was mounted one deck higher also on the ship's port side looking out over the EM's measurement area and collected data continuously.

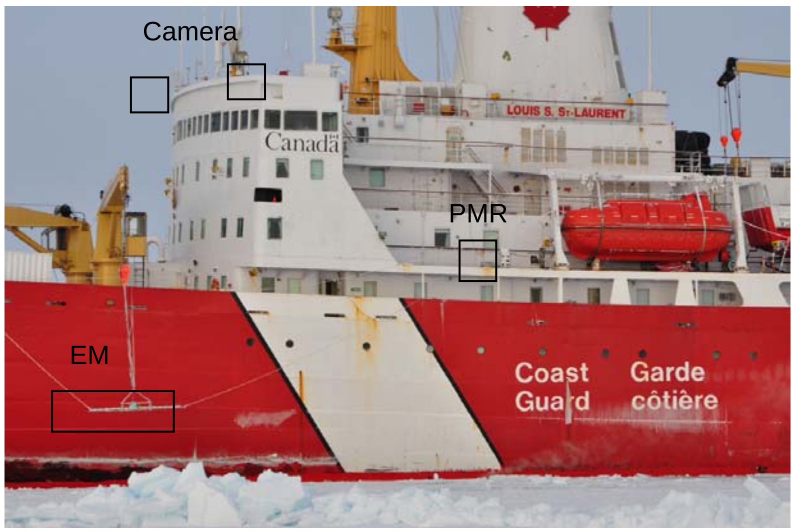


Figure 1. Pictures of EM , PMR and forward-looking camera.

EM ice thickness profiles and PMR observation

An Electro-Magnetic induction device EM31/ICE (EM) and laser altimeter LD90 will be used for sea-ice thickness sounding. EM provides apparent conductivities in mS/m which can be converted to a distance between the instrument and sea water at sea-ice bottom (H_E) by using inversion method. LD90 provides a distance between the instrument and snow/sea-ice surface (H_L). The total thickness of snow and sea-ice (H_T) can be derived by subtracting H_L from H_E. Ice concentration can be measured by EM system.

To develop new algorithm for estimation of the Arctic snow/sea-ice total thickness by using satellite-borne passive microwave radiometer (PMR), snow/sea-ice brightness temperatures and surface temperature measurements will be conducted. The portable PMR, called MMRS2A, which is newly developed by Mitsubishi Tokki System Co. Ltd., Japan, have 5 channels which are the vertically polarized 6GHz, 18GHz and 36GHz, the horizontally polarized 6GHz and 36GHz with radiation thermometers and CCD cameras. The radiation thermometers IT550, which are developed by HORIBA Corp., Japan, were used. Those sensors were mounted on the port side below the bridge in 55 incident angle which is same angle as the satellite-borne passive microwave radiometer AQUA/AMSR-E. All data are collected every 1 second continuously except during CTD and ice stations.

EM and PMR ice thickness observation started at 24 July and ended at 14 August. 21 ice thickness profiles are observed as shown in figure 4 and summarized in table 1. The total distance of 21 profiles are xxxx km. EM was calibrated three times on 27 July, 13 and 14 August over open water.

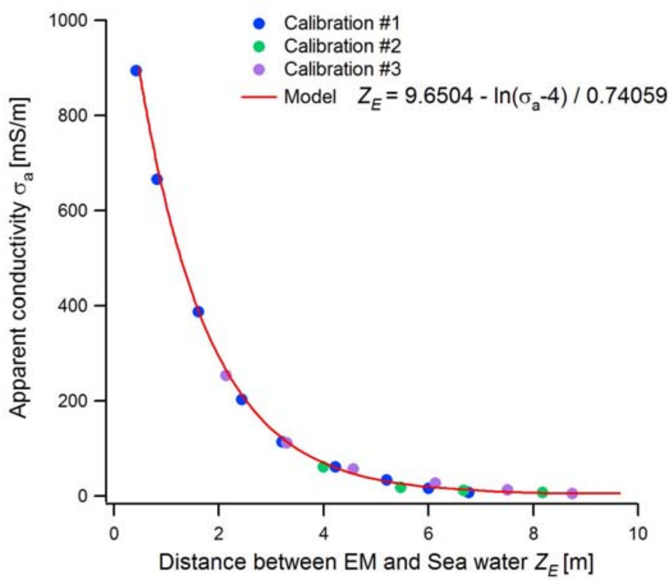


Figure 3. Result of EM calibration over open water.

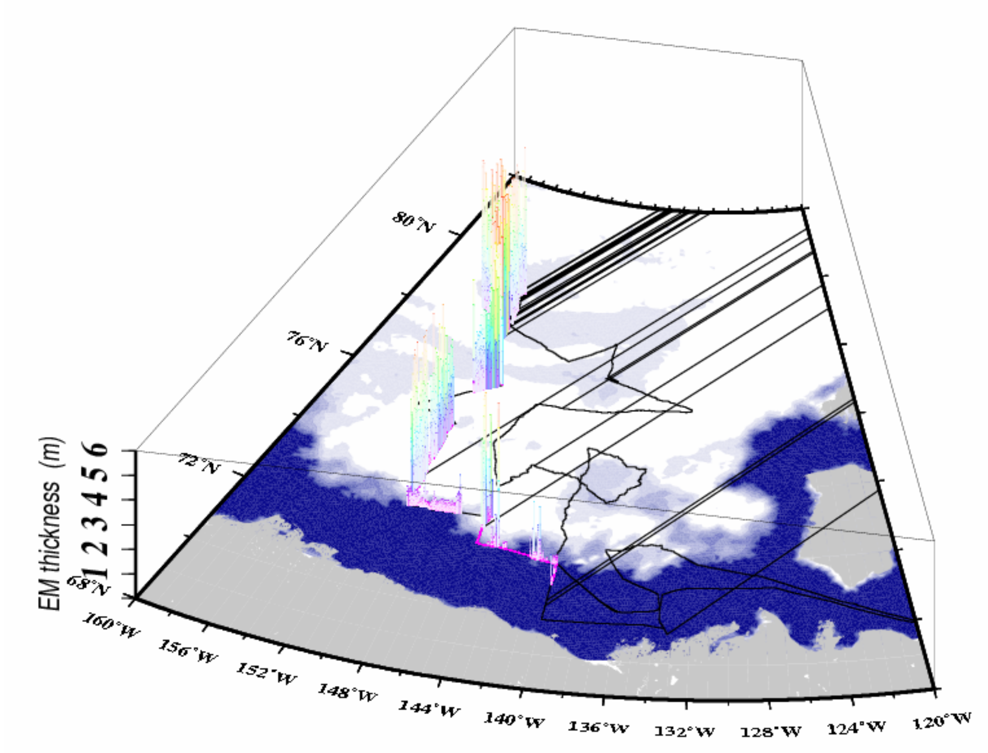


Figure 4. EM thickness profile during 24 July – 14 August, 2011. Background image is sea ice concentration on 27 July, 2011 derived from AMSR-E.

Table 1. EM and PMR observation log.

Profile Number	Start Time(UTC)	Start Position	End Time(UTC)	End Position	Length of profile [km]
1	Jul. 24 14:32	72.30143N 135.72522W	Jul. 25 00:02	70.85422N 133.89552W	591.09
2	Jul. 26 22:07	71.00023N 139.99963W	Jul. 27 16:59	72.64407N 144.7233W	715.03
3	Jul. 27 18:52	72.6192N 146.65497W	Jul. 28 04:26	72.49967N 150.00388W	370.35
4	Jul. 28 05:08	72.49945N 150.00287W	Jul. 29 00:37	73.93933N 150.02033W	252.39
5	Jul. 29 00:49	73.93867N 150.01982W	Jul. 29 13:07	75.00042N 149.9993W	167.99
6	Jul. 31 17:48	75.98423N 149.87288W	Jul. 31 21:53	76.2959N 148.2526W	183.98
7	Jul. 31 23:31	76.35075N 148.03332W	Aug. 1 17:44	77.98675N 149.9741W	376.95
8	Aug. 1 23:15	76.70915N 135.1832W	Aug. 2 07:48	75.00415N 140.0134W	-
9	Aug. 2 08:48	78.06133N 149.81615W	Aug. 2 15:45	78.55413N 150.0107W	70.36
10	Aug. 3 01:23	78.99797N 150.10248W	Aug. 3 16:10	78.00855N 150.09942W	713.59

11	Aug. 4 02:48		Aug. 5 02:22		
12	Aug. 5 04:43		Aug. 5 16:11		
13	Aug. 6 00:31		Aug. 7 21:27		
14	Aug. 8 04:14		Aug. 8 18:58		
15	Aug. 9 00:36		Aug. 10 04:34		
16	Aug. 10 07:32		Aug. 11 04:03		
17	Aug. 11 22:10		Aug. 12 04:19		
18	Aug. 12 06:52		Aug. 13 05:26		
19	Aug. 13 06:50		Aug. 13 15:32		
20	Aug. 13 20:12		Aug. 14 04:33		
21	Aug. 14 06:33		Aug. 14 15:45		

Two looking-forward digital cameras on port and starboard sides on the upper bridge recorded sea ice concentration and melt pond every 30 minutes during 28 July – 17 August. These images will be used for calculation of concentrations of open water, melt pond, and ice.

On-Ice Measurements

Ice Thickness Survey

Kazu Tateyama (KIT)
Kunio Shirasawa (HU)
Hiroki Shibata (KIT)

Ice station measurements

Drill-hole and EM Survey

An electromagnetic induction device (EM) is capable of measuring a total thickness of snow and sea-ice. The output signal of EM; i.e. the apparent conductivity (in mS/m) can be converted to the distance (in m) between the instrument and the sea-ice bottom, i.e., the seawater-sea-ice interface with an inversion method. More accurate thickness values of EM can be derived from calibrations with drill-hole thicknesses. Calibrations of an ice-based EM31SH, whose boom is shorter than a ship-borne EM31/ICE, were performed at each ice station in conjunction with drill-hole measurements, which provide snow depth, freeboard and total thickness of sea-ice. The apparent conductivity of the Vertical Magnetic Dipole (VMD) and Horizontal Magnetic Dipole (HMD) modes was collected every 2 m on the transect line, and correspondingly, the drill-hole was made on the same transect line but every 10 m. The ice station was decided to establish on an ice floe large enough for buoy deployment. Transect lines were determined nearby or surrounding the buoys' deployment array. EM31SH and drill-hole measurements carried out on each ice station are summarized in Table 1.

Comparison of EM total snow and sea-ice thicknesses with drill-hole thicknesses are shown for Ice Stations 1 to 4 in Figs. 1 to 4, respectively. Each transect line is variable in thickness, but comparison indicates a rather good agreement between EM and drill-hole thicknesses even though melt ponds are included on the transect line.

Apparent conductivities are compared with drill-hole thicknesses, together with the data obtained from the JOIS2010 experiment in Fig. 5. The JOIS2011 data during this cruise were separated from the ones including melt ponds and water-filled-gap as well with different symbols in the figure. The regression line was calculated from all JOIS2010 and JOIS2011 data but without melt ponds and water-filled-gas data. Comparison indicates a good agreement even though melt ponds are included. The thickness composing of water-filled-gap does not appear a good agreement with the regression line, probably appearing deformed ice, whose thickness might be converted by a different model.

A probability density function (PDF) was calculated from EM31SH and drill-hole thicknesses, shown in Fig. 6. GEM (Ground-based EM; i.e., EM31SH) thicknesses show double primary peaks at 2.7 and 3.0 m, while drill-hole thicknesses show a primary peak at 2.6 m, indicating multiyear ice. It must be noted that the sampling interval on the transect line was 2 m for GEM and 10 m for drill-hole, obviously in different spatial resolution.

Snow Pit Survey

Snow depth, temperature profiles, crystal type and size, density and salinity in the surface layer measured at four ice stations during the cruise are summarized in Table 2. Sampling intervals were every 1 cm from the interface between the surface layer and the underlying layer till the surface, where the intervals were 0.5, 1.0 or 1.5 cm, depending on the total thickness of the surface layer. At Ice Station #1 (on 4th of August) the air temperature was 0.5°C, the thickness of the surface layer was 5.5 cm, and the temperature of the surface layer was between -0.3°C at the interface and -0.5°C at the surface. The whole surface layer was likely corn snow or most likely granular ice with the grain size of 2-8 mm. At Ice Station #2 (on 5th of August) the air temperature was 3.5°C, the thickness of the surface layer was 4.5 cm, and the temperature of the surface layer was between -0.1°C at the interface and 0.2°C at the surface. The whole surface layer was likely corn snow or most likely granular ice with the grain size of 2-6 mm. At Ice Station #3 (on 6th of August) the air temperature was 0.8°C, the thickness of the surface layer was 5.5 cm, and the temperature of the surface layer was -0.1°C except 0°C at the depths of 1 and 3 cm from the interface. The whole surface layer was likely corn snow or most likely granular ice with the grain size of 4-10 mm. At Ice Station #4 (on 8th of August) the air temperature was 1.2°C, the thickness of the surface layer was 3.5 cm, and the temperature of the surface layer was between -0.1°C at the interface and 0.2°C at the surface. The whole surface layer was likely corn snow or most likely granular ice with the grain size of 3-8 mm. As a result, we considered that there was no snow in the surface layer.

Those snow properties will be utilized in association with PMR (Passive Microwave Radiometer) brightness temperatures in order to validate a general microwave radiation transfer model for the data obtained from satellite remote sensing. Together with ice core data they will be also used for evaluating snow and sea-ice conditions at the end of melting and at the beginning of freezing seasons.

Melt Pond Survey

Melt ponds were found in vast areas during the entire cruise. Buoy deployment sites were determined on relatively larger ice floes in an area, and transect lines for drill-holes and EM31SH survey were performed nearby the buoys or surrounding the buoy array. It was obvious that various melt ponds were found on the transect line. Melt pond measurements were summarized in Table 3. As a number of melt ponds were too large and deep to survey, only smaller melt ponds were measured.

Table 1. A summery of EM31SH and drill-hole measurements.

Ice Station	Latitude Longitude	Transect Line	Length of profile [m]	Freeboard/total thickness ratio		Ice thickness [m]	
				Mean	s.d.	Mean	s.d.
St.1	77°34'07"95N 145°56'12"15W	Line-1	156	0.12	0.03	2.78	0.70
St.2	78°00'26"26N 138°57'15"52W	Line-1	100	0.13	0.05	2.96	0.42
		Line-2	44			2.62	0.42
		Line-3	44			1.83	0.36
		Line-4	64			2.15	0.66
St.3	77°00'10"08N 140°01'03"16W	Line-1	115	0.14	0.03	3.15	0.44
		Line-2	60			2.79	0.38
		Line-3	60			2.93	0.31
		Line-4	56			3.04	0.27
St.4	76°05'23"67N 138°16'41"44W	Line-1	130	0.14	0.03	2.52	0.62

Table 2. A summary of snow pit measurements.

Ice Station	Date	Time	Sampling Site	Tair (℃)	Depth (cm)	Temp (℃)	Grain Size (mm)	Texture	Snow Sample Temp (℃)	Snow Sample Cond (μS)	Snow Sample Salinity
1	04.08	11:54	Start of Line-1	0.5	5.5	-0.5	2-8	Corn Snow/Granular Ice?	23.4	10.9	0
					5	-0.5	2-8	Corn Snow/Granular Ice?			
					4	-0.3	2-8	Corn Snow/Granular Ice?			
					2	-0.2	2-8	Corn Snow/Granular Ice?			
					1	-0.3	2-8	Corn Snow/Granular Ice?			
					0 (Snow-Ice Intfc)	-0.3	2-8	Corn Snow/Granular Ice?			
2	05.08	15:06	Start of Line-1	3.5	4.5	0.2	2-6	Corn Snow/Granular Ice?	23.4	8.1	0
					3	0	2-6	Corn Snow/Granular Ice?			
					2	0	2-6	Corn Snow/Granular Ice?			
					1	-0.1	2-6	Corn Snow/Granular Ice?			
					0 (Snow-Ice Intfc)	-0.1	2-6	Corn Snow/Granular Ice?			
3	06.08	14:15	Start of Line-1	0.8	5.5	-0.1	4-10	Corn Snow/Granular Ice?	23.4	6.2	0
					5	-0.1	4-10	Corn Snow/Granular Ice?			
					4	-0.1	4-10	Corn Snow/Granular Ice?			
					3	0	4-10	Corn Snow/Granular Ice?			
					2	-0.1	4-10	Corn Snow/Granular Ice?			
					1	0	4-10	Corn Snow/Granular Ice?			
					0 (Snow-Ice Intfc)	-0.1	4-10	Corn Snow/Granular Ice?			
4	08.08	14:35	Start of Line-1	1.2	3.5	0.2	3-8	Corn Snow/Granular Ice?	23.4	5.4	0
					3	0	3-8	Corn Snow/Granular Ice?			
					2	-0.1	3-8	Corn Snow/Granular Ice?			
					1	0	3-8	Corn Snow/Granular Ice?			
					0 (Snow-Ice Intfc)	-0.1	3-8	Corn Snow/Granular Ice?			

Table 3. A summary of melt pond size, water depth, freeboard and salinity.

Ice Station	Melt Pond Site	Mean size A (m)	Mean size B (m)	Mean water depth A (m)	Mean water depth B (m)	Mean Freeboard (m)	Salinity (ppt)	Specific Conductivity (mS)
1	60 m	2.89	2.05	0.17	0.13	0.17	0.4	1.116
	82 m	1.35	2.35	0.1	0.1	0.12	0.3	0.657
	110 m	3.67	5.65	0.16	0.17	0.15	3.4	6.27
2	22 m	3.38	2.71	0.52	0.61	0.22	1.7	3.253
	71 m	4.05	2.81	0.09	0.07	0.26	0.2	0.494
	A Large MP	N.M.	N.M.	0.17	N.M.	0.17	3.3	6.12
3	18 m	1.72	4.45	0.09	0.09	0.2	0.7	1.456
	54 m	4.85	7.94	0.22	N.M.	0.27	4.4	7.85
	88 m	N.M.	N.M.	0.21	N.M.	0.23	4.7	8.34
4	61 m	4.99	6.31	0.2	0.11	0.27	0.7	1.475
	71 m	1.73	2.37	0.18	0.13	0.23	0.1	0.292
	121 m	3.66	0.81	0.14	0.15	0.11	1.2	2.281

A: Along-Transect Line; B: Across-Transect Line

N.M.: Not Measured

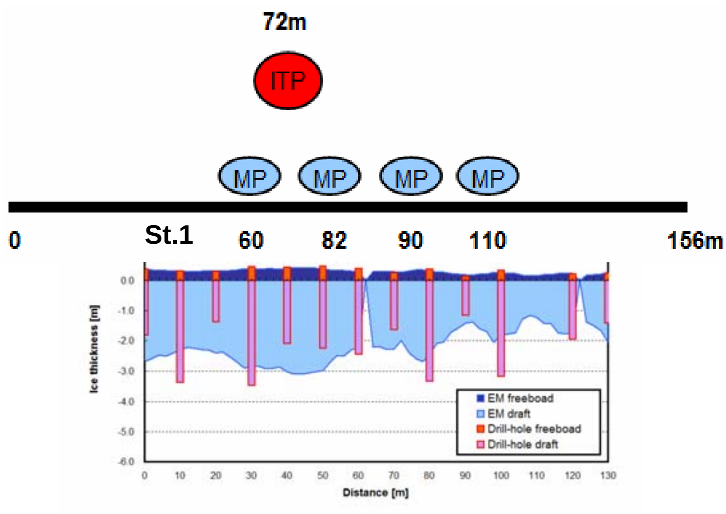
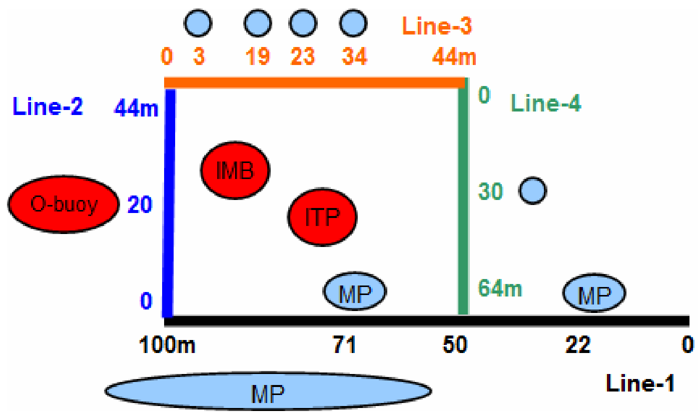


Figure 1. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #1 (77°34'07"95N, 145°56'12"15W) on 4th of August 2011.



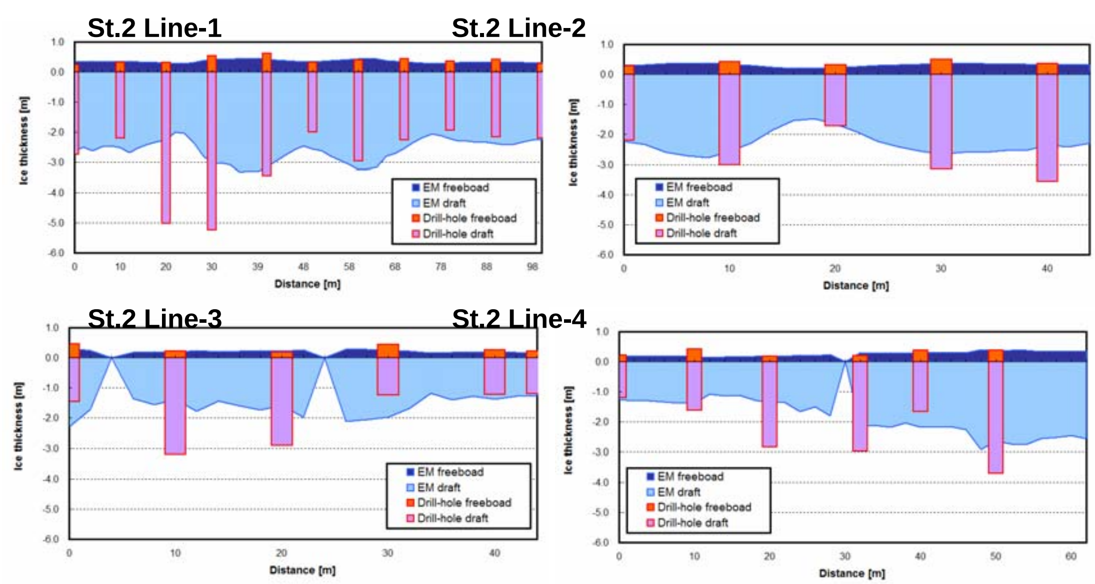


Figure 2. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #2 (78°00'26"26N, 138°57'15"52W) on 5th of August 2011.

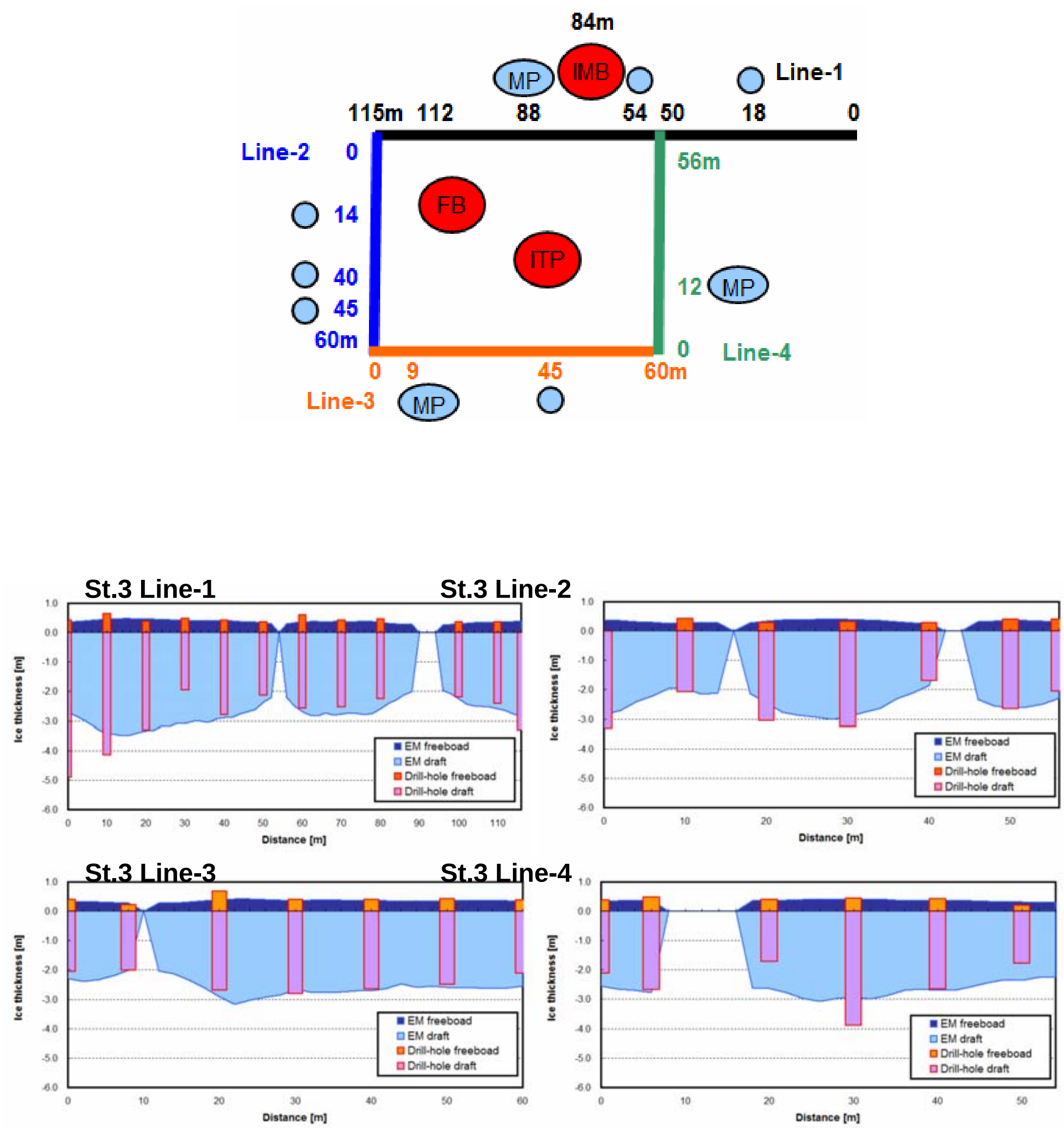


Figure 3. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #3 (77°00'10"08N, 140°01'03"16W) on 6th of August 2011.

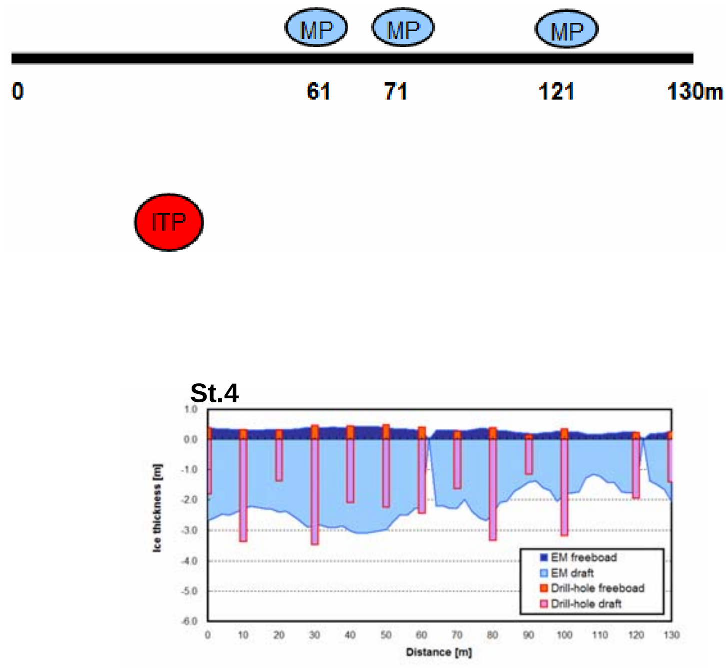


Figure 4. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #4 (76°05'23"67N, 138°16'41"44W) on 8th of August 2011.

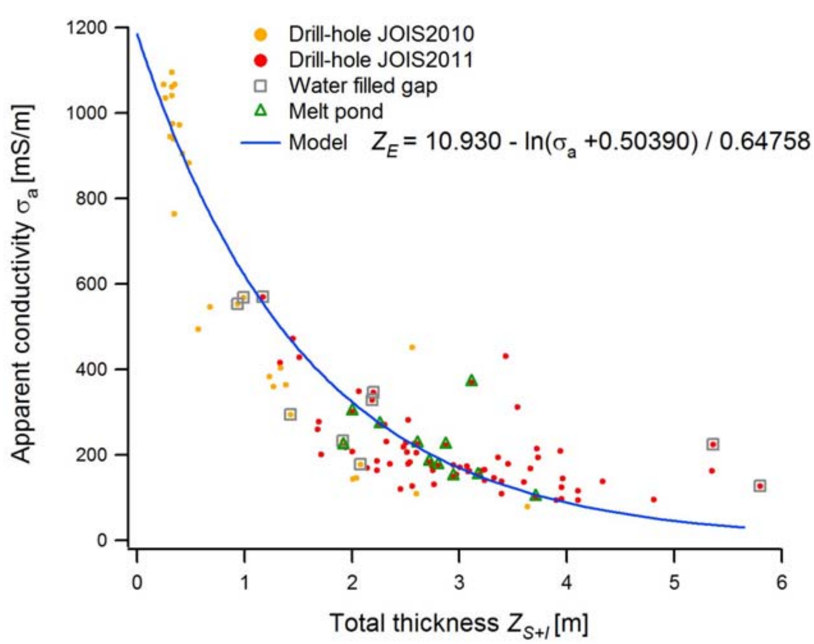


Figure 5. Comparison of EM31SH apparent conductivity with drill-hole total thickness.

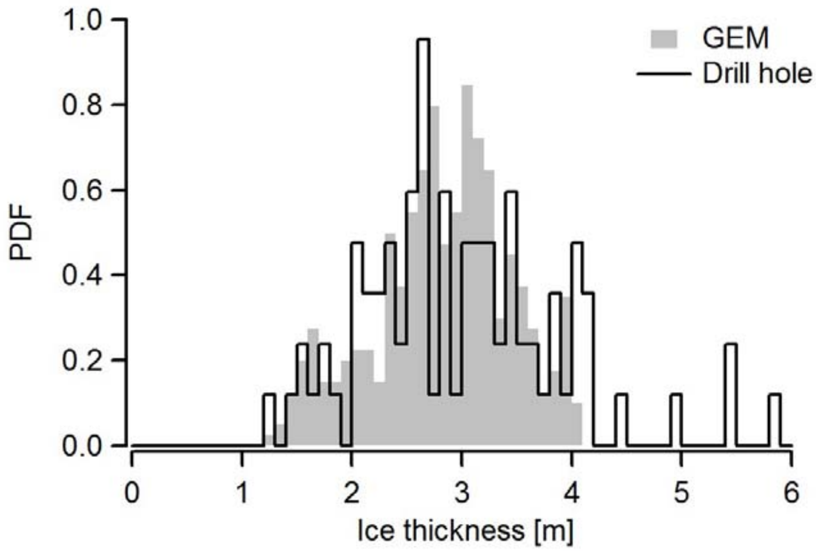


Figure 6. PDF of total snow and ice thickness calculated from EM31SH and drill-hole thicknesses. The bin size is 0.1 m.

5.12 Ice Observation Program

Alice Orlich, University of Alaska Fairbanks, Jeffrey Nguyen
PI: Jennifer Hutchings, International Arctic Research Center

Photo 1. A local observing the observers.

We would like to extend our appreciation to Captain Andrew McNeill, helicopter pilot Chris Swannell and the crew of the CCGS Louis S. St-Laurent for making these ice observations and sampling excursions possible. In addition, Chief Scientist Bill Williams is due accolades for creating opportunities for our team to access the sea ice at every chance possible.

Special thanks go to Kunio Shirasawa and Kazu Tateyama for generously sharing their field data and wisdom while collaborating with us during ice visits. Roger Provost of the Canadian Ice Service brought a wealth of knowledge and experience aboard and graciously tutored us during complex ice conditions. Information Technology Specialist Carey McGrath patiently assisted during the installation of our webcam system. Finally, we would like to thank all of our eager volunteers who helped to optimize our efficiency and productivity during ice visits.

Our program consists of multiple activities: Hourly ice observations from the bridge, helicopter reconnaissance flights, on-ice sampling, buoy deployment, collaborations with other participating scientists and volunteer training. Ice observations recorded during the Louis S. St-Laurent 2011-20 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 areas. The observations collected will be useful for investigating the evolution of the ice cover over the last five years when used in conjunction with satellite and buoy data. The ice camera images we collected, in combination with visual ship and helicopter-based observations, will also be used to develop an autonomous camera based ice observation system. Our ongoing participation in the JOIS cruises has been vital in working towards a satellite validation project and the development of a standardized ship-based sea ice observation program.

The cruise occurred 21 July – 18 August 2011, exposing the mid-season sea ice melt conditions throughout the Beaufort Sea and Canada Basin. Since the first year of the IARC team's participation, 2006, the JOIS cruise has been scheduled at various times throughout the summer season. Attention should be given when comparing the 2011 data to the results from the early years 2006-2008. Both the 2009 and 2010 where we experienced the onset of freeze-up of the sea ice for the entirety of the cruise track, the cruises were conducted a month later in the season than the current and previous cruises.

Observations from the Bridge: Methodology

While traveling in ice, one or both observers were present on the bridge. A typical observation includes a three-stage process. The first stage starts at the top of the hour and involves recording sea ice conditions and gathering ship data from bridge instruments such as latitude/longitude location, navigational details, and meteorological data onto the observation datasheets. The second stage involves taking photographs from monkey island, web camera maintenance, and observing sky conditions. The final stage of an observation requires data input and webcam monitoring, both of which can be accomplished from the chart room or from the private berth. Often the observer/s remain/s on bridge beyond the designated observation time to further study the sea ice conditions, discuss the evolving science plan, and gather input from others present who have witnessed interesting features, wildlife, etc.

A combination of ASPECT (Worby & Alison 1999), Standard Russian, Canadian Ice Service and the WMO sea ice codes were used to describe ice conditions. The codes are described in detail and available as an appendix to this report. During each observation period we estimated the total ice coverage within 3Nm of the ship (when visibility allowed), the types of ice present and the state of open water. For the primary, secondary, and tertiary ice types we recorded the percent coverage, thickness, flow size, topography, percent sediment coverage, extent of algae presence, snow type, snow thickness and stage of melt for each type. Other types of ice present that were at lower concentrations than the three main types were also documented. We observed basic meteorological phenomena of cloud coverage and type, visibility and precipitation.

Photo 2. View during an observation made from monkey island during a back-and-ram event.

Comments on Bridge Observations
Ideally, the program aims to take continual hourly observations throughout the 24-hour cycle each day of the cruise. When on station, observations are suspended. This season's persistent fog and overcast conditions impaired the ideal observation area, and at times the ship's icenav system and radar was instrumental in assessing the ice conditions.

Some hours of observations were lost during the period of ice visits which dictated that both of the primary observers be available for the long hours on the ice station. For approximately 3 days, the evening observations were not completed due to the adjusted sleep schedule. 24-hour observations were resumed after the last ice station.

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 underrepresented 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 conditions automatically. In addition, we continued to take routine hourly photographs from monkey island for consistency checks and the opportunity to capture specific features of the ice.

Webcam Imagery
Webcams have been positioned atop the rail of monkey island for multiple seasons. The images serve to supplement the hourly visual in-situ observations made from the bridge while traveling in ice. Frequency of image capture is altered by changing the settings

manually via the software program. The rate of capture was increased this year to as often as every 1 minute for the forward-looking camera and up to every 10 seconds for the port-side camera while in transitional or interesting ice. The intention was to increase the chance of a better photo record, given the probability of the poor visibility effecting and therefore negating many of the images. Images are stored on the ship's NOAA server in the IceCameras folder of the S-drive. The forward-looking camera (1) is trained on the bow of the ship, with the ship shown in the lower quarter of the image, the ocean and ice set in the center half, and the sky bordering the upper quarter. The port-side camera(2) is positioned to capture dynamic ice movement and rolling that occurs when the ship passes through ice. In the view, the ice thickness pole with 10cm color band measurements which is secured perpendicular to the ship, as well as the passive microwave instruments from Dr. Tateyama's study, can be seen. Both cameras are the netcam XL from Stardot Technologies.

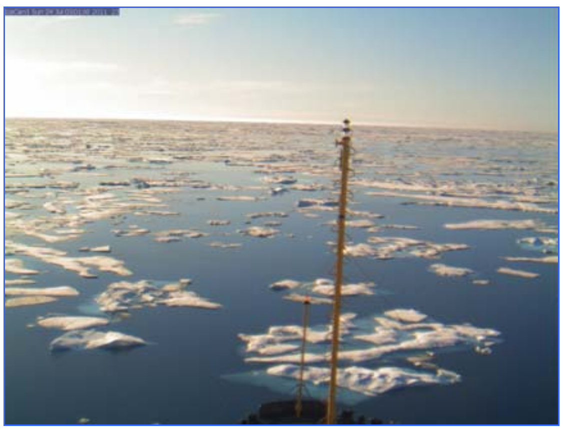


Photo 3. Early ice caught on Cam1.

Photo 4. Cam2 image with thickness pole and PMRs.

Comments on webcam operations
The webcam system requires initial set-up and installation, then programming via the main frame computer or a laptop with access to the ship's net. The cameras are unpacked and electronic connections and camera operability is tested while inside the ship. Once the cameras are properly recording, the installation includes mounting the cameras on the rail of Monkey Island and running the cables into the ice observer's office. Typically the cables are run through the window and into the net board. Further details of the technology, installation and photo archiving are available as an appendix to this report.

The cameras can be accessed via the ice observation program laptop in the chart room or from a personal laptop linked to the ship's net in a berth. This flexibility allows for real-time adjustment if ice conditions become more interesting based on ship speed, varying daylight or weather conditions. Also, capture frequency can be reduced if the ship is on station.

Due to the forward exposure of the camera 1, close attention should be made to the clarity of the case window. It is common for freezing rain and snow to accumulate and cause poor image capture. The icing can be easily removed by soaking a soft sponge with hot water and holding it to the frozen case window until it is completely melted. We have found that a sponge and approximately 1-2cups of hot water from the tap works well. On occasion, the port-side camera window collects rain or fog droplets which are easily wiped clean for an improved image capture.

Both camera cases have ventilation that unfortunately allows drifting snow and moisture to condense within the housing and occasionally affect image capture and electronic connections. These openings can be filled with packing foam or paper towels and sealed with duck tape.

Aerial Ice Observations

When invited onto ice reconnaissance flights, an IARC ice observation team member typically sits behind the CIS ice specialist, allowing full window access for photography and ice observations. In addition to personal supplies in a day pack positioned behind the front seat, the IARC observer would conduct sea ice surveys with a digital camera, handheld GPS unit and clipboard to complete the flight form. Ideally, the flight would maintain an altitude of 2,000’ to provide a wide horizon, yet observable sea ice and ocean detail. The electronic record of the flight, including GPS waypoints along the route for where photos were taken as well as other details of the flying conditions and comments about the ice is available on the end of cruise data disk. Typically, the CIS ice specialist posts the resultant recon map to the science of public drive, making a digital copy available for reference. We participated in two ice reconnaissance flights during this cruise.

Comments on aerial ice observation operations

Given that each flight has unique objectives, the IARC observer needs to be able to adjust expectations and equipment, if required. Adverse weather conditions or ship logistics may alter the flight plan, resulting in extended or shorted flight time, reduced altitude, or unplanned delays on the ice. For these reasons, participants would always pack additional clothing and safety gear, as well as back-up batteries and observational supplies. On occasion, the IARC observer is invited to assist with buoy recovery reconnaissance or buoy deployment ice floe selection. These flights are equally valuable, as they provide better perspective to the ice conditions surrounding the area of interest. When flying in areas of low ice concentration, the CCGS requires passengers to wear the orange neutral buoyancy flight suits provided by the ship. There are only 3 suits available, and the sizes are restricting for most guests. It would be helpful to increase the number of suits in stock on the ship and to acquire more size options.

On-ice measurements

Floe thickness transects and ice core samples are conducted when the IARC team is invited onto ice floes chosen for buoy deployments. The general goal is to provide characterization of the floe by completing one or more ice thickness survey drill transect lines and sampling ice with a 9-mm corer at multiple locations. While working in tandem with the KIT/TUMSAT crew who are walking with the EM31SH sensor, drill holes are made at 10-meter increments at depths up to 8 meters along the line to help validate the EM. The locations of ice core sampling sites are selected based on conference with the

EM crew and the objective of sampling various thicknesses (preferably up to 3m) or ice types found within the ice station. The drill hole data is recorded as a series of depths along the line, with details of total ice thickness, freeboard, snow cover, and a GPS waypoint.

Photo 5. Volunteers persist along a 50m drill transect line with the 2" auger system.

Photo 6. A core section is measured for length before temperatures are taken and the core is sectioned into 10cm pieces for later analysis.

The core sample data includes identical records as well as photographs of each core section, temperatures at 10 cm intervals, and measurements of 10cm sample sections which are bagged and transported to the ship for further processing. Once melted and measured for volume, salinity, conductivity are determined using a YSI handheld salinometer. Density is calculated from these parameters.

Table 1. Ice Cores

Date	Station	Core	Line#	Dist.(m) on line	Latitude	Longitude
4-Aug	ITP53	A	1	0	77 33.984	145 55.920
5-Aug	ITP52/IBO1	A	1	0	78 00.454	139 57.251
	ITP52/IBO1	B	4	15	~	~
6-Aug	ITP54/IBO2	A	1	~	~	~
	ITP54/IBO2	B	1	80	77 00.112	140 02.330
	ITP54/IBO2	C	3	14	~	~
8-Aug	ITP55/IBO3	A	1	30	76 05.189	138 16.727
	ITP55/IBO3	B	1	108	~	~
	ITP55/IBO3	C	1	90	76 05.366	138 16.669

~ no data

Table 2. Thickness Transects

Date	Station	Line#	Dist(m)	# Drill Holes	Begin Lat	Begin Lon	End Lat	End Lon
4-Aug	ITP53	1	100	11	77 33.984	-145 55.920	77 34.170	-145 56.373
5-Aug	ITP52/IBO1	1	100	11	78 00.454	-139 57.251	78 00.474	-139 56.807
	ITP52/IBO1	2	50	6	78 00.474	-139 56.807	78 00.477	-139 56.529
	ITP52/IBO1	3	44	6	78 00.477	-139 56.529	78 00.460	-139 55.846
	ITP52/IBO1	4	60	6	78 00.460	-139 55.846	78 00.407	-139 55.191
6-Aug	ITP54/IBO2	1	115	12	77 00.166	-140 01.141	77 00.080	-140 02.929
	ITP54/IBO2	2	60	7	77 00.080	-140 02.929	77 00.053	-140 04.382
	ITP54/IBO2	3	60	7	77 00.053	-140 04.382	77 00.030	-140 05.725
	ITP54/IBO2	4	50	6	77 00.044	-140 06.220	77 00.053	-140 06.698
8-Aug	ITP55/IBO3	1	130	13	76 05.405	-138 16.661	76 05.326	-138 16.747

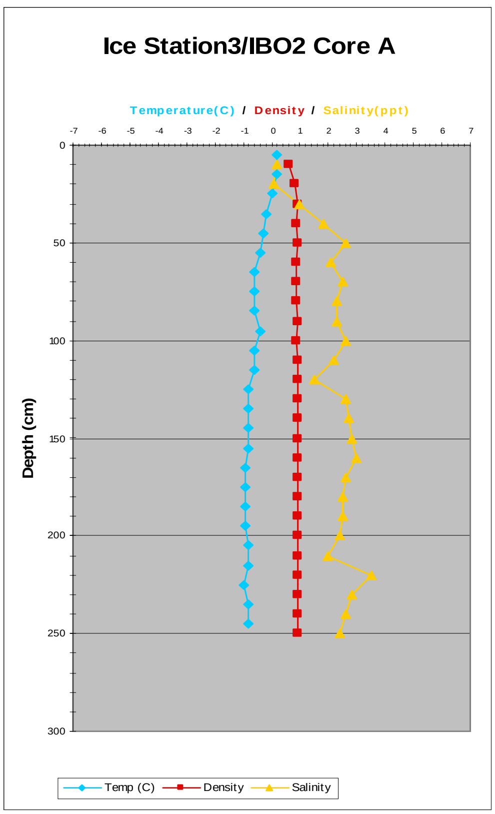


Fig. 1 Physical characteristics of a sample core.

The field team has a minimum efficiency of two persons. However, when human resources are available and logistics allow, volunteers from the science crew are assigned to either the drill or core team. Another factor dictating the breadth of the on-ice program is time allotted for the ice station. The briefest visit can last less than two hours if conducted during a single ITP deployment.

Typically, this ice station occurs first in the science plan and is a great opportunity for the field team to test equipment and practice a safe, efficient routine. Optimum conditions

Fig. 1 illustrates a simple analysis of the temperature, density and salinity of a core taken at the third ice station, IBO 2.
A total of nine cores were taken for the IARC team and an additional three cores were collected for Michiyo Kawai at the first and second ice stations. Full data reports for the core samples will be available upon request.

can occur when there is a multi-buoy site, or Ice Based Observatory (IBO), which can last up to 8 hours. During these ice visits the data collection is exponentially increased, as the volunteer crew can employ as many as 5 additional technicians. During this cruise, the IARC team was able to participate in 4 ice stations – one ITP and 3 IBOs. After the first visit, volunteers were invited along to assist with the on-ice measurements.

Comments on ice visits

Generally, the plan for a station is decided up to a day in advance, allowing for complete preparation of gear, supplies and volunteers. However, it is not uncommon for an ice visit invitation to occur in a shorter time frame, thus emphasizing the need to always have the gear clean and packed for immediate departure. Additional fuel in a spare jug, duplicate ice core sampling supplies (bags and buckets), and a complete personal day pack should always be stored in the helicopter hanger amongst the field gear staging area.

Volunteer Training

A preliminary training for volunteers was conducted approximately a week before the first ice station. Topics covered included ice sampling goals, research methodology, gear familiarization, equipment operation, safety awareness and field etiquette. The volunteer program provides opportunities to access the sea ice and learn about field research techniques, and in turn theoretically increases the volume of data from each ice station.

As the learning and experiential curve is steep for people new to sea ice field work, and the brief time allotted to the sea ice team is extremely valuable, it was a tremendous relief to have the seasoned crew of Glenn Cooper, Kelly Young, Mike Dempsey, Sarah Zimmermann and Kenny Scozzafava willing to lead teams at the ice stations, as well as Kohei Mizobata and Kazu Tateyama stepping in when needed.

GPS buoy deployment

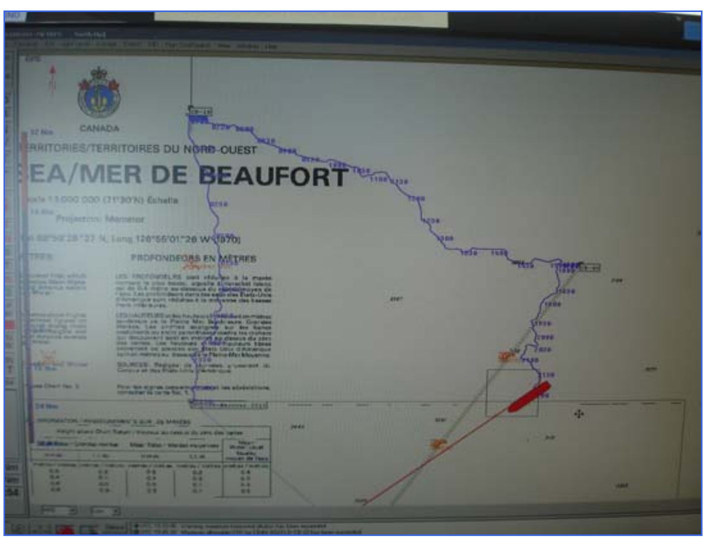
Four GPS buoys were deployed in a 5Nm x 5Nm array surrounding the 2nd IBO site which included an ITP, Obuoy, IMB, AOFB as well as an Ice Beacon array. IARC grad student Alice Orlich was assisted by Linda White and Chris Swanell during the deployment of the buoys. The operation was completed in 1.5 hours, after which Orlich returned to the IBO2 site to complete on-ice sampling.

Photo 7. Orlich and Swanell secure one of the GPS buoys.

The area of interest was dominated by thick first year ice in an advanced stage of melt, but multiyear floes with substantial level ice distant from melt ponds and ridges were selected. The buoys were secured with anchors attached to each handle of the buoy. The anchors were set into a 2” hole hand drilled with an auger at an approximate depth of 2 meters. The buoys had been tested aboard the ship a week in advance of deployment. Transmission was confirmed by Dr. Hutchings within hours on Thursday, 28 July 2011. An aerial photo survey was conducted en route to each chosen ice floe, and additional photos and notes were taken to document the installation of each buoy as well as the floe features and conditions. After each buoy was successfully deployed, a confirmation email was received from Dr. Hutchings noting the updated location and the success of the operation. The buoys will be tracked as they continue to transmit their location on the International Arctic Buoy Program website: http://iabp.apl.washington.edu/index.html.

Synopsis of ice types along cruise

For most of the cruise, the ship traveled through ice conditions which were dominated by thick first year ice in an advanced stage of melt with extensive melt pond coverage revealing well developed thaw holes in the majority of the ponds. Occasional multi-year ice was encountered as the ship sailed north beyond 78N on the 150W line. The highest concentration of multiyear floes was in the area of 76N/134W where up to 40% of the ice present in the total 80-90% concentration was in medium to large sized floes which hosted about 30% melt pond coverage. The largest multiyear floes were easily avoided along the southern 140 line. The trail of cake and small-sized multiyear ice floes which composed most of the ice edge in the Beaufort Sea along the eastern and southern interface with open water was resilient until we crossed it at 71N 139W.



Visibility posed a problem for both ship navigation and ice observation from the bridge. Persistent low-level fog and overcast skies lead to reduced ship speed which then ensured safe detection of thicker ice, but also a biased route through thinner, first year ice. Officers on watch relied on the icenav system to identify leads to avoid breaking floes.

Photo 8. The purple ship track demonstrates how multiyear ice was avoided between stations.

Unfortunately, this means that some of the hourly observations taken during this period are not wholly representative of the 3Nm area of interest surrounding the ship. In these cases, the adverse conditions are noted and a greater length of time and distance of travel from the top of the hour is considered before completing the observation. A few helicopter reconnaissance flights were made to view conditions ahead of the ship, however, many were for selection of ideal ice station floes and were relatively short in distance, or they were conducted in poor visibility which hampered quality ice observing. Given the sustained low visibility and ease of travel through the ice pack for the duration of the cruise, ice conditions which would contribute to this local meteorology along the route correlate with the ship-based observations of dominant thinning first year ice with a high presence of melt ponds and progressively expanding leads.

Ideas for program development:
Use unmanned aircraft systems (UAS) launched and recovered by hand from the ship to survey ice up to approx 40nm away from the ship.
Install one to three web cameras with wide angle lenses on the aloft conn (crow's nest), with priority for a forward looking then port and starboard looking cameras to survey the ice. From this higher vantage point the view is greater and the camera has better protection from the weather. The windows however would need some method for regular cleaning.

5.13 Ice Core Sampling for DIC/TA/Ca Analysis

PI: Michiyo Yamamoto-Kawai (TUMSAT)

Three ice cores (Chem A, Chem B, IBoy#1) were collected during the 2011-JOIS cruise for analysis of DIC, TA and Ca in sea ice. At sampling site, a core was sampled for thickness, salinity, temperature, and density measurement and then 2nd core was taken for for DIC/TA/Ca analysis. Cores were cut into ~10cm pieces and stored in Ziploc bags and kept frozen.
Samples will be analyzed by Dr. Soren Lysgaard.
Refer to the cruise report from Alice Orlich and Kazu Tateyama for information about salinity, temperature and density of ice core, ice thickness distribution around the ice station etc..

Chem A was collected Aug 4, near CB12 at the ITP53 site (77° 34.2'N, 145° 56.4'W)
IBoy#1 and ***Chem B*** were collected Aug 5, at the ITP/52/IMBB/O-Bouy site (78° 0.4'N, 139° 55.5'W).

APPENDIX A: Participants

Table 3. Cruise Participants

Name	Affiliation	Role
Bill Williams	DFO-IOS	Chief Scientist
Michiyo Kawai	TUMSAT	Principal Chemist/ Alkalinity

Kenny Scozzafava	DFO-IOS	Oxygen Analysis
Linda White	DFO-IOS	Nutrient Analysis /Lab Supervisor
Marty Davelaar	DFO-IOS	DIC Analysis
Mike Dempsey	DFO-IOS	CTD Watch/ Chief Technician
Sarah Zimmermann	DFO-IOS	CTD Watch/ Data Analysis
Kelly Young	DFO-IOS	CTD Watch /Zooplankton/ Ammonium Analysis
Glenn Cooper	DFO-IOS	CTD Watch/ pH Analysis
Edmand Fok	DFO-IOS	CTD Watch/ IT
Hugh Maclean	DFO-IOS	CTD Watch/ Salinity Analysis
Baptiste Marcere	Trent U	CTD Watch/ CDOM Collection
Rick Krishfield	WHOI	WHOI moorings
John Kemp	WHOI	WHOI moorings
Jim Dunn	WHOI	WHOI moorings
Steve Lambert	WHOI	WHOI moorings
Daniel Montlucon	ETH Zürich	Sediment traps/ InSitu Pumping
Mary-Louise Timmermans	Yale University	WHOI Dispatch / CTD Watch
Peter Lavrentyev	UAkron	Microzooplankton
Jennifer Putland	UAkron	Microzooplankton
Kazu Tateyama	KIT	Ice thickness / CTD Watch
Kunio Shirasawa	HU	Ice thickness / CTD Watch
Hiroki Shibata	KIT	Ice thickness / CTD Watch
Kohei Mizobata	TUMSAT	XCTD /CTD Watch
Alich Orlich	UAF	Ice observer
Jeffrey Nguyen		Ice observer
Carlton Rauschenberg	CRREL	CRREL O-Buoy
John 'Wes' Halfacre		CRREL O-Buoy

Table 4. Principal Investigators not on-board ship

Name	Affiliation
Fiona McLaughlin	DFO-IOS
Eddy Carmack	DFO-IOS
John Nelson	DFO-IOS
Svein Vagle	DFO-IOS

Bill Li	DFO-BIO
Andrey Proshutinsky	WHOI
John Toole	WHOI
Motoyo Itoh	JAMSTEC
Koji Shimada	TUMSAT
Chris Guay	Pacific Marine Sciences and Technology
Celine Gueguen	Trent University
Don Perovich	CRREL
Jennifer Hutchings	IARC
Igor Polyakov	IARC
Tim Eglinton	WHOI / ETH Zürich

Table 5. Affiliation Abbreviation

CRREL	Cold Regions Research Laboratory, New Hampshire
DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, Alaska
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
KIT	Kitami Institute of Technology, Japan
WHOI	Woods Hole Oceanographic Institution, Massachusetts
TUMSAT	Tokyo University of Marine Science and Technology

APPENDIX B: Science Station Locations (those not included in text)

Table 6. CTD/Rosette Stations

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample #'s
1	AG5	7/23/2011 7:28	70.5532	122.9067	675	641	1 - 20
2	CABOS	7/24/2011 0:34	71.8278	131.7678	1150	1105	21 - 44
3	CB31B	7/24/2011 9:20	72.3388	134.0030	2100	2048	45 - 68
4	CB28aa	7/26/2011 7:59	69.9977	139.9928	58	53	69 - 76
5	MK1	7/26/2011 9:49	70.2313	140.0002	243	240	77 - 89
6	MK2	7/26/2011 12:07	70.4007	140.0025	500	498	90 - 111
7	MK3'	7/26/2011 15:06	70.6505	140.0005	1250	1258	112 - 134
8	MK4	7/26/2011 18:18	70.8145	140.0012	1430	1613	136 - 159
9	CB28b	7/26/2011 21:46	71.0003	140.0008	2076	2073	160 - 183
10	MK6	7/27/2011 2:16	71.5847	139.9990	2450	2477	184 - 207
11	StnA	7/27/2011 16:23	72.6438	144.7242	3350	3155	208 - 231
12	CB2a	7/28/2011 4:17	72.5002	150.0025	3650	3715	232 - 255
13	CB2	7/28/2011 11:29	73.0090	149.9802	3650	3742	256 - 279
14	CB3	7/28/2011 23:03	73.9502	150.0415	3736	3815	280 - 303
15	CB4-cal	7/29/2011 10:58	74.9232	150.0637	3800	803	304-325
16	CB4	7/29/2011 19:40	75.0118	150.0412	3800	3818	326-349
17	CB5	7/31/2011 5:16	75.3178	153.2357	3840	3821	350-373
18	CB7	7/31/2011 16:42	75.9822	149.8793	3840	3823	374-397
19	CB8	8/1/2011 6:31	76.9812	149.9483	3826	3815	398-421
20	CB9-cal	8/2/2011 0:51	78.0257	149.8742	3826	1001	422-445
21	CB11	8/2/2011 22:05	79.0105	150.0000	3826	3808	446-469
22	CB10	8/3/2011 8:57	78.3365	153.2222	2612	2570	470-493
23	CB9	8/3/2011 23:54	78.0290	150.1662	3840	3812	494-517
24	CB12	8/4/2011 11:00	77.7175	146.6612	3812	3802	518-541
25	CB13	8/5/2011 1:44	77.3198	143.5880	3780	3778	542-565
26	CB16	8/6/2011 0:32	77.9513	139.9665	3753	3740	566-589
27	CB15	8/6/2011 11:05	77.0797	139.9848	3734	3723	590-613
28	PP7	8/7/2011 10:53	76.5352	135.6540	3587	3570	614-637
29	PP6	8/8/2011 1:45	76.2267	132.8250	3127	3106	638-661
30	CB17	8/9/2011 3:15	76.0163	139.7578	3695	3684	662-685
31	CBC	8/9/2011 16:41	75.9777	144.8752	3785	3778	686-709
32	CB6	8/10/2011 4:23	74.7073	146.6172	3781	3770	710-733
33	CBS	8/10/2011 17:37	73.5440	145.1385	3666	3655	734-757
34	CB19	8/11/2011 3:55	74.2688	143.2943	3697	3690	758-781
35	CB21-CAL	8/11/2011 13:02	74.0438	140.0785	3536	802	782-805
36	CB18	8/12/2011 4:09	74.9803	140.0177	3671	3619	806-829
37	CB40	8/12/2011 15:30	74.5110	135.6648	3281	3265	830-853
38	CB22	8/13/2011 4:36	73.4558	137.9457	3135	3116	854-877
39	CB21	8/13/2011 13:28	73.9828	139.9425	3497	3487	878-901
40	CB27	8/14/2011 3:50	73.0028	140.1980	3272	3257	902-925
41	MK7	8/14/2011 10:01	72.5422	140.0777	3044	3025	926-949

42	CB29	8/14/2011 15:26	72.0008	139.9938	2700	2676	950-973
43	MK6	8/14/2011 19:42	71.6190	140.0423	2550	2521	974-997
44	SB1	8/15/2011 16:03	70.5720	136.7030	753	743	no samples
45	SB2	8/15/2011 17:27	70.5447	136.5905	560	552	no samples
46	SB3	8/15/2011 18:27	70.5178	136.4853	408	395	no samples
47	SB4	8/15/2011 19:34	70.5038	136.4268	336	328	no samples
48	SB5	8/15/2011 20:10	70.4903	136.3722	100	75	no samples
49	SB6	8/15/2011 20:32	70.4773	136.3190	65	60	no samples
50	SB7	8/15/2011 21:01	70.4627	136.2637	57	55	no samples
51	SB8	8/15/2011 21:37	70.4387	136.1605	60	52	no samples
52	SB9	8/15/2011 22:15	70.4097	136.0443	60	52	no samples

Table 5. XCTD launch locations

Stn.#		Filename	yyyy	mm	dd	Latitude (°N)			Longitude (°W)			Bot.Depth (m)
XCTD	1	XCTD-000020110724.RAW	2011	7	24	72	06.4081	N	132	55.0178	W	1705
XCTD	2	XCTD-000120110724.RAW	2011	7	24	72	14.5416	N	135	52.3407	W	2398
XCTD	3	XCTD-000220110726.RAW	2011	7	26	70	30.8052	N	140	00.2616	W	690
XCTD	4	XCTD-000320110727.RAW	2011	7	27	71	18.2175	N	139	58.0600	W	2130
XCTD	5	XCTD-000420110727.RAW	2011	7	27	71	43.9559	N	141	40.6016	W	2848
XCTD	6	XCTD-000520110727.RAW	2011	7	27	71	49.7099	N	143	15.9016	W	3085
XCTD	7	XCTD-000620110728.RAW	2011	7	27	72	36.6532	N	146	45.1688	W	3500
XCTD	8	XCTD-000720110728.RAW	2011	7	28	72	32.9566	N	148	15.5480	W	3590
XCTD	9	XCTD-000820110729.RAW	2011	7	29	73	29.1380	N	150	00.5496	W	3724
XCTD	10	XCTD-000920110729.RAW	2011	7	29	74	28.9525	N	149	59.5437	W	3735
XCTD	11	XCTD-001020110731.RAW	2011	7	31	75	08.2091	N	151	37.0651	W	3843
XCTD	12	XCTD-001120110731.RAW	2011	7	31	75	37.5230	N	151	34.9717	W	3841
XCTD	13	XCTD-001220110801.RAW	2011	8	01	76	31.0505	N	148	26.8107	W	3821
XCTD	14	XCTD-001320110801.RAW	2011	8	01	77	30.0205	N	149	52.4066	W	3828
XCTD	15	XCTD-001420110803.RAW	2011	8	03	78	29.7475	N	149	59.4328	W	3822
XCTD	16	XCTD-001520110803.RAW	2011	8	03	78	40.5215	N	151	41.6364	W	3833
XCTD	17	XCTD-001620110803.RAW	2011	8	03	78	14.5014	N	152	19.8620	W	3836
XCTD	18	XCTD-001720110803.RAW	2011	8	03	78	06.4873	N	151	00.6444	W	3826
XCTD	19	XCTD-001820110804.RAW	2011	8	04	77	59.4410	N	149	47.9883	W	3825
XCTD	20	XCTD-001920110804.RAW	2011	8	04	77	54.2581	N	148	53.3257	W	3822
XCTD	21	XCTD-002020110804.RAW	2011	8	04	77	48.2685	N	147	47.4944	W	3821
XCTD	22	XCTD-002120110805.RAW	2011	8	04	77	30.0667	N	145	02.5089	W	3800
XCTD	23	XCTD-002220110805.RAW	2011	8	05	77	38.4513	N	141	45.1572	W	3772
XCTD	24	XCTD-002320110806.RAW	2011	8	05	78	00.2129	N	139	56.8201	W	3754
XCTD	25	XCTD-002420110806.RAW	2011	8	06	77	29.8113	N	140	00.1422	W	3739
XCTD	26	XCTD-002520110807.RAW	2011	8	07	76	51.2828	N	138	30.0115	W	3695
XCTD	27	XCTD-002620110807.RAW	2011	8	07	76	42.0290	N	136	59.5762	W	3654
XCTD	28	XCTD-002720110808.RAW	2011	8	08	76	23.8445	N	134	01.1373	W	3391
XCTD	29	XCTD-002820110808.RAW	2011	8	08	76	12.7090	N	136	04.3531	W	3360
XCTD	30	XCTD-002920110808.RAW	2011	8	08	76	10.8766	N	135	26.5539	W	3505
XCTD	31	XCTD-003020110809.RAW	2011	8	08	76	05.5694	N	137	50.7670	W	3625
XCTD	32	XCTD-003120110809.RAW	2011	8	09	76	00.1635	N	141	38.3972	W	3740
XCTD	33	XCTD-003220110809.RAW	2011	8	09	76	00.9030	N	143	22.6587	W	3767
XCTD	34	XCTD-003320110810.RAW	2011	8	09	75	34.0622	N	145	35.7943	W	6791
XCTD	35	XCTD-003420110810.RAW	2011	8	10	75	07.2190	N	145	59.7080	W	3785
XCTD	36	XCTD-003520110810.RAW	2011	8	10	74	19.2589	N	146	07.4448	W	3756
XCTD	37	XCTD-003620110810.RAW	2011	8	10	73	55.5691	N	145	40.9166	W	3736
XCTD	38	XCTD-003720110811.RAW	2011	8	11	73	53.9026	N	144	07.7716	W	3698
XCTD	39	XCTD-003820110811.RAW	2011	8	11	74	08.5837	N	141	44.3252	W	3648
XCTD	40	XCTD-003920110812.RAW	2011	8	12	74	29.4956	N	139	40.7010	W	3611
XCTD	41	XCTD-004020110812.RAW	2011	8	12	74	50.0155	N	138	27.5409	W	3525
XCTD	42	XCTD-004120110812.RAW	2011	8	12	74	35.7314	N	137	11.0165	W	3378
XCTD	43	XCTD-004220110813.RAW	2011	8	12	74	09.9539	N	136	06.5682	W	3203
XCTD	44	XCTD-004320110813.RAW	2011	8	13	73	48.3598	N	136	44.8958	W	3237
XCTD	45	XCTD-004420110813.RAW	2011	8	13	73	43.3023	N	138	59.1819	W	3370
XCTD	46	XCTD-004520110814.RAW	2011	8	14	73	30.8371	N	140	10.4956	W	3418
XCTD	47	XCTD-004620110815.RAW	2011	8	15	71	17.4096	N	139	01.2445	W	2121
XCTD	48	XCTD-004720110815.RAW	2011	8	15	71	00.3941	N	138	07.6059	W	1650
XCTD	49	XCTD-004820110815.RAW	2011	8	15	70	43.4743	N	137	15.4424	W	1410

Table 6. ADCP Cast Locations

ADCP LOG Cruise 2011-20 JOIS

File Name	Year	Month	Day	Time (UTC)	STATION	Comments
###_000000.LOG						
96	2011	7	26	19:48:00	mk4	
97	2011	7	26	21:59:00	cb28b	
98	2011	7	26	3:15:00	mk6	
99	2011	7	28	5:18:00	cb2a	ADCP was left on between casts CB2a and CB2!
99	2011	7	28	5:18:00	CB2	ADCP was left on between casts CB2a and CB2!
100	2011	7	28	23:18:00	CB3	
101	2011	7	29	12:30:00	CB4	
102	2011	7	29	19:56:00	CB4_2	deep cast at BGOS-A
103	2011	7	30	5:33:00	CB5	fore and aft lines reset
104	2011	7	31	19:01:00	CB7	
105	2011	8	1	6:41:00	CB8	
106	2011	8	3	10:37:00	CB10	
107	2011	8	4	0:45:00	CB9	
108	2011	8	4	11:07:00	CB12	When closing saw error message re nav. Need to check before next cast
114	2011	8	8	2:06:00	PP6	pin 1 replaced on bulkhead of ADCP
115	2011	8	9	3:27:00	CB17	
116	2011	8	9	18:58:00	CBC	
117	2011	8	10	4:33:00	CB6	pulled after 20 minutes due to ice
118	2011	8	11	4:03:00	CBS	
119	2011	8	11	5:51:00	CB19	
120	2011	8	11	14:09:00	CB21cal	
121	2011	8	12	4:23:00	CB18	
122	2011	8	13	4:48:00	CB40	
123	2011	8	13	6:20:00	CB22	
124	2011	8	13	15:33:00	CB21	
125	2011	8	13	4:04:00	CB27	
126	2011	8	14	5:35:00	CB29	
127	2011	8	14	19:55:00	MK6	

Table 7. Vertical Net Hauls for Zooplankton. Summary of the number of samples taken at each station, based on net mesh size (53, 150 or 236 m, or all for live tow) and tow depth (100, 200, 500m).

		Mesh				
Station	**Depth**	**53**	**150**	**236**	**All**	**Total**
AG5	100	2	2	2		6
CABOS	100	1	1	1		3
	500	1	1	1		3
CB10	100	2	2	2		6
CB11	100	1	1	1		3
CB12	100	2	2	2		6
CB13	100	2	2	2	1	7
CB15	100	2	2	2	1	7
CB16	100	2	2	2		6

CB17	100	2	2	2		6
	200				1	1
CB18	100	2	2	2		6
	200				1	1
CB19	100	2	2	2		6
CB2	100	2	2	2		6
CB21	100	4	4	4		12
	500	1	1	1		3
CB22	100	2	2	2		6
CB27	100	2	2	2		6
CB28aa	50	1	1	1		3
CB29	100	2	2	2		6
CB2a	100	2	2	2		6
CB3	100	2	2	2		6
CB31b	100	2	2	2		6
CB4	100	2	2	2		6
	200				1	1
	500	1	1	1		3
CB40	100	2	2	2		6
CB5	100	2	2	2		6
	500	1	1	1		3
CB6	100	2	2	2		6
	200				1	1
CB7	100	2	2	2		6
CB8	100	2	2	2		6
CB9	100	1	1	1		3
	200				1	1
	500	1	1	1		3
CBC	100	2	2	2		6
CBS	100	2	2	2		6
MK2	100	1	1	1		3
MK3	100	2	2	2		6
MK5	100	2	2	2		6
MK6	100	4	4	4		12
MK7	100	2	2	2		6
PP6	100	2	2	2		6
PP7	100	2	2	2		6
STA-A	100	1	1	1		3
	200				1	1
	500	1	1	1		3
Total number of samples		78	78	78	8	242

Table 8. Sampling for POC Study (Traps, Pumps, Rosette Samples and Seawater Loop Samples) - Daniel Montlucon

Stations	Lat (N)	Long (W)	Date (local)	Time (local)	Sampling
CABOS	71.8274	131.7701	23/07/11	'18:50	ship intake: deuterium 4 mL
Transit #1	72.3262	135.4387	24/07/11	'07:55	ship intake: deuterium 4 mL
Transit #2	70.0286	138.0125	23/07/11	'23:00	ship intake: deuterium 4 mL
CB-28 (+ start of transit to MK-1)	69.9969	139.9984	26/07/11	'01:42	ship intake: deuterium 4 mL , 29cm filter (662 L, stop @ 03:35), 500 L (lignin)
MK-4	70.8142	140.0010	26/07/11	'12:05	ship intake: deuterium 4 mL , 29cm filter (622 L, stop @ 14:40)
CB-28b	71.0007	139.9981	26/07/11	'16:35	ship intake: deuterium 4 mL
MK-6	71.5855	139.9986	26/07/11	'20:50	ship intake: deuterium 4 mL
Transit #3	72.6285	144.8181	27/07/11	'11:00	ship intake: deuterium 4 mL
Transit #4 (near Sta A-A)	72.5803	147.3057	27/07/11	'18:37	ship intake: deuterium 4 mL
CB-2a	72.5003	150.0013	27/07/11	'22:12	ship intake: deuterium 4 mL , 29cm filter (725 L, stop @ 01:15 on 28/07/11)
CB-4 (BGOS-A)	74.9964	149.9890	29/07/11	'06:30	ship intake: deuterium 4 mL , 29cm filter (2866 L, stop @ 17:30)
	75.0116	150.0414			CTD-16 (full cast): C14-DIC (500-mL), C14-DOC (1L), deut (4mL)
					In situ pumps: 2 casts, 5 pumps (x1 142mm GFF, x1 142mm GF-75 per pump)
					Sediment trap: recovered (18 samples), deployed
CB-9 (BGOS-B)	77.9901	149.9679	01/08/11	'13:29	ship intake: deuterium 4 mL , 29cm filter (2338 L, stop @ 01:45 on 02/08/11)
	78.0289	150.1662			CTD-23 (full cast): C14-DIC (500-mL), C14-DOC (1L), deut (4mL)
					In situ pumps: 1 casts, 5 pumps (x1 142mm GFF, x1 142mm GF-75 per pump)
					Sediment trap: recovered (18 samples), deployed
CB-11	79.0114	150.0363	02/08/11	'16:58	ship intake: deuterium 4 mL
CB-9 #2	78.0005	150.0060	03/08/11	'09:26	ship intake: 29cm filter (1898 L, stop @ 19:07)
CB-12	77.5814	145.9344	04/08/11	'12:49	ship intake: deuterium 4 mL
CB-13	77.3198	143.5807	04/08/11	'18:17	ship intake: deuterium 4 mL
CB-16	77.9966	139.9282	05/08/11	'07:45	ship intake: deuterium 4 mL
	77.9939	139.9413	05/08/11	'07:59	ship intake: 29cm filter (2350 L, stop @ 16:35)
	77.9509	139.9663			CTD-26 (full cast): deut (4mL)

CB-15	76.9682	139.2282	06/08/11	'08:38	ship intake: deuterium 4 mL
PP6	76.2674	132.8094	07/08/11	'12:23	ship intake: deuterium 4 mL
	76.2264	132.8262			CTD-29 (half cast): deut (4mL)
CB-17	76.0159	139.7568	08/08/11	??:??	ship intake: deuterium 4 mL , 29cm filter (1162 L, stop @ 22:59)
	76.0166	139.7575			CTD-30 (half cast): deut (4mL)
CBC	75.9785	144.8616	09/08/11	'10:56	ship intake: deuterium 4 mL
CB-6	74.7074	146.6164	09/08/11	'21:22	ship intake: deuterium 4 mL
CBS	73.5439	145.1387	10/08/11	'10:45	ship intake: deuterium 4 mL
CB-19	74.2665	143.2929	10/08/11	'22:18	ship intake: deuterium 4 mL
CB-21 (BGOS-D)	73.9941	138.9703	11/08/11	'12:55	ship intake: deuterium 4 mL
CB-18	74.9811	140.0294	11/08/11	'22:03	ship intake: deuterium 4 mL
CB-40	74.5109	135.6648	12/08/11	'08:26	ship intake: deuterium 4 mL
	74.5110	135.6647			CTD-37 (half cast): deut (4mL)
CB-22	73.4563	137.9449	12/08/11	'22:11	ship intake: deuterium 4 mL
CB-21 (BGOS-D)	73.9828	139.9422	13/08/11	'06:26	ship intake: deuterium 4 mL , 29cm filter (2001 L, stop @ 13:01)
	73.9830	139.9440			CTD-39 (full cast): deut (4mL)
					Sediment trap: deployed
CB-27	73.0017	140.2055	13/08/11	'19:45	ship intake: deuterium 4 mL , 29cm filter (1004 L, stop @ 23:15), 500 L (lignin)
	73.0007	140.2440			CTD-40 (half cast): deut (4mL)
CB-29	72.0009	139.9936	14/08/11	'08:23	ship intake: deuterium 4 mL
	72.0007	139.9941			CTD-42 (full cast): deut (4mL)
MK-6	71.6193	140.0424	14/08/11	'12:46	ship intake: deuterium 4 mL
Transit #5	70.6128	136.8622	15/08/11	'08:42	ship intake: deuterium 4 mL