Joint Ocean Ice Study (JOIS) 2013
Cruise Report

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,*
August 1 to September 2, 2013
IOS Cruise ID 2013-04

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2013 is an important contribution from Fisheries and Oceans Canada to international Arctic climate research programs. Primarily, it involves the collaboration of Fisheries and Oceans Canada researchers with colleagues in the USA from Woods Hole Oceanographic Institution (WHOI). The scientists from WHOI lead the Beaufort Gyre Exploration Project (BGEP, **http://www.whoi.edu/beaufortgyre/**) and the Beaufort Gyre Observing System (BGOS) which forms part of the Arctic Observing Network (AON).

In 2013, JOIS also includes collaborations with researchers from:

Japan:
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan, as part of the Pan-Arctic Climate Investigation (PACI) collaboration with DFO.
- National Institute of Polar Research (NIPR), Japan as part of the Green Network of Excellence (GRENE) Program.
- Tokyo University of Marine Science and Technology, Tokyo, Japan.
- Kitami Institute of Technology, Hokkaido, Japan.

USA:
- Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.
- Yale University, New Haven, Connecticut, USA.
- International Arctic Research Center (IARC), University of Alaska Fairbanks, Alaska, USA.
- Oregon State University, Corvallis, Oregon USA.
- Cold Regions Research Laboratory (CRREL), Hanover, New Hampshire, USA.
- Bigelow Laboratory for Ocean Sciences, Maine, USA.
- Applied Physics Laboratory, University of Washington, Seattle, Washington, USA.
- University of Montana, Missoula, Montana, USA.
- Naval Postgraduate School, Monterey, California, USA.
- Pacific Marine Environmental Laboratory /National Ocean and Atmosphere Administration (NOAA), Seattle, Washington, USA.
- University of Rhode Island, Kingston, Rhode Island, USA.
- University of Akron, Akron, Ohio, USA.

Canada:
- Environment Canada
- Trent University, Peterborough, Ontario, Canada.
- Université Laval, Québec City, Québec, Canada.
- Université Montréal, Montréal, Canada

France:
- Laboratoire d'Océanographie de Villefranche, Villefranche-sur-Mer, France

Research questions seek to understand the impacts of global change on the physical and geochemical environment of the Beaufort Gyre Region of the Canada Basin of the Arctic Ocean and the corresponding biological response. We thus collect data to link interannual- and decadal-scale perturbations in the Arctic atmosphere to interannual and decadal basin-scale changes in Beaufort Gyre, its freshwater content, freshwater sources, ice properties and distribution, water mass properties and distribution, ocean circulation, ocean acidification and biota distribution.

2. CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S. St-Laurent* began August 1st and finished September 2nd, 2013. The research was conducted in the Canada Basin from the Beaufort Shelf in the south to 79°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 underway expendable and non-expendable temperature and salinity probes increased the spatial resolution of CTD measurements. Moorings and ice-buoys were serviced and deployed in the deep basin and in the Northwind and Chukchi Abyssal Plains for year-round 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 levels. Underway measurements were made of the surface water. Weather balloons, a ceilometer and radiometer were used to aid atmospheric studies Daily dispatches were posted to the web.

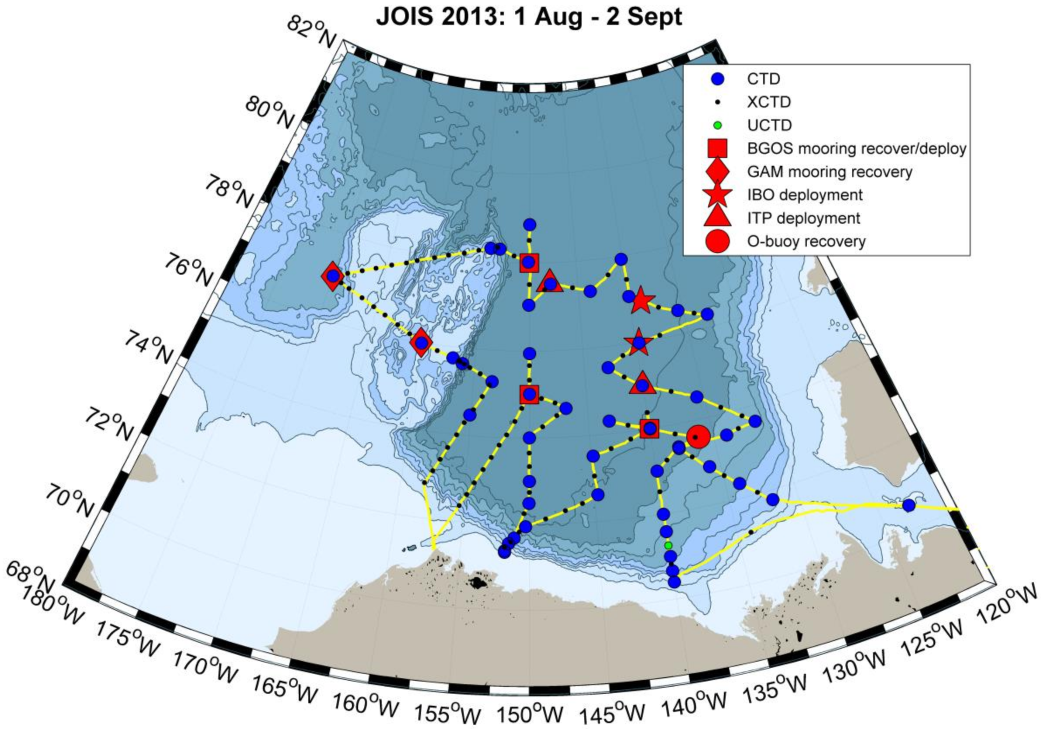

Figure 1.The JOIS-2013 cruise track showing the location of science station.

PROGRAM COMPONENTS

Measurements:

- At CTD/Rosette Stations:
    - 52 CTD/Rosette Casts (4 to 55) at 49 Stations (DFO) with 1195 water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (DFO, TrentU, TUMSAT, WHOI, ULaval, UAkron, UMontreal, URI))
        - At all stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a, and O_2/Ar and Triple Oxygen Isotope
        - At selected stations: Ammonium, ^{129}I, CFC/SF_6, N_2O, microzooplankton and polyfluoroalkyl compounds
    - Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts (DFO)
    - 89 Vertical Net Casts at 44 select Rosette stations typically to a depth of 100m with one cast to 500m. Mesh size is 50, 150 and 236 □m. (DFO)
    - 22 stations (19 using the smaller foredeck rosette with a SBE 19+ CTD, the others using the main rosette and CTD) sampling 6 to 8 depths to assess the microbial diversity in the Canadian Basin using molecular tools (ULaval)
    - 20 stations (using foredeck rosette with SBE19+ CTD and / or submersible pump) sampling 6-8 depth for Rn/Ra isotopic ratio profiles

- 88 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1100m depth (JAMSTEC, WHOI , TUMSAT)

- 1 UCTD (underway temperature, salinity and depth profiles) (DFO)

- Mooring and buoy operations
    - 5 Mooring Recoveries (3 deep basin (WHOI), 2 in the Chukchi and Northwind Abyssal Plains (TUMSAT , NIPR, performed by WHOI)
    - 3 Mooring Deployments (3 deep basin (WHOI)
    - 4 Ice-Based Observatories (IBO, WHOI)
        the first consisting of:
            1 Ice-Tethered Profiler (ITP71, WHOI)
            1 M-Y UpTempo buoy (APL)
        the second:
            1 Ice-Tethered Profiler (ITP70, WHOI, UMontana)
            1 Ice Mass Balance Buoy (IMBB, CRREL)
            1 Arctic Ocean Flux buoy (AOFB30, NPS)
            1 O-buoy (BLOS)
            1 Ice Tethered Micros (Yale University)
            1 Doble wave buoy (LOV)
            4 GPS Buoys at corners of 10 nm square around IBO site (OSU)

the third:

1 Ice-Tethered Profiler (ITP68, WHOI)
1 Ice Mass Balance Buoy (IMBB, EC)
1 M-Y UptempO Buoy (APL)

the fourth:

1 Ice-Tethered Profiler (ITP69, WHOI, UMontana)
1 Ice Mass Balance Buoy (IMBB, CRREL)

  - In addition to the 2 Uptempo buoys deployed at the ice satations, 3 UpTempo buoys were deployed in open water. One was deployed near station TU1 (Marlin-Yug type), one near TU2 (Pacific Gyre type) and one near CB3 (Pacific Gyre type) (APL).

- Ice Observations (OSU/KIT/WNI)
  Hourly visual ice observations from bridge with periodic photographs taken from Monkey's island 2 cameras (one forward-looking and one port-side camera).
  Underway ice thickness measurements using a passive microwave radiometer (PMR, August 6th-30th, 2013) and an electromagnetic inductive sensor (EM31-ICE, August 6th-7th, 2013).
  Radiation balance of solar and far infrared using a CNR-4 net-radiometer mounted on the bow while the ship was underway in or near the sea-ice (August 6th-30th)
  On-ice measurements at 2 IBO sites of EM and drill-hole ice thickness transects and ice-cores for temperature and salinity profiles as well as iron and microdiversity.
  On-ice observations of spectral albedo of ice and snow cover using an ASD FieldSpecPro and melt pond study.

- Cloud and weather observations:
  45 radiosondes (weather balloons) deployments (42 at CTD/Rosette stations, 3 between stations)
  Continuous cloud presence, cloud base height and base level measurements using a ceilometer.
  Continuous incoming short wave radiation

- Underway collection of meteorological, depth, and navigation data, photosynthetically active radiation (PAR), and near-surface seawater measurements of salinity, temperature, chlorophyll-a fluorescence and CDOM fluorescence (DFO).
  A combined 60 water samples were collected from the underway seawater loop for Salinity (DFO), and CDOM (TrentU). In addition, near-surface seawater was continuously measured for partial pressure of CO2 (pCO2) and pH (UMontana).

- Daily dispatches to the web (WHOI)

- Drift bottles launched at 4 locations (DFO)

3. COMMENTS ON OPERATION

3.1 Ice conditions

Ice cover was almost entirely absent last year but there was extensive ice cover in August 2013. The ice was nearly melted in the south and west (<50cm thick at 70-80% concentration with a large fraction of melted-through melt ponds), and much thicker in the north and east (~125-200cm thick with ~90% concentration). Consequently, our progress through the ice was rapid over the Northwind Ridge but significantly slowed in the north and east. Notably, thick and compressed ice at our furthest east stations, near Prince Patrick Island and Banks Island required the use of all 5 of the ships engines, often full ahead, to make reasonable progress. This was due to a tongue of older ice that extended southward along the edge of the Canadian Arctic Archipelago.

We suggest the extensive ice cover in 2013 was due to anomalous wind. From April 2013 onwards: anomalous eastward winds, during a time that typically has westward wind, held ice in the Beaufort Gyre, up against the Canadian Arctic Archipelgo, reduced ice speeds and reduced ice-albedo feedback via leads. Thus ice ‘melted in place’ rather than opening-up and moving out of the region. Similar anomalously low summer ice speeds with similar ice extent were last seen in 2006.

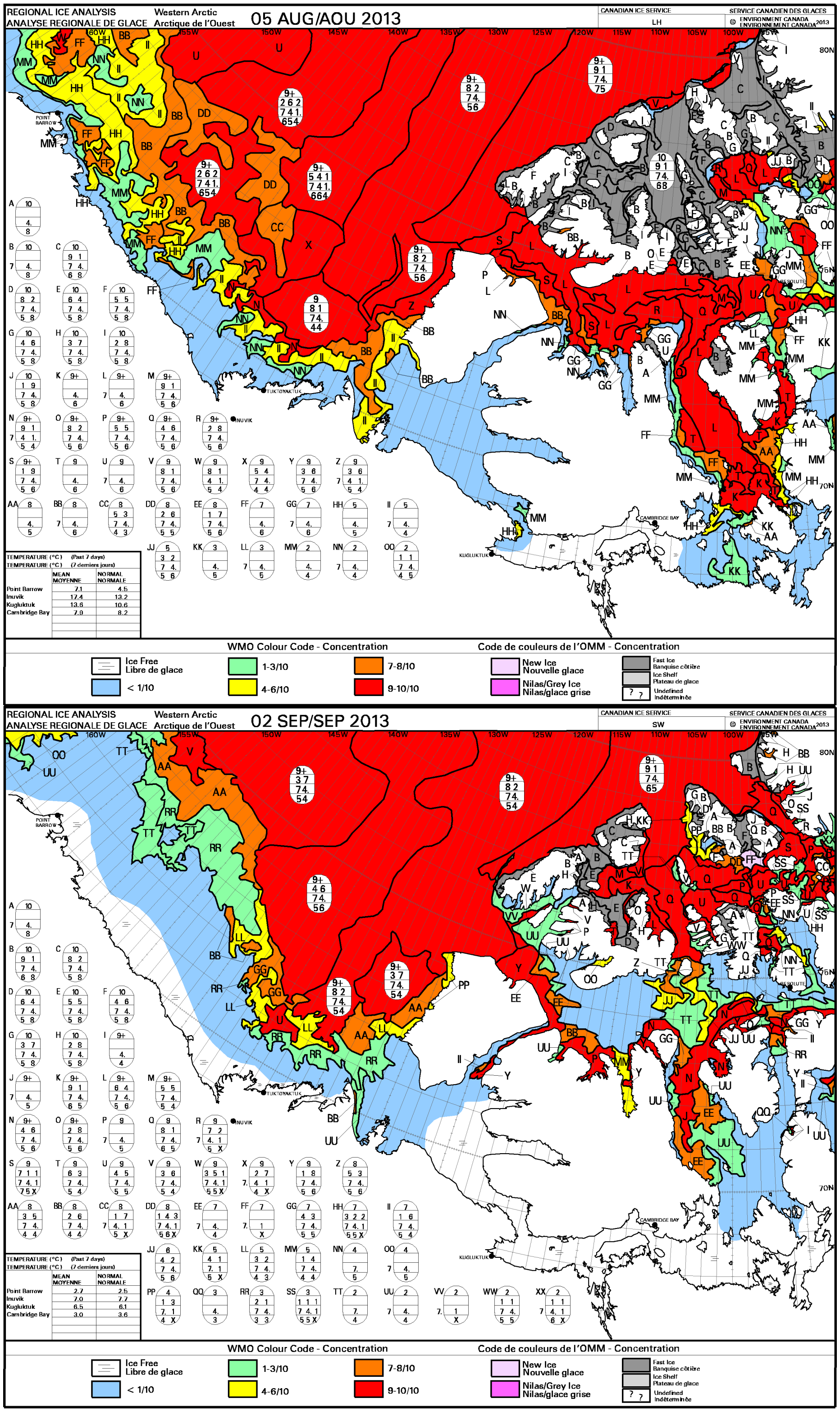

Figure 2: Canadian Ice Service ice concentration charts from the beginning and end of the cruise for the southern part of the JOIS cruise track

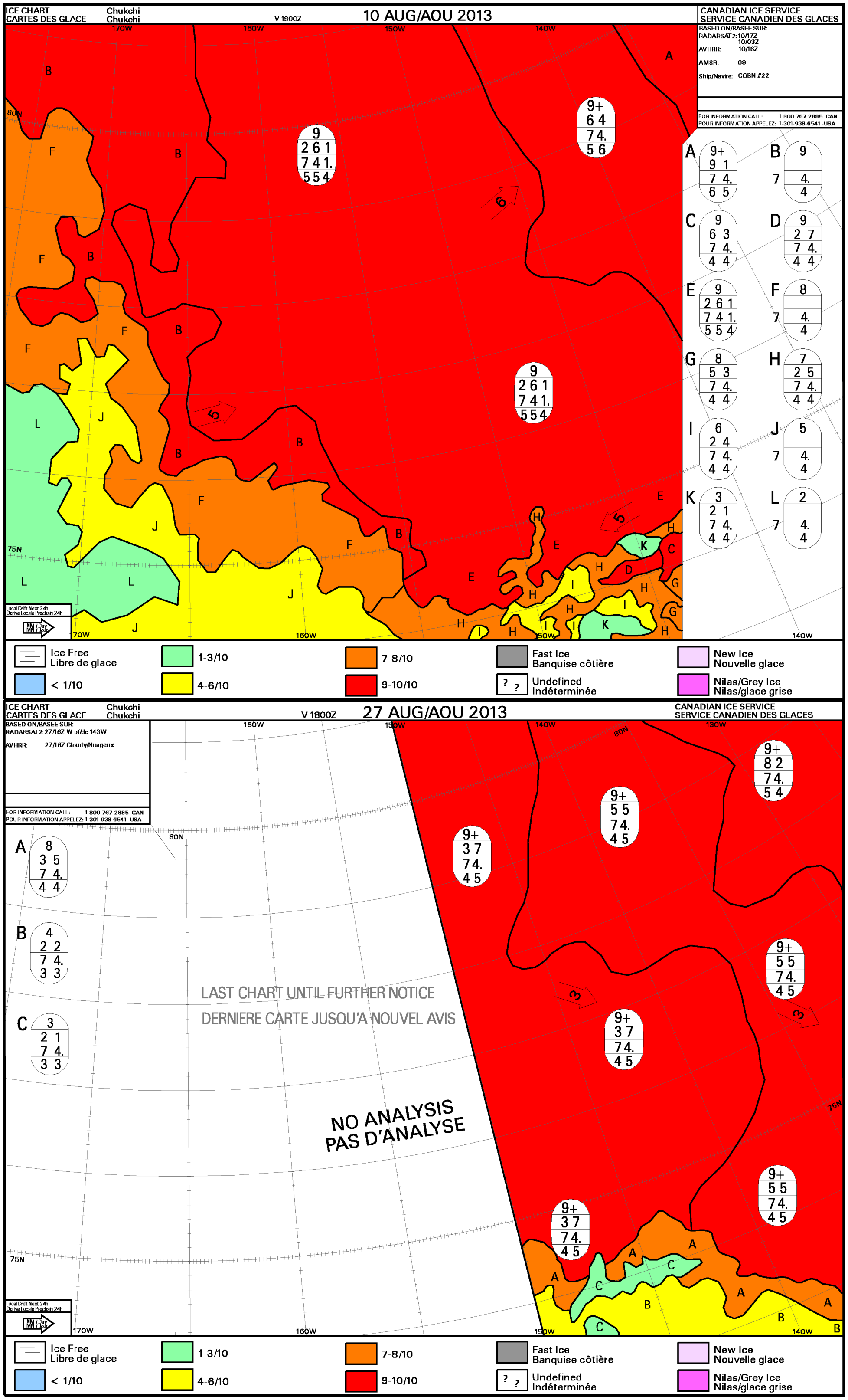

Figure 3: Canadian Ice Service ice concentration charts for the northern part of the JOIS cruise track. Note dates of analyses for this region do not cover the full length of the cruise.

3.2 Completion of planned activities

The goals of the JOIS program, led by Bill Williams of Fisheries & Oceans Canada (DFO), were met this year due to efficient multitasking and above average transit speeds in light ice which maximized the time available for sampling and the spatial coverage. Some ship time was lost: 2 days for crew familiarisation at the beginning of the cruise, 1.5 days for bereavement evacuation to Barrow, Alaska, and 4.6 hours for engine room repairs. These delays lead to replacing some CTD/Rosette casts on the high resolution Northwind Ridge and Mackenzie Line sections with XCTDs, and limiting the eastward boundary of our sampling in heavy ice.

Our primary goals were largely met during this successful 32-day program. We would like to note:
a) The efficiency and multitasking of Captain and crew in their support of science.
b) We did not need to miss stations and/or plan alternate routes due to weather
c) We minimized the science program prior to the cruise by:
    i) Keeping additional projects that might require wire-time to a minimum
    ii) Selecting the minimal geographic extent needed for the science stations.

4. ACKNOWLEDGMENTS

The science team would like to thank Captains Marc Rothwell and Andrew McNeill the crews of the *CCGS Louis S. St-Laurent* and the Coast Guard for their support. At sea, we were very grateful for everyone's top-notch performance and assistance with the program. There were a lot of new faces onboard and we appreciate the effort everyone took to come up to speed on the program. Of special note was the engineering department's rapid response to examine and repair problems or even suspected problems with equipment such as with the foredeck winch, the seawater loop, the boat deck and foredeck A-frames, the portable power generator and ice-auger power head. We'd like to thank the Canadian Ice Service and ice specialist Jean-Yves Rancourt for assistance with ice images and weather information. It was a pleasure to work with helicopter pilot Colin Lavalee and mechanic Steve Lloyd for their 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.

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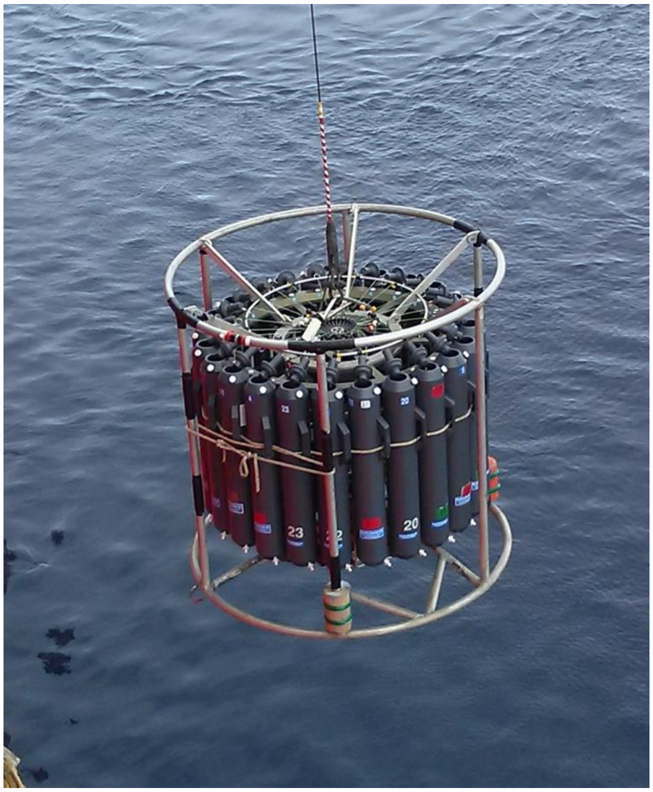
5. PROGRAM COMPONENT DESCRIPTIONS

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)
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 V7.22.5 acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, dissolved oxygen sensor, fluorometer, transmissometer, CDOM fluorometer and altimeter. In addition, an ISUS nitrate sensor was used for casts shallower than 1100 m and a PAR sensor for casts <2000 m. A surface PAR sensor was installed for all casts. Continuous PAR data was collected for the whole cruise as part of the underway suite of sensors going to SCS. These 1-minute averaged data are reported with the underway suite of sensors.



During a typical station:
During a typical cast, the rosette would be deployed followed by the ADCP. Two zooplankton vertical net hauls (bongo) to 100m were conducted from the foredeck and at select stations a secondary foredeck rosette with 12 bottles and a SBE19+ CTD was deployed to 100m for either microplankton DNA studies or Radon and Radium sampling. The ADCP was recovered prior to the main CTD. Please see the individual reports for more information on the ADCP, bongo, and foredeck rosettes.

During a typical deployment:
On deck, the transmissometer and CDOM sensor windows were sprayed with deionised water and wiped with a lens cloth prior to each deployment. The package was lowered to 10m to cool the system to ambient sea water temperature and remove bubbles from the sensors. After 3 minutes the package was brought up to just below the surface to begin a clean cast, and lowered at 30m/min to 300m, then at 60m/min to within 10m of the bottom. Niskin bottles were normally closed during the upcast without a stop. During a “calibration cast” and when closing bottles of extreme interest, the rosette was yo-yo’d to mechanically flush the bottle, meaning it was stopped for 30sec, lowered 1 m, raised 2 m, lowered 1 m and stopped again for 30 seconds before bottle closure. The instrumented sheave (Brook Ocean Technology) provides a readout to the winch operator, CTD operator, main lab and bridge, allowing all to monitor cable out, wire angle, tension and CTD depth.

Two configuration files (xmlcon file) were used for the cruise due to replacing the transmissometer for cast 15. Transmissometer SN 993 was used for casts 1-14 and SN 1052 was used for casts 15-55. The configuration file included the ISUS and PAR even though they were used only on a few of the casts. The data fields will be ignored in processing on casts when the sensors were not installed.

All Niskin o-rings (end caps, valves and spigots) were replaced with new baked o-rings to reduce any contamination for the CFC/SF6 sampling.

New Niskin bottles were available as backup but no new bottles were needed.

Both pylons were serviced before the cruise with all latches removed and cleaned and o-rings replaced.

Performance notes:

The SBE9+ CTD overall performance was good. Editing and calibration have not yet been done, but the data will likely meet the SBE9+ performance specifications given by Seabird. Header information of position, station name, and depth has not been quality controlled yet. Salinity and oxygen were sampled from the water and will be used to calibrate the sensors. Due to the asymmetrical plumbing on the temperature and conductivity sensor pairs, some post processing will be required for phase adjustment.
CDOM and Chlorophyll-a water samples were collected and can be used for calibration at the user's discretion.

We chipped the bottom of one of the Niskins due to a "dry" fire of the bottom endcap. The Niskin was removed and replace.

Temperatures were below freezing for roughly a week. This meant ice was forming on the block, wire, under the rosette deck. It would be good to bring the ice chummy (removes water from wire on upcast using pressurized air) along even for these 'summer' cruises.

Transmissometer changed for cast 15. Sensor sn#993 replaced with sn #1052. It looked like the transmission profile had an progressive offset after each deep cast. This had been a problem with this sensor before being sent to the factory. However sn #1052 also drifted with depth. The cable was removed and connectors were examined mid-cruise.

The pylon trigger release mechanisms was swapped out with the spare every week (pylons sn452 and 498), washing and rinsing well before reinstalling, however the tackiness in the latches didn't improve much after cleaning.

ISUS sensor batteries replaced 16 Aug. Symptom was that data looked fine on deck but then with time would drop to zero volts then after a minute or so spike up to larger value but then drop back to zero. Communicating with ISUS showed that the system was in a cycle of starting up, sensing low power, shutting down and then trying to restart. Voltage measured 12V on the battery pack and through the instrument, ISUS reported 11.52V. When the battery pack was opened, it was found there was corrosion on one of the dummy batteries and also heavy corrosion on one of the alkaline D cells. No seawater leak. The dummy battery contact was sanded clean and all D cell batteries replaced. There was no desiccant inside and we had none to add. ISUS performed well afterwards. Battery pack measured 16V and ISUS reported voltage of 13V (using hyperterm). ISUS was back on for Cast 26 (Station CBW) and for following foredeck rosette casts.

PAR sensor failed. Rubber splicing tape wrapped around cable to instrument's bulkhead connector removed and it was clear there had been seawater leak into this connection. PAR's bulkhead connector lost a pin with plenty of green corrosion. The connector on the cable looked in rough shape as well. Sensor and cable tied up with red flagging to indicate repair needed.

PAR cable with red flagging cut apart on 18 Aug to use the still good 6-f wetmate end for an adapter cable to connect the communications cable to the new bulkhead connector on the foredeck rosette's AFM.

Y-cable on main CTD rosette that is used to connect to ISUS and PAR found to have a slightly corroded pin on 26 Aug. Pin was black along the base and flakes came off when scratched with a fingernail. Connector had not been used in a week or so and not sure if this corrosion was new or old. The connector was wrapped in red flagging. As the PAR sensor was no longer in use, the ISUS was connected to the good leg of the Y connector for the cast 44, CBC2, the last time it was used on the main CTD rosette.

There was trouble at the very end of the cruise with communication with the pylon and closing Niskin bottles. This may have been happening occasionally throughout cruise with the occasional missed bottle but became a noticeable issue starting with cast 49 and continued to the end at cast 55. The pylon did not confirm the bottle fire when firure from the Seasave software or through direct commands pushing the "fire" button on the deck unit. Cycling the power on the CTD, deck unit and computer did not help. For the last few casts the bottom bottles did not close and then at some point on the upcast the pylon began responding with bottle closure. The error message displayed on the Seasave software was: "FFFFFFF Unsupported modem message: 06 2D 06 from the SBE Carousel". The spare deck unit was swapped in and cables on the CTD unplugged and checked, however the problem continued on the following cast. Typically this affected Niskins 1 and 2. These casts were performed during the last ½ day of data collection and there was not time, nor deeper water to troubleshoot the issue.

A frame:

A-frame had been removed, refurbished and reinstalled prior to cruise. Except for small hydraulic leak near the start of the cruise the A-frame worked well.

Hawboldt winch:

Although wire has been greased, the wire looked rusty on the first uses.

Spooling worked well.

Brake initially did not hold when we went down to depth (>2500m) but the brake was tightened 1-2 inches (!) along the threaded brake post and then it held. At cold temperatures we heard "meows", whale songs, and clacking/chatter on upcast. The noise seemed to be coming from the forward end of the winch though it was not determined where the noise was coming from. As the weather warmed, it was no longer a problem. On a typical upcast there is a regular chunk-a-chunk-a which might be associated with the brake?

Block:

Performed well except for period of freezing where out going wire was bouncing on the wheel likely due to ice buildup. We did not see any indication that the block had shifted on its bearing. This happened last year and caused wear on the side of the block.

Configuration:

Table 1. Seabird SBE911+ CTD system used during 2013-03 and -04

SBE9-0756 (Casts 1-55)		
Sensor (s/n)	**Lab Calibration**	**Comment**
Pressure (91164)	26 Feb 2010	
Temperature, Primary (SBE3 4397)	26 Sep 2012	
Temperature, Secondary (SBE3 4402)	26 Sep 2012	
Conductivity, Primary (SBE4 2992)	26 Sep 2012	
Conductivity, Secondary (SBE4 2984)	26 Sep 2012	
Oxygen (SBE 43 435)	20 Nov 2012	Plumbed with primary sensors.
Transmission (Wetlabs CST-993DR)	23 Jun 2013 or 28th (factory calibration)	Casts 4 to 14.
Transmission (Wetlabs CST-1052DR)	15 Jun 2013 or 18 Jun 2013? (bench calibration)	Casts 1 to 3 (part of C3O cruise), 15 to 55.
Fluorescence (Seapoint SCF 2841 with 30x gain)	1 Oct 2006	Plumbed with secondary sensors.
Altimeter (Benthos Datasonics PSA-916D 1161)	31 Mar 2005	
Nitrate (Satlantic ISUS v3 #121)		
CDOM (Wetlabs FLCDRTD-1076)	6 Nov 2006	
PAR (Biospherical QSP2300 70123)	31 Aug 2009	
SPAR (QSR2200 sn20281)	9 Apr 2007	Typically on SWL

5.2 Foredeck Rosette Casts:

PI: Bill Williams (DFO-IOS)
Sarah Zimmermann (DFO-IOS)

Foredeck rosette

A second smaller rosette was used on the foredeck to collect shallow (typically 200m and less) additional water samples for the microbial diversity program and the Radon222 and Radium sampling program (see below). The rosette had 12 10-L Niskins positioned non-symmetrically that allowed room for an internally-recording SBE 19+ with PAR and nitrate ISUS sensor. The CTD was connected with the pylon using an Auto Fire Module (AFM) . Because multiple bottles were needed at certain depths, the time delay bottle closure method was used instead of using pressure values. The CTD sensors were calibrated pre-cruise by Seabird and checks can be made to the water sample salinities drawn from the Niskins.

Issues

The SBE19+ had been shipped from calibration at Seabird missing the battery endcap. Luckily Rick Krishfield had spare with him.

As the rosette is stored outside, there is a problem when temperatures drop below freezing. The pylon latches freeze up and even during the soak and deployment in the water do not warm up enough to release. Pouring hot water over the pylon prior to putting the rosette in the water was effective for freeing up the latches.

Sampling is difficult in freezing conditions. Creating a shelter from the wind and cold would be helpful if we are continuing with foredeck work.

Connections to cables, most being the old sea-con style, were difficult to seat properly and remove in the cold conditions. A number of bulkhead connectors from the CTD and AFM were in poor shape due to seawater leaks that occur more readily when connections are not seated well and/or work themselves loose in the cold. A hot-air gun was used occasionally to pre-warm the connectors before removal and seating until the hot-air gun broke. It would be great to replace all connectors with wet-mate style.

AFM’s serial communication bulkhead connector (old style plug) was very difficult to plug into and was used extensively for communicating with AFM and CTD before and after each cast. Pin 3 bent and broke off on 18 August. Scott was able to replace the 4-pin bulkhead connector with a spare 6-pin wetmate style bulkhead connector.

The winch used for the foredeck rosette and bongos had problems with hydraulic hose connectors, both the quick releases and the connection to the powerpack. To stop the leaking of hydraulic fluid it was necessary for the engineering dept to replace the hose set with a fixed hose (no quick releases).

Wire out counter display was found to be broken when set up for its first use. The backup display sent for the main CTD winch was used though we did not recalibrate the counter. It would be good to include calibration instructions in winch book and w/ display.

5.3 Side-of-ship ADCP

Edmand Fok, Sarah Zimmermann (DFO-IOS)

PI: Svein Vagle (DFO-IOS)

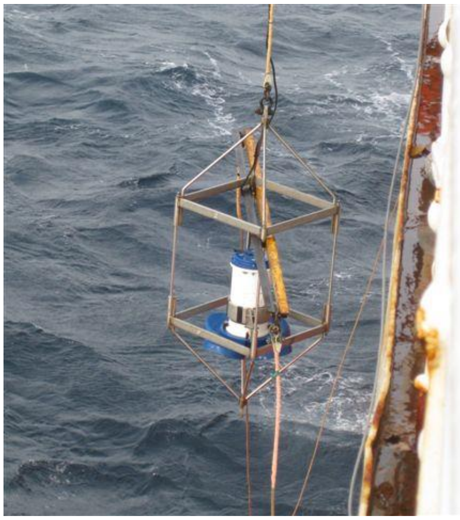


Figure 2. ADCP being lowered to 5m during rosette cast. *Photo by Sarah Zimmermann*

While the ship is stopped for the CTD/Rosette casts, an RDI acoustic doppler current profiler (ADCP) was lowered over the side. The ADCP acoustically measures currents in the upper water column using backscatter from 4 150kHz transducers to determine currents at discreet intervals (bins) to a maximum of 350 m. Due to the clear water encountered off shore in the Canada Basin and the small currents in largely ice covered waters the instrument is working quite often to the limits of detection. The package was lowered by crane from the boat-deck 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.

Of note:

- GPS data was not being integrated into the ADCP data until cast 172 (11 Aug) due to issues with the GPS string not configured properly in the input software, GPSgate.
- Data will be affected by ship manoeuvring when we were in mobile thick ice (propeller wash, bubbler operation). On several stations the ADCP was recovered early to reduce the difficulty of keeping the foredeck rosette/nets wire, the CTD wire and ADCP wire all ice free.
- During on-ice stations the ADCP could not be deployed as the crane was in use for the helicopter operation.

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

5.4 XCTD Profiles

PIs: PIs: Koji Shimada (TUMSAT), Motoyo Itoh (JAMSTEC), Andrey Proshutinsky (WHOI), Rick Krishfield (WHOI), (Yasuhiro Tanaka (KIT))

XCTD (Expendable Conductivity, Temperature and Depth profiler, Tsurumi-Seiki Co., Ltd.) probes provided by JAMSTEC, WHOI and TUMSAT were deployed from the ship's stern with temperature, salinity and depth data acquired by computer located in the stern (AVGAS) hold. The data converter, MK-130 (Tsurumi-Seiki Co., Ltd.) was used for XCTD deployment and for data conversion from raw binary to ascii data (original and 1-m interval). Salinity, density and sound speed were automatically calculated after XCTD probe deployment. Types of XCTD probe were XCTD-1 and XCTD-3 which can be deployed when ship steams at up to 12 knot and 20 knot, respectively. The casts took approximately 5 minutes for the released probe to reach its final depth of 1100m. In open water, depending on the probe type, the ship may have slowed to 12 knots for deployment, but when ship is surrounded by sea ice ship had to stop or be slower. XCTD deployments were spaced every 20-30 nm on the ship track typically between CTD casts to increase the spatial resolution. In/around the Northwind Ridge area, XCTD deployments had higher horizontal resolution, especially across the slope region.

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

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

During this cruise, 120 XCTDs were successfully launched, and 3 (highlighted by gray and yellow in Table.1) failed. Some of the working XCTDs had shortened profiles (see Table.1) presumably due to broken wires.

CAUTION: Please use positions given in the XCTD table (see Appendix B) taken from the GPGGA GPS data based on deployment time and not those recorded in the data files. There are a few incorrect positions listed in the data files..

Figure 1: XCTD probe deployment from the ship's stern (2011) and XCTD data converter MK-150.

5.5 Zooplankton Vertical Net Haul.

David Spear (DFO-IOS)
PI: John Nelson(DFO-IOS)
Day Watch: David Spear (IOS), Kristina Brown (IOS),
Night Watch: Scott Rose (IOS), Sigrid Salo (NOAA)

Summary

A total of 89 bongo net hauls were completed at 44 stations. Bongos were harnessed and deployed in the same manner as previous JOIS cruises where nets were lowered at 30m/min and raised at 60m/min. Standard, duplicate tows to 100m were sampled at all stations except at CB21, where an additional 482 m tow was done.

The winch counter was found to be broken during installation and a replacement counter, set up for a different winch, was used. Although the target depth was 100m, the actual depth varied due to incorrect interpretation of the counter's readout and/or wire angles. An RBR *Virtuoso* pressure sensor was attached to the frame at the top of the nets and provided an accurate reading post cast of the maximum depth reached.

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

Stations with only one cast:
- 236 µm 95% ethanol
- 150 µm into buffered formalin (10%)
- both 53 µm combined to single buffered formalin (10%) sample

482m cast:
- 236 µm into buffered formalin (10%)
- 150 µm into 95% ethanol
- both 53 µm combined to single buffered formalin (10%) sample

Please see table of casts in Appendix B

5.6 Microbial Diversity

Adam Monier, Deo Florence Onda
PIs: Connie Lovejoy (ULaval)

Introduction and objectives

The Canada Basin, particularly its northern sector has been largely inaccessible until recently due to the persistence of perennial ice. In turn, there is limited knowledge and understanding of the ecology, diversity and distribution of the microbial communities in this region. The Canada Basin is also rapidly changing and mostly dominated by non-diatom species at this time (Li et al 2009). However, recent climatic changes resulted to ice-free high Canada Basin during summers in 2007 and 2012 provided opportunities to gather data and information particular for the region. Our goal for the 2013 cruise was to collect more samples to investigate possible changes in the eukaryotic microbial diversity and variability of in the Canada Basin. With the samples that we collect, we aim to understand the influences of physico-chemical conditions and possibly ice on microbial communities compared to the surrounding seas using genetic based approaches coupled with high-throughput sequencing.

Methodology

General Overview

Samples were collected mostly in stations that were visited in 2012 and few additional new stations. Furthermore, a standard of 6-8 depths were targeted to increase resolution for investigating genetic variation and possible community niche partitioning of species. Special samples from deep waters (~3800 m) and ice cores were also collected for other possible investigations.

Depths were chosen for sampling based on characteristics of the water column as profiled by the downcast of the CTD of the maindeck rosette. Standard depths include surface (~6 m), bottom of the mixed layer (~20-30 m), temperature minimum, above SCM, SCM, below SCM and bottom (~100 m). DNA/RNA, DAPI, FISH and chlorophyll samples were collected in all depths while HPLC and FNU samples only targeted the surface and SCM samples.

DNA and RNA

For DNA/RNA collection, large (>3 µm) and small (<3- 0.2 µm) fractions are filtered first through a polycarbonate filter with 3.0 µm pore-size and the Sterivex unit (0.2 µm, Millipore) using 6L of water sample. Large fraction samples are placed in 2-mL microfuge tubes and both filters were covered with RNALater (Ambio). Filters are left at room temperature for at least 15 minutes before being frozen at -80º C.   6 l of water were filtered at room temperature. Filters were stored in RNA Later buffer at -80 ºC.

Chlorophyll a and HPLC

Samples were also collected to determine/estimate the biomass of phototrophic organisms using chlorophyll a as the proxy. In all stations from all depths, large (>3 um) fractions were collected using 500 ml of seawater filtered through a glass fibre filter and stored in darkness at -80 ºC. Small fractions were attained by pre-filtration of the same quantity of water through a 3 µm polycarbonate filter before filtering onto a glass fibre filter. Chlorophyll *a* will be extracted with ethanol and quantified in the lab at Université Laval.

Pigment profiling by HPLC analyses were also collected at the surface and subsurface chlorophyll maximum depths. Two (2) liters of seawater was filtered through a glass fibre filter, flash-frozen in liquid nitrogen, and then stored at -80 ºC. In addition, we pre-filtered the same quantity of water through a 3 µm polycarbonate filter before filtering onto a glass fibre filter, in order to sample only the <3 µm size fraction.

Epifluorescent Microscopy

Samples for estimation of biovolume, abundance and gross taxonomic classification by microscopy were also collected. Slides were made for epifluorescent microscopy at each station and depth sampled. Cells for microscopy are collected and preserved as described by Thaler and Lovejoy (2012). In brief, 50 ml seawater is fixed in glutaraldehyde (1% final concentration), filtered onto a 25 mm black polycarbonate filter (0.8 µm for eukaryotic and 0.2 µm for prokaryotic, AMD manufacturing), stained with DAPI and mounted in a glass slide with oil. Slides are kept in opaque boxes and kept frozen until analysis. Seawater was fixed with 1 % glutaraldehyde and processed 1-24 hours after sampling.

Fluorescent in situ *Hybridization (FISH)*

FISH is a technique that uses fluorescent-labelled nucleic acid probes to identify a specific phylogenetic group of organisms under the microscope. Samples for FISH were collected in duplicate for eukaryotes and bacteria at each station and depth sampled. Seawater was fixed with 3.7 % formaldehyde and processed 6-24 hours after sampling. For eukaryotic organisms, 90 ml of fixed sample was filtered onto a 0.8 µm polycarbonate filter. For bacteria, 10 ml was filtered onto a 0.2 µm polycarbonate filter. Filters were air-dried and stored at -80 ºC.

Conventional Light Microscopy

At each station, at the surface and chlorophyll maximum, 225 ml of seawater was collected and added with 25 mL FNU solution as a fixative. At Université Laval, larger organisms, such as diatoms and dinoflagellates, will be identified to the highest possible taxonomic resolution on an inverted microscope.

Live culture and single-cell genetics

The 2013 sampling also attempted to collect and maintain live cultures of phytoplankton and fixed sample for single-cell genetics, particularly the larger species such as dinoflagellates. Two (2) liters of samples from the SCM and surface waters were filtered through a 3 um polycarbonate membrane, and then the filters were resuspended in 350 mL of filtered nutricline water enriched with F/2 medium in a clear culture bottle. Live samples were kept in ice with light until they reach the laboratory for further processing.

Large cell fractions (>3 um) were also collected and fixed following the same procedure described above, but filters were fixed in 10% formaldehyde for at least 30 minutes. Subsequently, fixed samples were filtered again using the same filter membrane, washed with filtered seawater and resuspended in 10 mL 70% methanol and stored in 4ºC until processing in the laboratory.

Summary

A total of 151 samples from different depths in 24 stations including the ice cores were collected during the campaign. With more depths and samples, a higher resolution to investigate microbial community partitioning and diversification can be carried out.

Please see full report for list of stations sampled and depths

5.7 ^{222}Rn and Ra sampling

Brice Loose, Roger (Pat) Kelly (URI)

Motivation:

The goals for these samples are to make an exploratory map of the scaling relationship between the gas transfer velocity (k) and the forcing conditions in the seasonal sea ice zone (SSIZ). Estimates of k will be produced using the radon deficit method aboard the JOIS1304 cruise to the seasonal sea ice zone. For the first time in the history of upper ocean radon measurements it will be possible to determine the time evolution of the mixed layer and the primary upper ocean forcing mechanisms using an ocean observing network. Ice-tethered Profiler data and model results forced with synoptic ocean and atmosphere conditions will be used to reconstruct the gas exchange forcing conditions in the sea ice zone. This capability will help constrain the uncertainty in estimates of k from radon and permit a relationship between k and the dominant turbulent forcing mechanisms in the SSIZ. Our objective is for this project to serve as a model for a longer-term effort that will make opportunistic measurements of k using radon deficit under the widest possible range of ice cover and forcing conditions permitted by the logistics programs of the Arctic and Antarctic.

Changes in the sea ice cover in the Arctic and Antarctic affect the physical and chemical structure of the upper ocean, and in turn impact the net ocean-atmosphere flux of CO_2 and gases important to marine biogeochemical processes. Changes in the advance and retreat of seasonal sea ice cover, represent feedbacks from anthropogenic climate change, which have potentially important consequences to the ocean carbon cycle, to the rate of ocean carbon sequestration and to ocean acidification. The study proposed here is to determine predictive scaling laws for gas exchange through Arctic Ocean sea ice, but these results may be applicable to Antarctic sea ice, which covers nearly 40% of the ocean surface south of 50°S during the austral winter and melts every austral summer. These scaling laws will provide much needed information on seasonal variability in marine biogeochemical processes, and knowledge of the CO_2 flux is critical to make a well constrained annual estimate of the global CO_2 sink, which is in turn critical for society to mitigate global warming caused by anthropogenic CO_2.

Figure 3. Scenes from the foredeck

Large-volume radium-224, 223, 228, and 226

Sampling

Large-volume (~200L) water samples for radium isotopes ($224_{t1/2=4\ d}$, $223_{t1/2=11\ d}$, $228_{t1/2=5\ yr}$, $226_{t1/2=1600\ yr}$) were collected at each radon sampling station using a submersible pump attached to a 5/8” ID garden hose. The sample pump was lowered through a gunwale in the foredeck to the water surface. 200 L of surface water were collected in barrel containers. At two stations (CB-27 and CB-29), a sample for short-lived isotopes was also collected at 30 m.

Analysis

The ~200L seawater sample is passed through MnO_2-impregnated acrylic fiber cartridges at a rate of <1L min^{-1} to sorb the radium isotopes onto the filters at >97% efficiency. The fibers were then analyzed for short-lived ^{224}Ra and ^{223}Ra at sea using a Radium Delayed Coincidence Counter (RaDeCC). Following the cruise, the samples will be analyzed for long-lived ^{228}Ra and ^{226}Ra using a gamma spectrometer at the URI-GSO isotope geochemistry facility.

Radon-222 and Radium-226

Sampling

Water samples for radon-222 abundance were collected in 30 L Keybler containers for subsequent degassing. Discrete samples were collected in vertical profile fashion at 6-8 depths within 70 m of the ocean surface layer. Rn/Ra profiles were collected at the following hydrographic stations: CB01, CB23A, CB22, CB19, STAA, CB2A, CB6, CB4, CB5, TU1, TU2, CB10, CB11, CB12, CB16, CB17, CB18, CB51, CB-27, and CB-29.

Samples were collected in one of two methods – by submersible pump or from the foredeck niskin rosette. When samples were collected by submersible pump, 26L were collected in each Keybler bottle. When collected from the niskin, 2 10L Niskins were closed at one depth and drained into a single Keybler. Niskin sampling usually resulted in 18-19 L sample, as some water was left for sampling for salts.

It is common for the ship to used compressed air bubblers to push ice away from the sides of the ship when on station. The bubbling was a cause for concern because of the potential to enhance radon loss. To avoid this artifact, the ship would drift on to a station and the submersible pump was deployed to take water at two depths above 10 m (the draft of the ship). At this time a CTD profile was also taken using a freefalling UCTD attached to a handheld line. These two measurements were meant to record the undisturbed surface layer. Subsequently, water was sampled from the niskin rosette from depths between 5 and 70 m. At four stations, the entire set of discrete samples was collected using the submersible pump. These stations were CB-17, CB-18, CB-27, CB-29.

Prior to collection of water samples, the 30-L Keybler bottles were evacuated to a vacuum of at least 25 in Hg, to minimize contamination with air and to facilitate filling the bottles by suction. Water was inlet to the Keybler through a fitting with stopcock at the base of the sample container. Upon filling, if the sample has been collected properly, the majority of the vacuum has been preserved.

Analysis

The 3.8 day half-life of radon-222 requires that water samples be analyzed for radon aboard the ship. Once collected, the Keybler is connected to an extraction board. UHP Helium fills the Keybler to neutral gauge pressure and a diaphragm pump is used to bubble the helium through the keybler, stripping the radon gas from the water and transporting it through a charcoal column bathed in dry ice / 1-propanol slurry at -78C. The extraction lasted 90-120 minutes.

Subsequently, the charcoal traps were heated to 450 C and purged with helium to flush the trapped radon into a cell for counting.

The cell is coated with zinc sulfide, which gives off three photons for every atom of radon that decays within the cell. Photon emissions are counted on a photon counter. To improve statistical uncertainty, each cell was counted for a period long enough to accumulate at least 1000 counts. Cells are recounted on different counters to help eliminate any bias in the efficiency or other matrix effects between cells and counters. Typically, 1000 counts accumulated on a minimum of three different counters.

After gas extraction, the water in the Keybler is gravity drained through a MnO_2 impregnated acrylic fiber cartridge to sorb dissolved radium-226 from the sea water. These filters are subsequently bagged and stored for radium-226 abundance, which will occur in the laboratory at URI-GSO.

Standard and blank preparation

The extraction efficiency off each extraction board was tested using a radium standard in the URI-GSO radioisotope laboratory. A second extraction efficiency test will be conducted after the equipment returns to GSO post cruise.

Background radiation emissions were tested for with two sequential steps. On two occasions during the cruise, counting cells were filled with pure helium and allowed to count in the normal fashion. This determined the background for each individual counting cell and its interaction with specific counters.

Next, sample extractions took place without the Keyblers connected to permit possible radon contamination from the extraction board to be accumulated onto the column. These column extractions were transferred to cells and counted in the normal fashion. Eight total cells were used. The extraction backgrounds are listed in **Table 1**.

Table 2. The background on the radon extraction and measurement system, calculated twice during the cruise from August 17-20 and again on August 31.

August 17 thru 20			31-Aug			
Board	**Column**	**Avg dpm**	**Board**	**Column**	**Avg dpm**	**Chg. Bkgd**
A	1	0.125				
C	2	1.133		2	1.420	0.287
A	3	0.533	D	3	0.363	-0.170
D	4	0.955	C	4	0.357	-0.598
A	5	0.684	D	5	0.536	-0.148
C	6	0.661	B			
C	6	0.809	A	6	0.525	-0.147
C	7	0.698	B	7	0.497	-0.202

B	8	1.304	A	8	0.427	-0.877

Reproducibility

To test the reproducibility of radon samples collected by the rosette all 12 bottles were tripped at the same depth and extractions were carried out on a total of 6 keyblers filled from these 12 bottles. Assuming that internal wave activity can be ruled out over the 12 minutes that it takes to trip all of the bottles, we observed a 1-sigma standard deviation of 10%. One unexplained outlier (Tank H on Column 3) was significantly lower than the rest. If this outlier is removed, the 1-sigma standard deviation decreases to 1.6%.

Problems and Solutions

We had concerns about a vacuum accumulating in the niskin when the bottle is drained. This can happen if the o-ring is covering the air inlet.   The concern is for artificially degassing radon. Preliminary comparisons with submersible pump samples from the same depth reveal no significant trend that can be associated with degassing.

Extraction Board C began to produce values that were consistently lower than its neighbors. This led us to be concerned about whether 100% extraction was being achieved within 90 minutes.   Subsequent to station TU2, all extractions were extended to 120 minutes. The problem with Board C appears to be the pump head of the diaphragm pump. It may be clogged with charcoal or the check valve may not be closing properly.
We observed column 1 to degrade and produce low values. This was apparently the result of a failed glass wool plug which allowed the charcoal to be removed from the column under vacuum. It appears that this failure occurred at STA-A or CB-19.   When discovered, we removed column 1 from use. Disassembling Board C found evidence of charcoal in the extraction line. We cleaned the line, but found no plug or constriction that could explain the poor flow rate.   When we connect the pump from board D to board C, high flow rates are achieved.

General Issues

Concern about the bubblers degassing the surface layer was addressed by asking the watch to drift onto station so that CTD profiles and surface water samples could be collected before the surface layer was disturbed by bubbling and mixing. This seemed to be an effective approach.

Preliminary Data

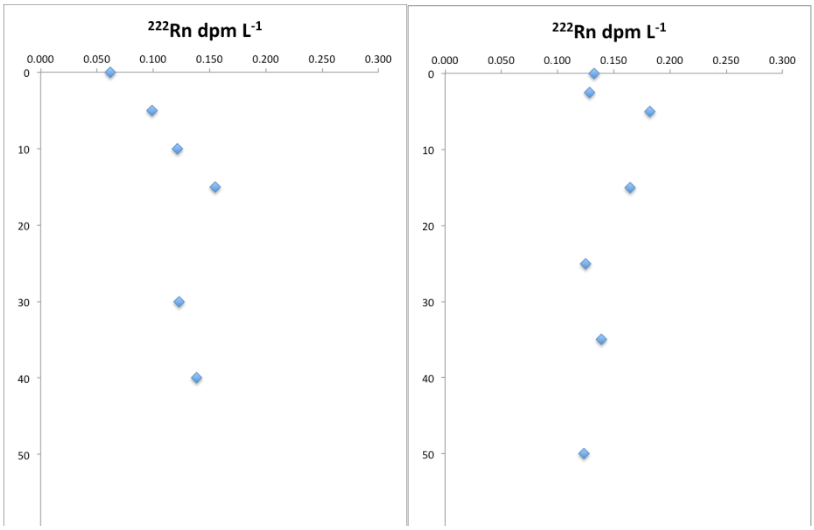


Figure 4. Profiles of radon-222 from station CB-27 (left side) and CB-11, right side. The ice cover at CB-27 in the marginal ice zone was less than 70%, according to the ice forecast. Ice cover at CB-11 was greater than 90%. The deficit in the surface layer at CB-27 likely reflects the greater amount of open water. At CB-11 a deficit also exists. Both stations will need to be corrected for sea ice melt, which will dilute the radon concentration and produce an "artificial" deficit.

5.8 Underway CTD Sampling

PI: Bill Williams (DFO-IOS)

Background

The Underway CTD (UCTD) is an XCTD replacement manufactured by Oceanscience (www.oceanscience.com). A winch with 500lb spectra line replaces the launcher and thin wire of the XCTD. The UCTD itself is a modified Seabird Fastcat that samples at 16Hz and descends at 4m/s. Up to 650m of the spectra line is wound onto the tail of the UCTD using the 'rewinder'. The UCTD is then dropped over the side of the ship and as it falls its load of spectra line unwinds. While the UCTD is falling, the ship is steaming along and the UCTD winch freely pays out the spectra line along the path of the ship. When the maximum depth of the UCTD is reached the winch is used to haul it back in. The UCTD has the advantage of being retrievable and higher accuracy than XCTDs.

Sampling

We require ice free water for UCTD sampling as the spectra UCTD line may break if it is dragged across ice. This year, the only fully open water we found in our sampling region was at the southern end of our 140W line. Two UCTD casts were planned there but only one cast completed. The rewinder broke before the second cast and so the UCTD was not deployed.

The successful UCTD cast was mid-way between MK6 and CB28b at 71 15.6N 140 00.1W on 30 August at 17:29 UTC.

Post-Cruise Analyses

UCTD data is post processed at the Institute of Ocean Sciences

5.9 Underway Measurements

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. *Please see separate report by Cory Beatty below for underway measurements of pCO2.*
- Hull temperature
- The Shipboard Computer System (SCS) was used to log
    a. From the Novatel GPS: all NMEA strings (GPRMC, GPGGA, and HEHDT) 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, driven by a geared motor. The pump rated flow rate is 10 GPM. It supplies seawater to the TSG lab (off of the main lab), where a manifold distributes the sweater to instruments and sampling locations. 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. On one of the manifold arms is a Kates mechanical flow rate controller followed by a vortex debubbler, installed inline to remove bubbles in the supply to the SBE-21 thermosalinograph (TSG) and the blue cooler containing the gas tension device and the oxygen sensing optode. Control of the pump from the lab is via a panel with on/off switch and a Honeywell controller. The Honeywell allows setting a target pressure, feedback parameters and limits on pump output.

Autonomous measurements were made using:

- ***SBE38: Inlet Temperature s/n 0319***

  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

  Temperature and Conductivity, chl-a Fluorescence (WET Labs WETStar fluorometer s/n WS3S-521P) and CDOM (WET Labs CDOM s/n WSCD-1281). The Fluorometer and

CDOM sensors were plumbed off of a separate, manifold output than that supplying the Temperature and Conductivity. GPS was provided to the SBE-21 data stream using the NMEA from PC option rather than the interface box. A 5 second sample rate was recorded.

- ***Blue Cooler:*** Total gas (Gas Tension Device) 40s sampling interval, Oxygen (Optode oxygen sensor) with 5 second sample rate. The GTD and oxygen sensor are sitting in a cooler of water from the seawater loop. Water that has passed through the debubbler runs through tubing through the GTD and out into the cooler. An overflow from the cooler runs into the sink. (Svein Vagle, DFO).
- ***SBE48: Hull Temperature s/n***
  This sensor was installed below waterline on the inside of the ship's hull. No thermo-coupling grease was used when mounted onto the hull's painted surface. Temperatures are an approximation of sea-surface temperatures.

Flow rate

The manifold readings were typically 13 PSI and 25% output. The flow rate to the gas cooler was roughly 35mL/sec. The flowrate to the fluorometers was quite high at 150mL/sec until 9 Aug when it as changed to roughly 10mL/sec based on information from the manual. On 20th Aug this was increased to 28 mL/sec to flow faster than the logging flowmeter's minimum sensitivity of 25mL/sec

New this year a flow meter was installed on the line running to the two fluorometers however there were issues in that the flow rate most suitable to the fluorometers was too slow for the meter to record.

Discreet Water Samples:

- Salinity and CDOM were collected to calibrate the underway sensors.

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 (2007 photo)

The data from these instruments 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 (inlet temperature) data from the engine room to the TSG instrument, to pass the SBE48 (hull temperature) data from the engine room to the computer and to pass the TSG and SBE48 data to the ship's data collection system (SCS).

SCS Data Collection System

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

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 and if setup also the soundspeed applied (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 and direction (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 contain the whole trip's data.

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 but averaged and recorded at 1 minute intervals.

Problems for 2013-04 with underway data

- There were several complete power shutdowns causing the IP addresses on many computers and the VLINX box (communication box in engine room for SBE38 and48 sensors) to change when the power came on again. All GPSgate software mapping needed to be changed to reassign the new IP addresses. Note: for the VLINX box, use ESP manager to find the new IP and modify GPSgate accordingly. Data was lost until the IP address issues were corrected.

- During the cruise the internal battery on NOAA server's raid card failed. The failure caused battery to deform, puffing up and pushing on the nearby electronic boards causing the server to crash. This battery failure caused the loss of raid information. Luckily enough the card is still usable but the raid information was lost. Raid information can be rebuilt from information saved on the disk. As of today, 2013 Aug 31, the server runs as long as the power is on. Otherwise a rebuild is needed. The very capable e-tech, Steve Miller, knows the process. There was a break in SCS data acquisition while the server was down.

- The optode sensor in the blue cooler failed during the prior leg (2013-03 C3O). GTD data files started being recorded 10th Aug and a new optode sensor installed August 14th. The optode was removed on a few occasions (recorded in the TSG log) when needed on the RBR Concerto CTD. Small bubbles tended to accumulate on the surface of the optode which were shaken off periodically.

- The recirculating pump in the blue cooler stopped working sometime between the 16th and 27th of August.

- Due to sea-ice conditions the seawater pump often turned off due to accumulation of snow/ice on the inlet strainers. The pump would automatically turn off as a safety to protect the machinery from burning out when the pressure at the pump was much higher than the pressure in TSG lab. At times the pump was manually turned off when accumulation was too frequent for the engine crew to clean the strainers. We typically were travelling through snow covered ice during the second half of the cruise (north and west in the Canada Basin) which seems particularly bad for clogging the strainers.

- On a two occasions brown water (with mud-like solids) was sucked into the seawater loop. The Chief Engineer believes this might have been a result of pipes nearby being cleaned and the outflow being pulled in the seawater loop. The blue cooler was emptied and refilled when the water was clear. See log sheet for details.

5.10 BGOS Field Operations

Rick Krishfield, Kris Newhall, Jim Ryder, Brian Hogue and Cory Beatty
P.I.s not in attendance: Andrey Proshutinsky, John Toole,(both WHOI) and Mary-Louise Timmermanns (Yale University)

As part of the Beaufort Gyre Observing System (BGOS; www.whoi.edu/ beaufortgyre), three bottom-tethered moorings deployed in 2012 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in August 2013 from the *CCGS Louis S. St. Laurent* during the JOIS 2013 Expedition. Furthermore, two similar moorings (labeled GAM-1 and GAM-2) which were deployed to the west of our array in 2012 as part of a collaboration with the National Institute of Polar Research (NIPR) and Tokyo University Marine Science and Technology Center (TUMSAT) in Japan were recovered this cruise. Four Ice-Tethered Profiler (ITP; www.whoi.edu/itp) buoys were deployed on ice floes, all in combination with other buoys from other organizations including an Arctic Ocean Flux Buoy (AOFB), Ice Mass Balance (IMBB) buoys, an atmospheric chemistry O-Buoy, an Ice-Tethered Micros (ITM), a wavebuoy and Uptempo buoys. Three Uptempo buoys were also deployed in open water.

Summary of BGOS 2013 field operations.

Mooring Designation	**Depth (m)**	**2012 Location**	**2013 Recovery**	**2013 Deployment**	**2013 Location**
BGOS-A	3824	75° 0.0066'N 150° 0.0347 'W	13-Aug 15:02 UTC	14-Aug 18:30 UTC	74° 59.6'N 149° 58.8'W
BGOS-B	3824	77° 59.9943'N 149° 59.9242'W	20-Aug 19:49 UTC	21-Aug 20:38 UTC	77° 59.4835'N 150° 3.4500'W
BGOS-D	3503	73° 59.6350'N 139° 58.8367'W	8-Aug 14:51 UTC	9-Aug 21:09 UTC	73° 59.78'N 139° 56.80'W
GAM-1	2103	75° 59.9965'N 160° 10.0083'W	30-Aug 18:15 UTC		
GAM-2	2222	77° 0.0166'N 170° 0.0132'W	18-Aug 14:24 UTC		
ITP71/MY Uptempo				22-Aug 23:29	77° 31.3'N 147° 52.2'W
ITP70/AOFB30/IMBB/O-Buoy/ITM3/Wavebuoy				25-Aug 01:15	76° 55.4'N 138° 50.9'W
ITP68/IMBB/MY Uptempo				26-Aug 20:23	75° 59.0’N 139° 43.1’W
ITP69/S-IMBB				27-Aug 17:48	75° 'N 140° '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. The top floats were positioned approximately 30 m below the surface to avoid ice ridges. 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. In addition, two moorings incorporate acoustic wave and current profilers (AWAC) provided by the University of Washington.

Ten years of data have been acquired by the 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.

Last year, in collaboration with NIPR and TUMSAT in Japan, two additional mooring systems (which are delineated GAM-1 and GAM-2) were installed west to augment the BGOS array. The configuration of these moorings is the same as the BGOS systems, except half as long as they were located in the shallower Chukchi/Northwind topography. These moorings were recovered this year, and data from their instruments retrieved. These moorings will be refurbished this winter in anticipation of redeployment next year.

Buoys:

The moorings only extend up to about 30 m from the ice surface in order to prevent collision with ice keels, so automated ice-tethered buoys are used to sample the upper ocean. On this cruise, we deployed 4 Ice-Tethered Profiler buoys (or ITPs), and assisted with the deployments of a Naval Postgraduate School AOFB, two US Army CRREL and one Environment Canada IMBBs, one O-Buoys, one ITMs, one British Antarctic Survey wave buoy, and four Uptempo temperature profiling buoys. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).   IBOs consisting of 6, 4, 2, and 2 buoy systems were deployed this cruise, and 2 of the Uptempo buoys were deployed in open water.

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. Two of the ITPs deployed this year also incorporated a MAVS acoustic velocity probe and integrated a SeaBird microcat on the mooring line. The other two ITPs included a biosuite sensor package consisting of DO, PAR, CDOM, flourometry, and turbidity sensors, and integrated SAMI CO2 and SAMI pH instruments on the mooring line. 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.

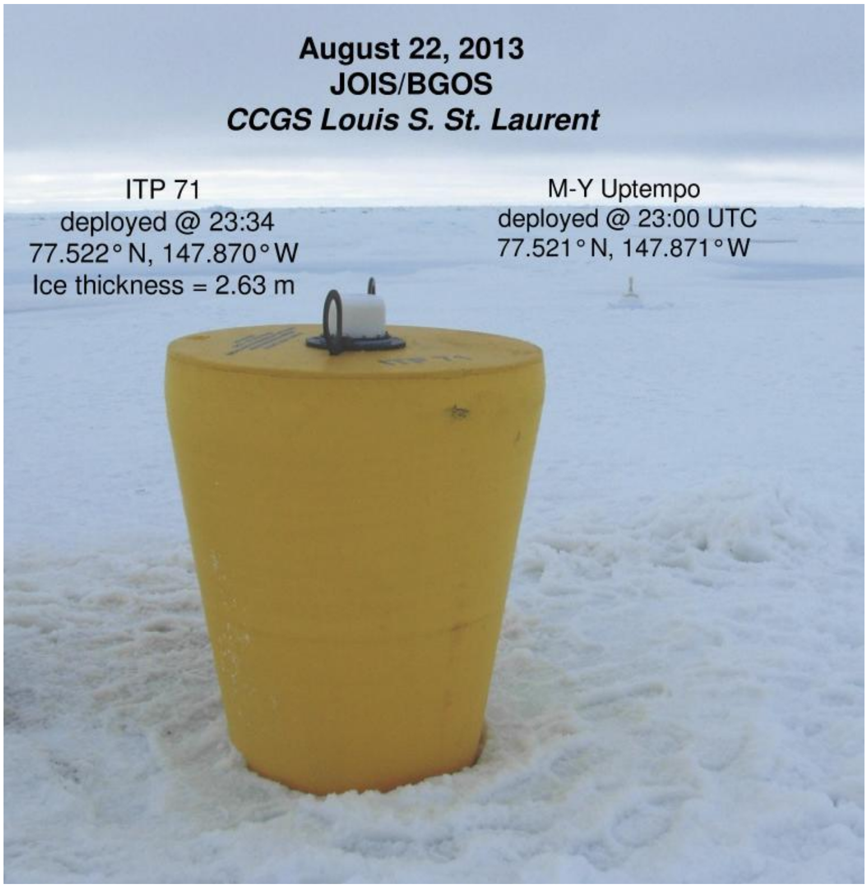
In coordination with the Captain acoustic release commands were sent to the release instruments just above anchor, which let go of the anchor, so that the floatation on the mooring could bring the systems to the surface. Then the floatation, wire rope, and instruments were hauled back on board. Data was dumped from the scientific instruments, batteries, sensors, and other hardware are replaced as necessary, and then the systems were subsequently redeployed for another year. The moorings were redeployed anchor first, which required the use of a dual capstan winch system to safely handle the heavy loads. Typically it took between 4-6 hours to recover or deploy the 3800 m long systems.

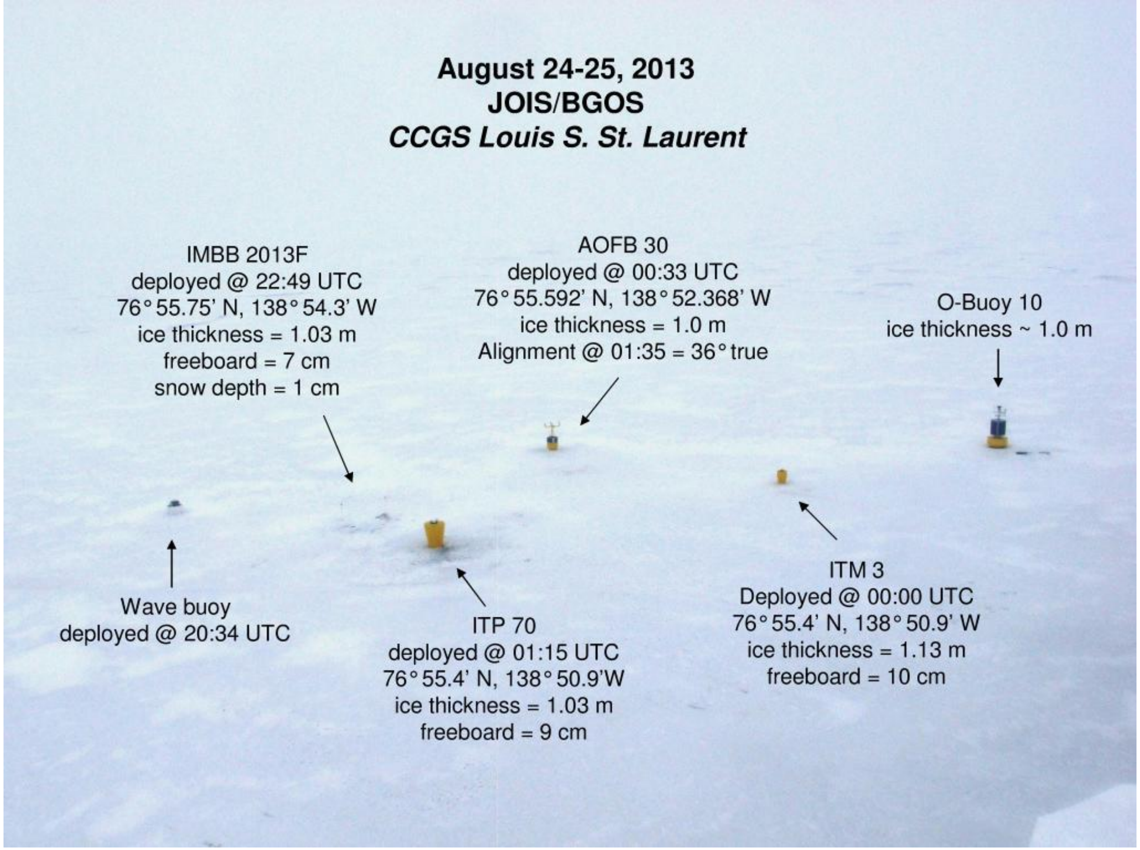
Complete year long data sets with good data were recovered from all ULSs, all ADCPs, the AWACS and every BPR. In addition two sediment traps collected samples for the duration of the deployment, while one stopped early. The MMPs had mixed results, with full year-long data recovered from some profilers, but incomplete results from other profilers.

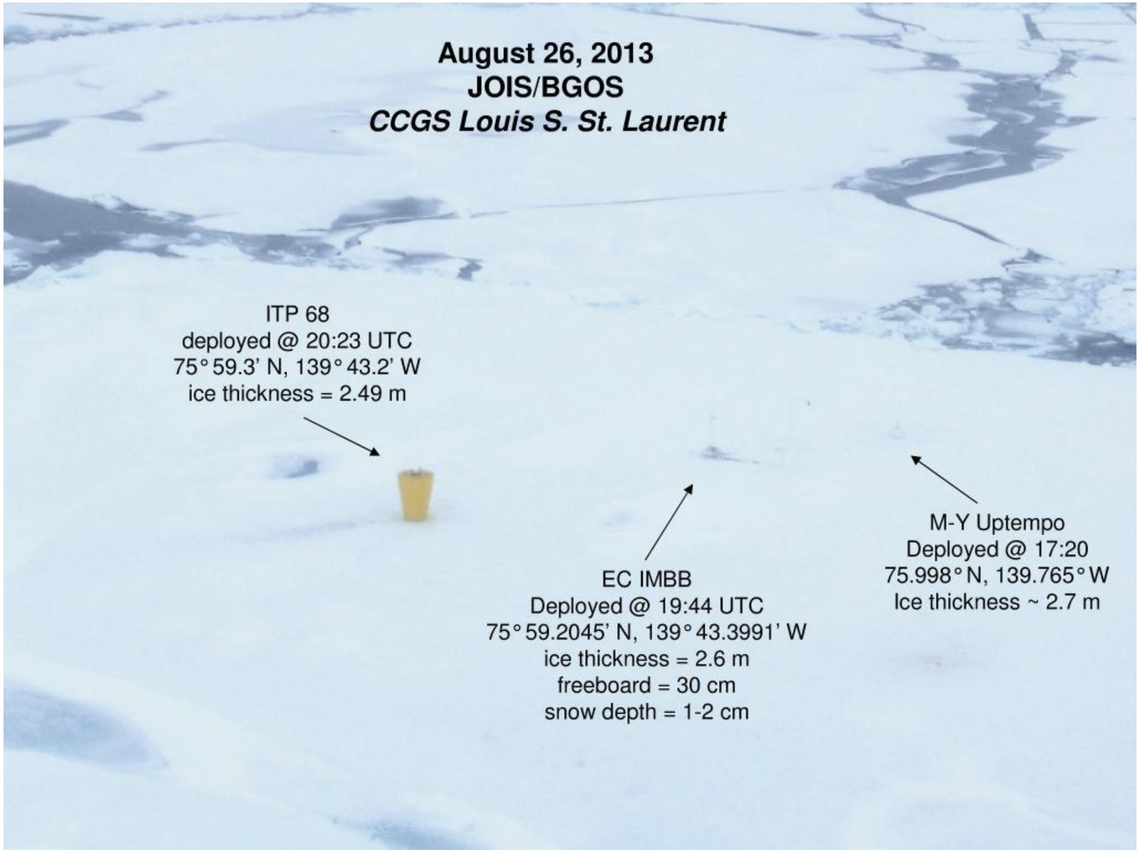
ITP deployment operations on the ice were conducted with the aid of helicopter transport to and from each site according to procedures described in a WHOI Technical Report 2007-05 (Newhall et al., 2007). Not including the time to reconnaissance, drill and select the ice floes, these deployment operations took between 3-7 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 during two largest ice stations while the IBO deployment operations took place. One O-buoy was also recovered this cruise.

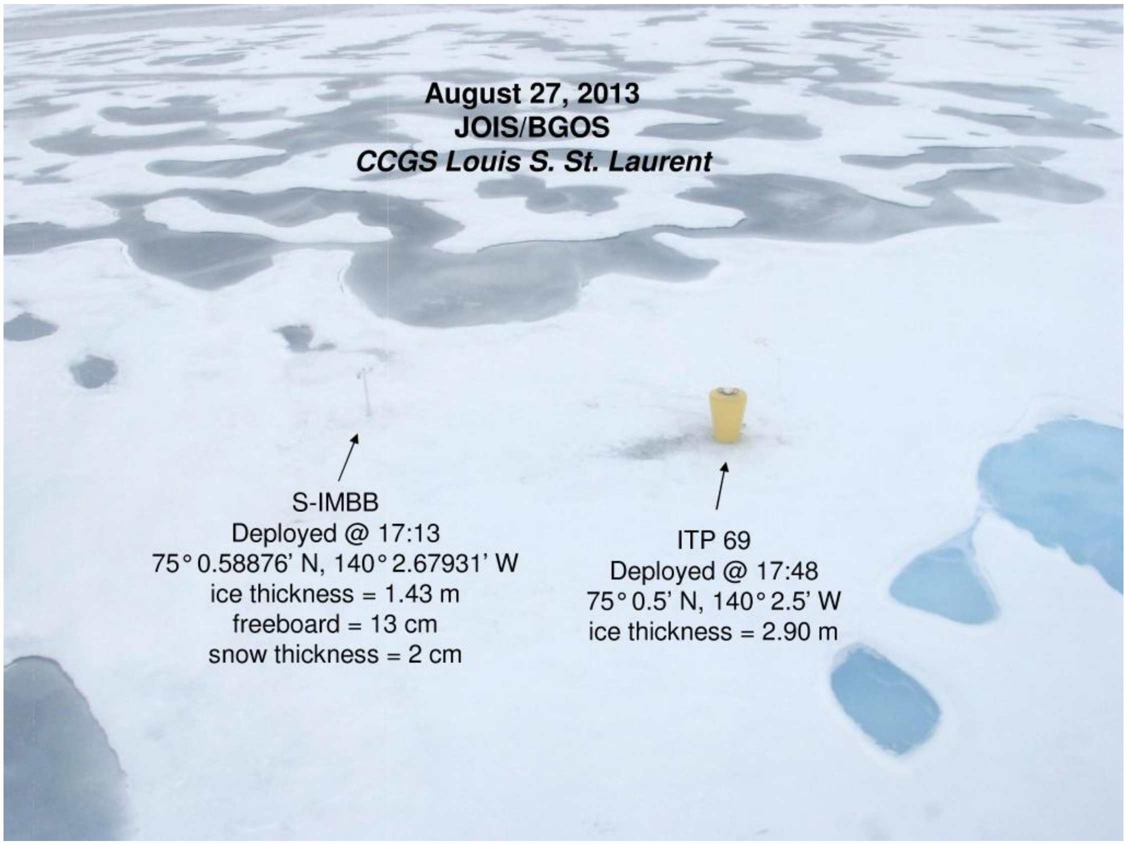
Other:

Dispatches documenting all aspects of the expedition were posted in near real time on the WHOI website at: www.whoi.edu/beaufortgyre/2013-dispatches.


August 22, 2013
JOIS/BGOS
CCGS Louis S. St. Laurent
ITP 71
deployed @ 23:34
77.522° N, 147.870° W
Ice thickness = 2.63 m
M-Y Uptempo
deployed @ 23:00 UTC
77.521° N, 147.871° W
ITP 71


August 24-25, 2013
JOIS/BGOS
CCGS Louis S. St. Laurent
IMBB 2013F
deployed @ 22:49 UTC
76° 55.75' N, 138° 54.3' W
ice thickness = 1.03 m
freeboard = 7 cm
snow depth = 1 cm
AOFB 30
deployed @ 00:33 UTC
76° 55.592' N, 138° 52.368' W
ice thickness = 1.0 m
Alignment @ 01:35 = 36° true
O-Buoy 10
ice thickness ~ 1.0 m
Wave buoy
deployed @ 20:34 UTC
ITP 70
deployed @ 01:15 UTC
76° 55.4' N, 138° 50.9'W
ice thickness = 1.03 m
freeboard = 9 cm
ITM 3
Deployed @ 00:00 UTC
76° 55.4' N, 138° 50.9' W
ice thickness = 1.13 m
freeboard = 10 cm


August 26, 2013
JOIS/BGOS
CCGS Louis S. St. Laurent
ITP 68
deployed @ 20:23 UTC
75° 59.3' N, 139° 43.2' W
ice thickness = 2.49 m
M-Y Uptempo
Deployed @ 17:20
75.998° N, 139.765° W
Ice thickness ~ 2.7 m
EC IMBB
Deployed @ 19:44 UTC
75° 59.2045' N, 139° 43.3991' W
ice thickness = 2.6 m
freeboard = 30 cm
snow depth = 1-2 cm



5.11 Arctic Ocean Sea Surface pCO_2 and pH Observing Network

Cory Beatty
P.I. Mike DeGrandpre (University of Montana)

U.S. National Science Foundation Project: Collaborative Research: An Arctic Ocean Sea Surface pCO_2 and pH Observing Network

Overview: This project is a collaboration between the University of Montana and Woods Hole Oceanographic Institution (Rick Krishfield and John Toole). The primary objective is to provide the Arctic research community with high temporal resolution time-series of sea surface partial pressure of CO_2 (pCO_2) and pH. The pCO_2 and pH sensors will be deployed on the WHOI ice-tethered profilers, or ITPs. Placed on the ITP cable just under the ice, the sensors will send their data via satellite using the WHOI ITP interface.

Cruise Objectives: Our objectives during the JOIS 2013 cruise were as follows:

1. deploy 2 pCO_2 and 2 pH sensor systems on WHOI bio-optical ITPs.

2. conduct underway pCO_2 measurements to provide data quality assurance for the ITP-based sensors and to map the spatial distribution of pCO_2 in the Beaufort Sea and surrounding margins.
3. deploy 1 SAMI pH on BGOS-A mooring and 1 SAMI-pH on BGOS-B mooring.
4. assist with other shipboard research activities and to interact with ocean scientists from other institutions.

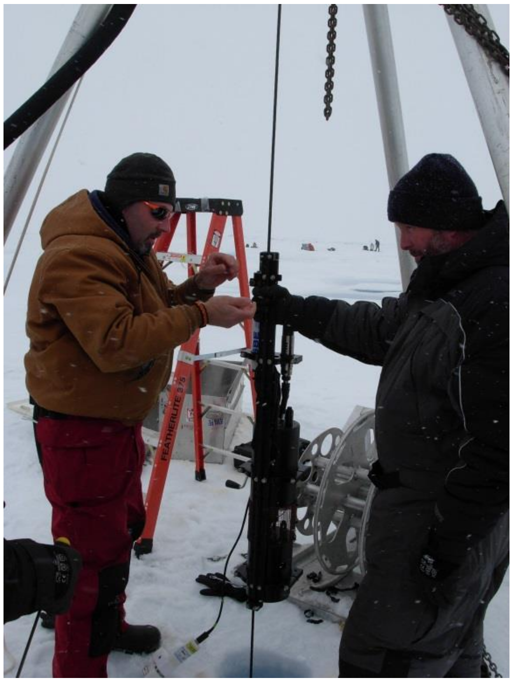


Figure 5. Figure 1: SAMI-CO2 being deployed on ITP 68 during the third ice station. A conductivity and dissolved oxygen sensor are also part of the system.

Cruise Accomplishments: We deployed a SAMI-CO_2 - SAMI-pH sensor pair on 2 separate ITPs, one pCO2-pH pair at the third ice station and the other pair at the fourth ice station. We collected underway pCO_2 data using an infrared equilibrator-based system (SUPER, Sunburst Sensors). The instrument was connected to the Louis seawater line located in the main lab. We also deployed a SAMI pH on both BGOS-A and BGOS-B moorings. The sensor data collection is summarized in the table below.

Table 1: Instruments utilized or deployed by the University of Montana during the JOIS 2013 cruise

Measurement system	**Instrument IDs**	**Location**	**Duration**
underway infrared-equilibrator pCO_2	SUPER (Sunburst Sensors)	entire cruise track (see IOS report in this document)	8/2/13 – 8/31/13
ITP SAMI-CO_2 including dissolved O_2, salinity and temperature & ITP SAMI-pH including PAR	WHOI ITP #68, SAMI-CO2 C57 SAMI-pH P0077	Third ice station, CO2 ~6.5 m depth pH ~5m depth (see WHOI cruise report in this document)	8/26/13 - present
ITP SAMI-CO_2 including dissolved O_2, salinity and temperature & ITP SAMI-pH including PAR	WHOI ITP #69, SAMI-CO2 C58 SAMI-pH P78	Fourth ice station CO2 ~6.5 m depth, pH ~5 m depth (see WHOI cruise report in this document)	8/27/13 – present

SAMI-pH	P66	BGOS-A mooring	8/14/13 – present
SAMI-pH	P5	BGOS-B mooring	8/21/13 - present

5.12 UpTempo program

PI: Mike Steele (UW)

Five buoys were deployed by the WHOI team during JOIS.as part of the UpTempo Program. Three were manufactured by Marlin-Yug configured to measure ocean temperature at nominal depths (m): 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 30, 35, 40, 45, 50, 55, 60 and ocean pressure at depth: 60m. The other two were Pacific Gyre buoys measuring ocean temperature at nominal depths (m): 0, 2.5, 5, 7.5, 10, 15, 20, 25, 30, 35, 40, 50, 60 and ocean pressure at depths: 20, 40, 60m.

"UpTempO buoys are designed to measure ocean temperature in the euphotic (light-influenced) surface layer of the Polar Oceans. These relatively inexpensive ocean buoys are designed to be easily deployed in open water or sea ice – covered conditions. As sea ice thins and retreats more and more each summer, the magnitude of ocean surface warming is accelerating. Our main goal is to measure this warming."

Text from: http://psc.apl.washington.edu/UpTempO/UpTempO.php

Buoy Type	**Manufact.**	**Deployment Date and Time (UTC)**	**Deployment Latitude (N)**	**Deployment Longitude (W)**	**Notes**
2013-05 Iridium ID # IMEI: 300234060456740 Ocean temperature and pressure from 0 to 60m.	Pacific Gyre	8/12/2013	74.01	150.08	Open water deployment near station CB3 (CTD Cast 22)
2013-07 Iridium ID # IMEI: 300234011242970 Ocean temperature and pressure from 0 to 60m.	Marlin-Yug	8/17/2013	75.98	160.06	Open water deployment near station TU-1 (CTD Cast 30)
2013-08 Iridium ID # (IMEI 300234060451580 Ocean temperature and pressure from 0 to 60m.	Pacific Gyre	8/18/2013	77.01	170.02	Open water deployment near station TU-2 (CTD Cast 31)
2013-09 Iridium ID # (IMEI 300234011242840 Ocean temperature and pressure from 0 to 60m.	Marlin-Yug	8/22/2013	77.52	147.84	Deployed at ice station with ITP71 (near station CB12 CTD Cast 37)
2013-10	Marlin-Yug	8/26/2013	76.00	139.75	Deployed

Iridium ID # (IMEI 300234011241960 Ocean temperature and pressure from 0 to 60m.					at ice station with ITP68 (near station CB17 CTD Cast 43)

5.13 O-Buoy Operations

Peter Peterson (pkpeterson@alaska.edu), University of Alaska Fairbanks
PI: Patricia Matrai(pmatrai@bigelow.org), Bigelow Laboratory for Ocean Sciences

Background:
Polar sunrise in the Arctic has been associated with production of reactive halogens from sea salt(e.g. Br, BrO). These halogen species have been shown to influence the Arctic environment by causing boundary layer ozone depletion events, mercury deposition events, and changing the overall oxidative chemistry of the Arctic boundary layer. The O-Buoy project aims to elucidate temporal and spatial characteristics of this chemistry by deploying O-Buoys in a variety of remote Arctic locations. The O-buoy measures CO_2 , ozone, halogen oxides, and meteorological data as part of the Arctic Observing Network. These data will enhance our understanding of the mechanisms behind halogen activation, allowing us to better understand how chemical processes taking place in the Arctic boundary layer will change as a result of declining perennial sea ice.

Operations:
OB8 was recovered on August 7th. OB8 was observed in open water. A recovery sling and line were attached to the buoy by two personnel in a manbasket and the buoy was winched up onto the foredeck. The recovered instrument provides insight into the durability of the system and ways in which the buoy can be improved.

OB10 was deployed on August 25th (UTC) at an ice station as part of an Ice Based Observatory located at 76 55' 20" N 138 50'13" W. . The buoy had made its first transmission home and other members of the O-buoy team looked at the data set and verified a successful deployment with all instruments functioning normally.

5.14 Ice Observations OSU

Judy Twedt (UW)
PI: Jennifer Hutchings (Oregon State University)

This year’s program consisted of multiple activities: Hourly ice observations from the bridge, on-ice sampling, buoy deployment, web camera ocean surface captures, collaborations with other sea ice researchers and albedo studies with the installation of a bow-mounted radiometer.

Photo 1. A view of the ice from JOIS 2013.

Ice observers Judy Twedt (UW), Yasuhiro Tanaka (KIT) and Genki Sagawa (Weathernews) recorded observations from the bridge into the software ASSIST(Arctic Ship borne Sea Ice Standardization Tool), which is a product of UAF's IARC sea ice group and GINA software programming department. Content and design was created based on collaborative input of the members of the international sea ice community and the project is sponsored by CliC(WCRP's Climate and Cryosphere Group).

As in previous years, the ice observations recorded during the Louis S. St. Laurent 2013 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 seven 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 the ASSIST program.

The cruise occurred 1 August – 2 September 2013, a time period which falls well before the average date of the melt season apex of mid-September. Since the first year of the IARC team's participation in 2006, the JOIS cruise has been scheduled at various times throughout the summer season. Attention should be given when comparing the 2013 data to the results from the years 2006-2008 and 2011(JOIS), which witnessed the early summer melt, or the later years with data from 2009 and 2010, 2011(UNCLOS) where we experienced the onset of freeze-up of the sea ice for the entirety of the cruise track because 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, an observer was 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 into the observation software. 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. The ice specialist Jean-Yves Rancourt was particularly helpful in discussing ice and metrological conditions when there was uncertainty.

A combination of the WMO, Canadian Ice Service and Standard Russian sea ice codes and the ASPECT (Worby & Alison 1999) observation program were used to describe ice conditions. During each observation period we estimated the total ice coverage within 1nm 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.

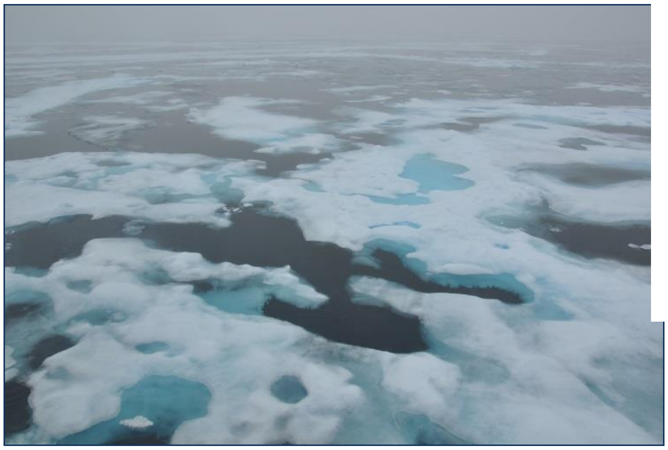


Photo 2. View during an observation made from as the ship enters an area of heavily melted multi-year ice.

Comments on Bridge Observations
Ideally, the program aims to take hourly observations throughout the 24-hour cycle each. When on station, observations are suspended. Access to monkey island was requested from the officer on watch and the RADAR system was temporarily deactivated for safety reasons when people went atop. Additionally, a small workspace was provided in the chart room.

While most daylight hours in transit of sea ice were recorded, some hours of observations were lost during xctd casts or the period of ice visits which dictated that all potential observers be available for the long hours on the ice station. Given the consistent ice coverage and composition during the day hours of transit, we can assume the ice to have been similar while underway during the dark hours.

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 periodic 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. 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 center 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 overturning 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 from Stardot Technologies.

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. This year the cameras were easily accessed via the new wireless system. 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.

The cameras can be accessed via the ship's wireless connection with addresses 10.1.20.31 (cam 1) and 10.1.20.33 (cam 2). 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. Additional documents on the set up and configuration of the netcams are available on the NOAA server: LSLNOAA/ScienceNet/2013-04-JOIS/Setup Documents/ICE CAMERA SET-UP folder.

Due to the exposure of the cameras, 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 at the front and back which unfortunately allows drifting snow and moisture to condense within the housing and occasionally affect image capture and electronic connections. In the past these openings were filled with packing foam or paper towels and sealed with duct tape. In 2013, we insulated the backside opening with bubble wrap, and left the front side open.

Bow-mounted Radiometer

The radiation balance of solar and far infrared was observed using a net radiometer (CNR1). This data will be used to help interpret satellite images of sea ice which have the advantage of providing extensive area but lack ground truthing. Information on the installation of the custom-designed boom and radiometer are available on the NOAA server at LSLNOAA/ScienceNet/2013-04-JOIS/Setup Documents.

On-ice Measurements

Photo 3. Flags mark the transect lines used for thickness and albedo surveys.

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.

It was agreed to have an ice sampler fly out on the floe immediately after the WHOI team was deployed. Sarah Zimmerman did this at the first IBO; Judy Twedt at the second. This provided the opportunity to discuss real estate issues with Rick Krishfield and take time to layout what were meant to be “clean” lines in the interest of the sensitive EM-31 and albedo instruments. Once the remaining ice group members joined the floe, there was a specific order to how the ice group conducted each activity. First, the EM-31 was deployed to get thickness estimates of the ice along the transect lines. Then the FieldSpec3 followed to capture undisturbed albedo of the surface along the lines. When given the points of interest (thickest, thinnest, or curious ice areas) the coring team would begin on the selected sites. As one side of the transect line is reserved for foot traffic, the drilling team proceeded while the albedo measurements were still underway on the other side. Drill holes are made at 10-meter increments at depths up to 8 meters along the line to help validate the EM. 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 4. 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 and conductivity are determined by typically using a YSI handheld salinometer. Density is calculated from these parameters.

Comments on Ice Visits

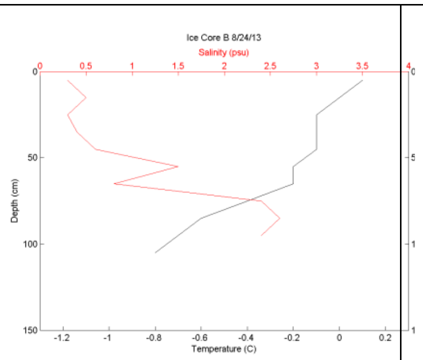
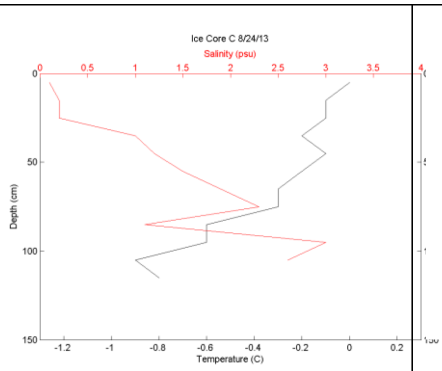
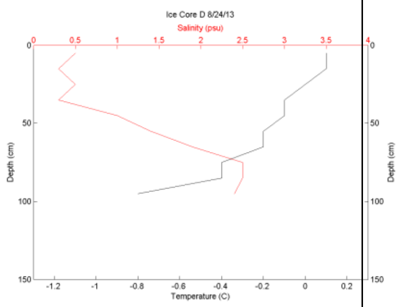
Generally, the plan for a station is decided more than one day in advance, allowing for complete preparation of gear, supplies and volunteers. However, it is not uncommon for an ice visit invitation to occur in a shorter time frame, thus emphasizing the need to always have the gear clean and packed for 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.

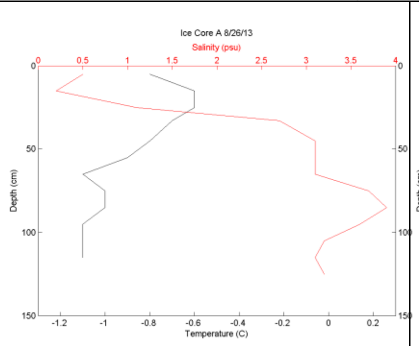
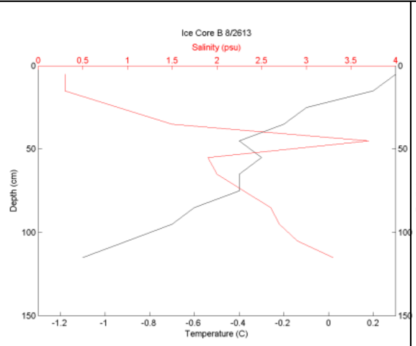
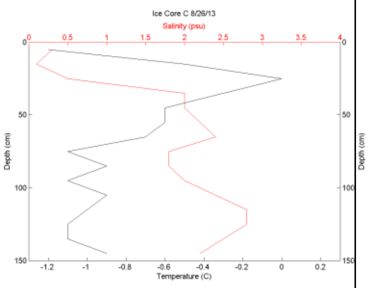
This year’s ice sampling was organized by Judy Twedt. Approximately one week prior to arriving on the ice station, ice sampling gear was tested for functionality. The Honda generator and Subaru power head both received oil changes and maintenance, pins for the ice corer and auger were lubricated, and sampling equipment was sorted and organized into bins according to usage. A helicopter packing list and inventory was provided to the science members who volunteered to assist with ice sampling.

At the first IBO Judy remained in the hangar assisting with gear loads until all of the other volunteers and cargo had been transported onto the ice, then Judy departed with Colin, Linda, and Karina for buoy deployment. Sarah Zimmerman was the first ice sampler to arrive on the ice and designate transect lines, walking paths, etc... She and Kristina Brown collected ice cores. Genke, Sigrid, and Adam collected ice thickness measurements with the EM sensor and 2” auger. Yasu and Ogi made albedo and snow measurements.

At the second IBO Judy arrived first on the ice to designate transect lines and traffic patterns. Sarah, Kristina, and Judy collected core samples. Genki, Sarah-Ann, and Deo made thickness measurements. Ogi and Yasu performed a snow, albedo, and melt pond study.

At both sites, three types of cores were collected. The first was for temperature, salinity, and density. Once these cores came out of the ice, they were immediately measured for temperature every ten centimeters, then sliced into 10cm segments and stored in coolers. The other two types of cores were for Iron and DNA analysis, and were left as undisturbed as possible. They were minimally cut, as necessary to fit into the coolers.

IBO I Core Sample Salinity and Temperature Profiles		
		
Freeboard: 11cm Snow depth: 4cm	Freeboard: 10cm Snow depth: 3.7cm	Freeboard: 8cm Snow depth: 5cm

IBO II Core Sample Salinity and Temperature Profiles		
		
Freeboard: 4cm Snow depth: 2cm	Freeboard: 3.1cm Snow depth: 2.3cm	Freeboard: 6.5cm Snow depth: 2cm

GPS Buoy Deployment

In the morning of August 16 the GPS buoys were prepared for deployment by inserting the vacuum port screw into the side of the container, plugging in the battery, and resealing the case. Confirmation of their location was confirmed by Dr. Jenny Hutchings the following day.

The buoys were deployed August 24 with Colin Lavalee (CCG pilot), Linda White (IOS), and Karina Mora (CCG seaman). Anchors were attached to buoys by drilling two holes through the ice with the 2" ice auger on either side of the buoy, just below the handles. A scrap metal bar, obtained from the ships engineers, with a rope tied to one end served as an anchor. The ~15cm metal bar was lowered down through the ice and caught by the underside of the ice, in a T formation and the loose end was tied to the handle of the buoy. The time required to set up on the ice, drill two holes, anchor the buoy, and reload the equipment into the helicopter was approximately 25 minutes.

Waypoints had been calculated in the morning several hours prior to departure, once the coordinates of the floe had been confirmed. By the time we departed in the afternoon, the floe had drifted considerably, and the waypoints were no longer 10 miles from the floe and we had to recalculate in the helicopter. In the future, it's important to make the calculations shortly before departing, to minimize drift error.

The northern, western, and eastern buoys were deployed approximately 10 nm from the IBO. The southernmost buoy was deployed approximately 7nm south of the IBO, as freezing rain prevented us from traveling further.

Buoy ID	Location	Latitude (N)	Longitude (W)	thickness (m)
278130	North	77° 04'950	139° 00'230	1.5
274150	East	76° 56'589	139° 12' 418	2.5
598180	West	76° 59'493	139° 37'756	1.5
279150	South	76° 48'758	138° 58'509	2.5

Four GPS buoys were deployed in a 10nm x 10nm array surrounding the 1st IBO. UW graduate student Judy Twedt was assisted by Linda White, Karina Mora, and Colin Lavalee during the deployment of the buoys. The operation was completed in 2 hours.

Photo 5. Linda White and Judy Twedt prepare an anchor for the GPS buoy

Synopsis of Ice Types along Cruise Track

We first encountered ice on 5 August, near 71N 139W – about 8/10 concentration and a mixture of multi-year and first year ice, between 1 and 1.5 meters thick. The floes were small to medium, easily navigable, and heavily melted. On 7 August we reached mooring BGOS-D, where the ice was 1-2 meters thick, still a mixture of first year and multi-year ice, and the open water was beginning to freeze up in thin patches of sheet ice. This was near 73N 136W. Near 72N 150W, the ice concentration was reduced to less than 4/10 of small, heavily melted multi-year cake ice.

On 13 August, near 75N 149 W we encountered a patch of ~2 m thick multi-year ice with some thin first year and nilas in the breaks between the old ice. As we headed further west, the ice concentration increased, but the ice was heavily covered in thaw holes.

The first vast floe we encountered was on 18 August, near 75N 157W. The floe was quite thin—mostly melted first year ice less than 50 cm, with some multi-year ice and sheet ice. Further north, near 78N, 158W, we encountered solid, snow-covered ice pack, with nilas growing in between the openings and leads in the ice pack. Melt ponds were largely absent in this ice, but again replaced with frozen thaw holes.

We encountered the strongest ice pack on the return trip – from74N 135E to 73N 138W. This ice was more consolidated than the other flows, predominantly 1.5-2.5 m thick first year ice with few melt ponds but snow-covered, frozen thaw holes.

Photo 6. Example of thick first year and multi-year ice.

Ice Program Data Locations

Ice watch observations: www.icewatch.gina.alaska.edu, csv files at:

LSLNOAA/ScienceNEt/ASSIST_observations
Ice Camera photos: LSLNOAA/IceCamera/2013CamX
Radiometer & Ice station data: LSLNOAA/ScienceNet/2013-04-JOIS/Data/Icedata
Instrument set-up: LSLNOAA/ScienceNet/2013-04-JOIS/Setup documents

5.15 Ice Observations KIT and WNI

PI at sea: Yasuhiro Tanaka (KIT), Genki Sagawa, (Weathernews, Japan)
PI on shore: Kazutaka Tateyama (KIT)

Measurements:

- Underway Ice thickness observations
  Underway measurements of ice thickness from an electromagnetic induction sensor, Passive microwave Radiometers (PMR), Net radiometer, and fixed forward-looking cameras.
- Ice station measurements
  Spectrum albedo survey, EM Survey, and Snow Pit Survey.

Underway measurements
Yasuhiro Tanaka (KIT)
Genki Sagawa (WNI)

Underway measurements of ice thickness were made using, an Electromagnetic induction (EM) sensor, Passive Microwave Radiometers (PMR), the forward and upward looking cameras. The radiation balance of solar and far infrared was observed using a net radiometer (CNR-4, with Ventilation Unit) corroborated with Judy Twedt, UW. 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 with a new FRP water proof case 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. But we couldn't measure ice thickness by EM sensor because electronic board inside EM was broken on 7 August.

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

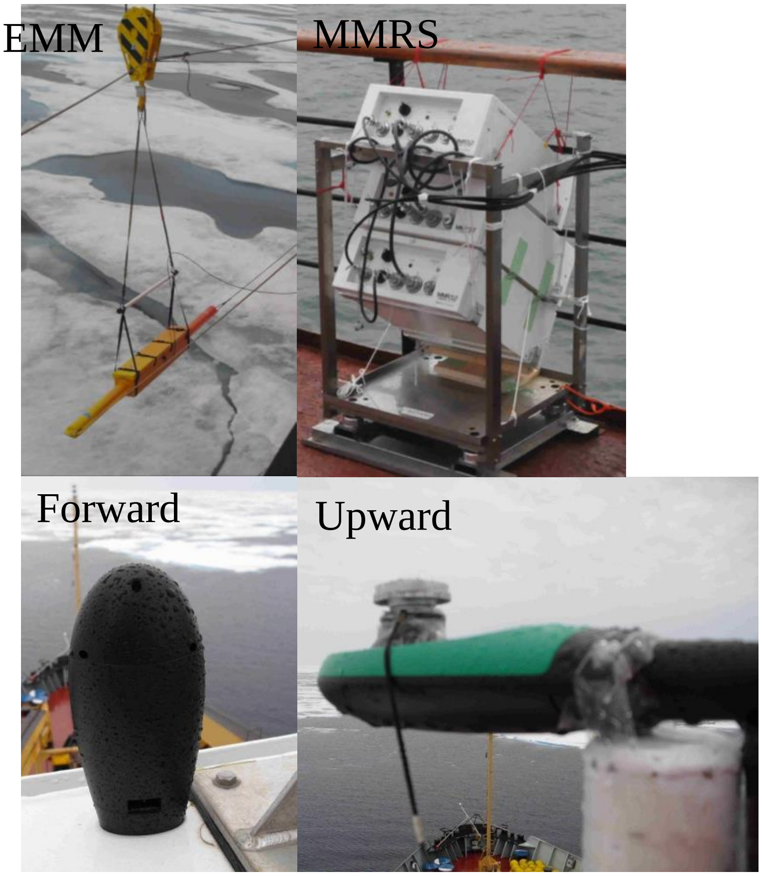


Figure 2. Pictures of EM, PMR, forward and upward-looking cameras.

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/AMSR2. All data are collected every 1 second continuously except during CTD and ice stations.

EM ice thickness observation started at 6 -7 August. 2 ice thickness profiles are observed as shown in figure 4 and summarized in table 1. The total distance of 1 profiles are 291 km.

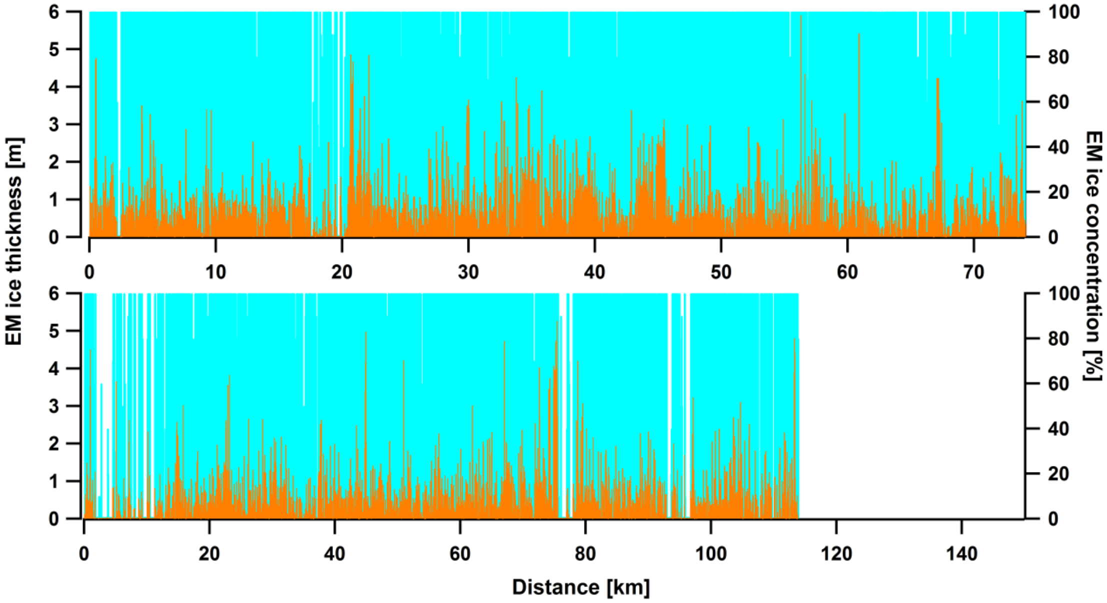


Figure 4 Profiles of EM observations.

Table 1. EM observation log.

Profile Number	Start Time(UTC)	Start Position	End Time(UTC)	End Position	Length of profile [km]
1	2012/8/6 1:57:54	71.766427 N 131.864884W	2012/8/6 19:54:15	72.757201N 135.50539W	175.13
2	2012/8/6 21:26:05	72.878974 N 135.863154W	2012/8/7 11:02:41	73.494108N 137.4497W	115.13

PMR observation started at 6-30 August (except for ship stop period). A looking-forward (for sea ice and melt pond condition observation) and –upward (for cloud condition observation) digital camera on the upper bridge recorded sea ice concentration and melt pond every 5 minutes during 6 – 17August. These images will be used for calculation of concentrations of open water, melt pond, and ice.

CNR-4 on the bow recorded every 10 seconds during 6 -30 August. This data will be used for assuming ice albedo feedback.

On-Ice Measurements

Ice Thickness Survey

Yasuhiro Tanaka (KIT)
Genki Sagawa (WNI)

Ice station measurements

Drill-hole and EM Survey

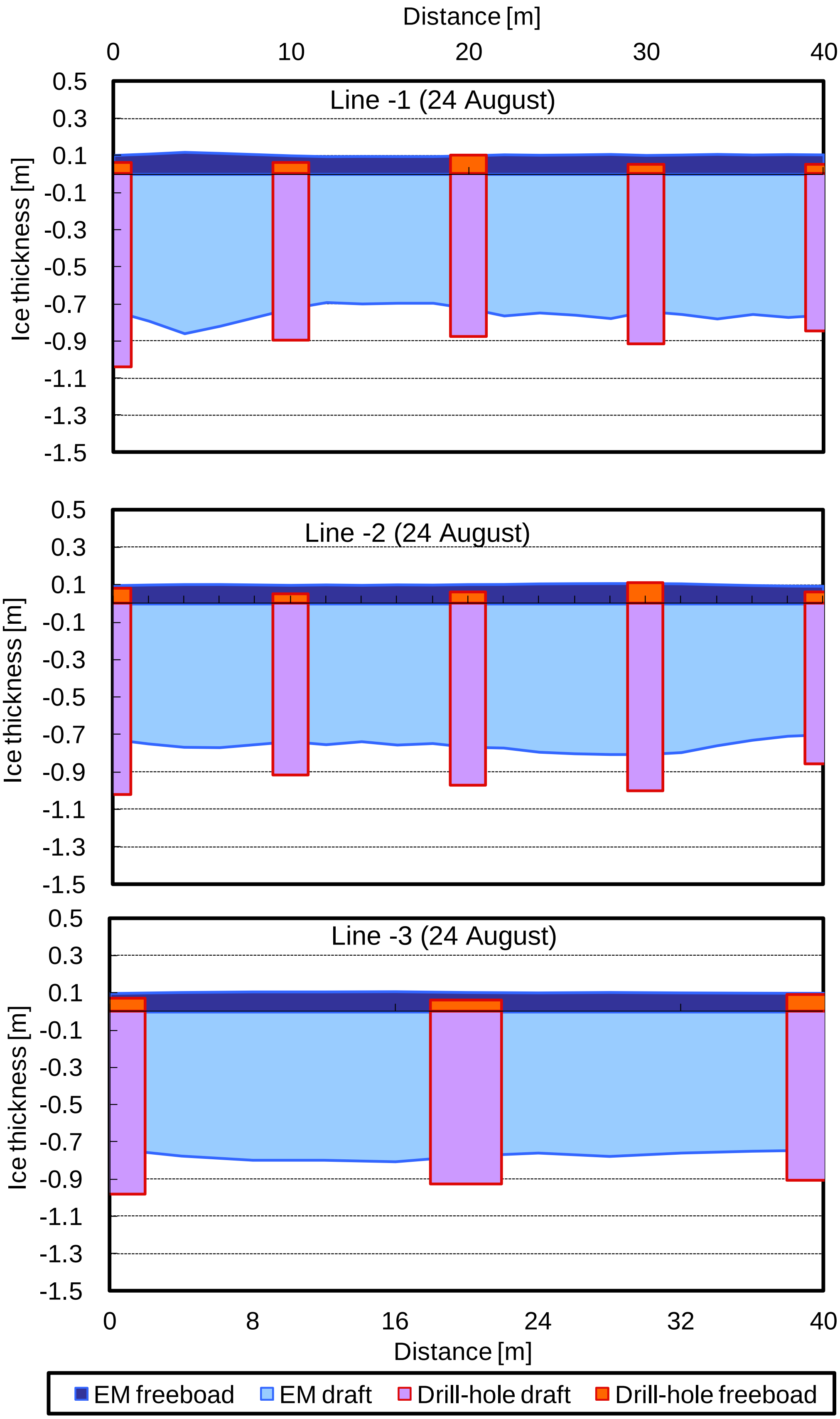
An electromagnetic induction device (EM) is capable of measuring a total thickness of snow and sea-ice. The output signal of EM; i.e. the apparent conductivity (in mS/m) can be converted to the distance (in m) between the instrument and the sea-ice bottom, i.e., the seawater-sea-ice interface with an 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 (every 4m only line-3, 24 August) 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 2 in Fig. 1, respectively. Each transect line is variable in thickness, but comparison indicates a rather good agreement between EM and drill-hole thicknesses even though frozen ponds or melt ponds are included on the transect line.

Spectral albedo of ice and snow cover was measured by ASD FieldSpecPro on the 1nd and 2nd ice station. Spectral albedo measurements carried out 350nm - 2500nm wavelength region at near transect lines and measured 10 times at each other point. Total spectral albedo measurements is 30 points (300 data).

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

Ice Station	Latitude Longitude	Transect Line	Length of profile [m]	Snow depth [m]		Ice thickness [m]	
				Mean	s.d.	Mean	s.d.
St.1	76.937722N 138.64589W	Line-1	40	0.03	0.01	0.82	0.05
		Line-2	40	0.04	0.01	0.82	0.03
		Line-3	40	0.04	0.01	0.83	0.00
St.2	75.986111N 139.719444W	Line-1	60	0.02	0.01	0.94	0.17
		Line-2	60	0.03	0.01	0.89	0.09


Distance [m]
0
10
20
30
40
Line -1 (24 August)
Ice thickness [m]
0.5
0.3
0.1
-0.1
-0.3
-0.5
-0.7
-0.9
-1.1
-1.3
-1.5
Line -2 (24 August)
Line -3 (24 August)
0
8
16
24
32
40
Distance [m]
EM freeboad
EM draft
Drill-hole draft
Drill-hole freeboad

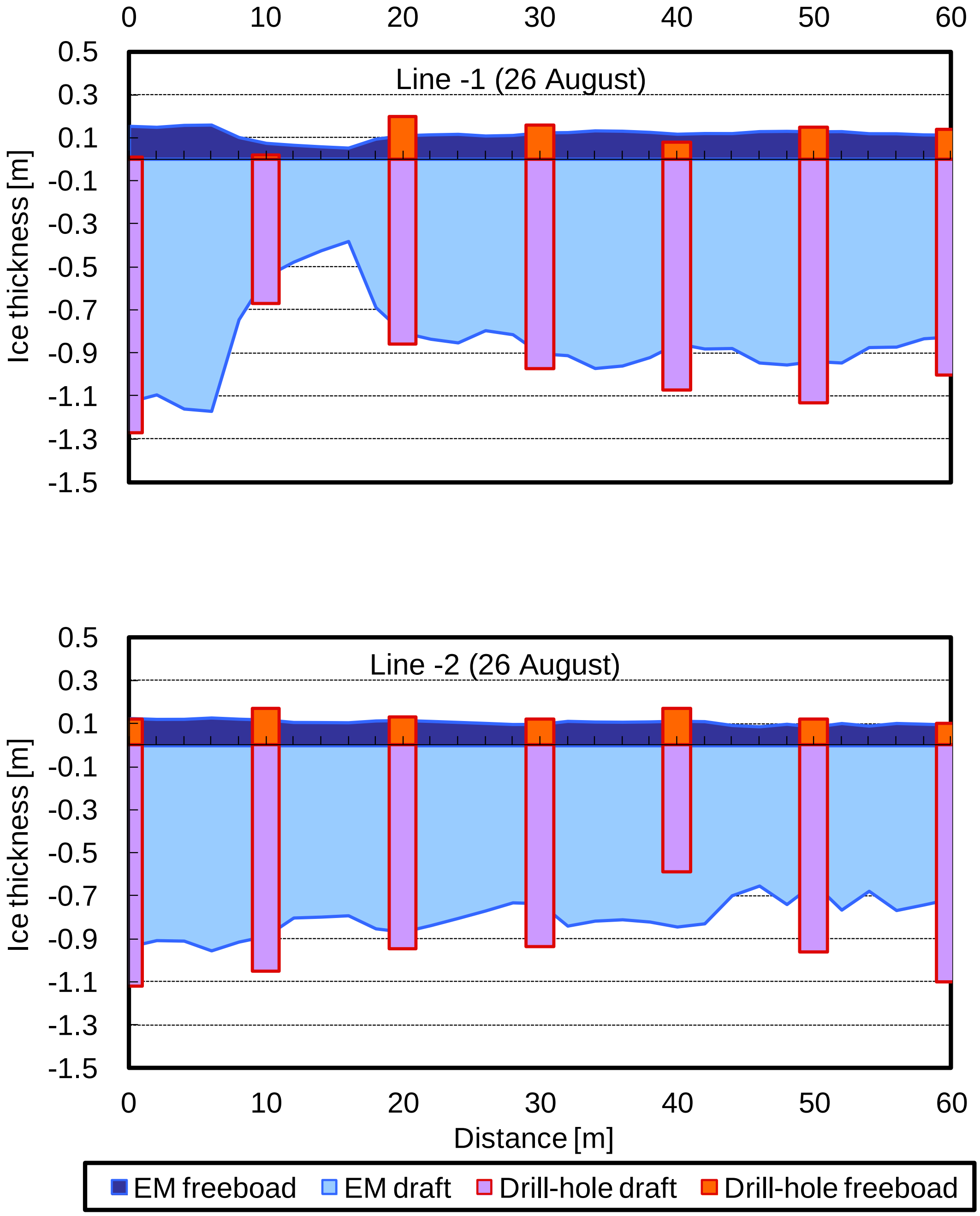


Figure 1. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #1 on 24th of August 2013 and #2 on 26th of August 2013.

5.16 Radiometer and Ceilometer Measurements

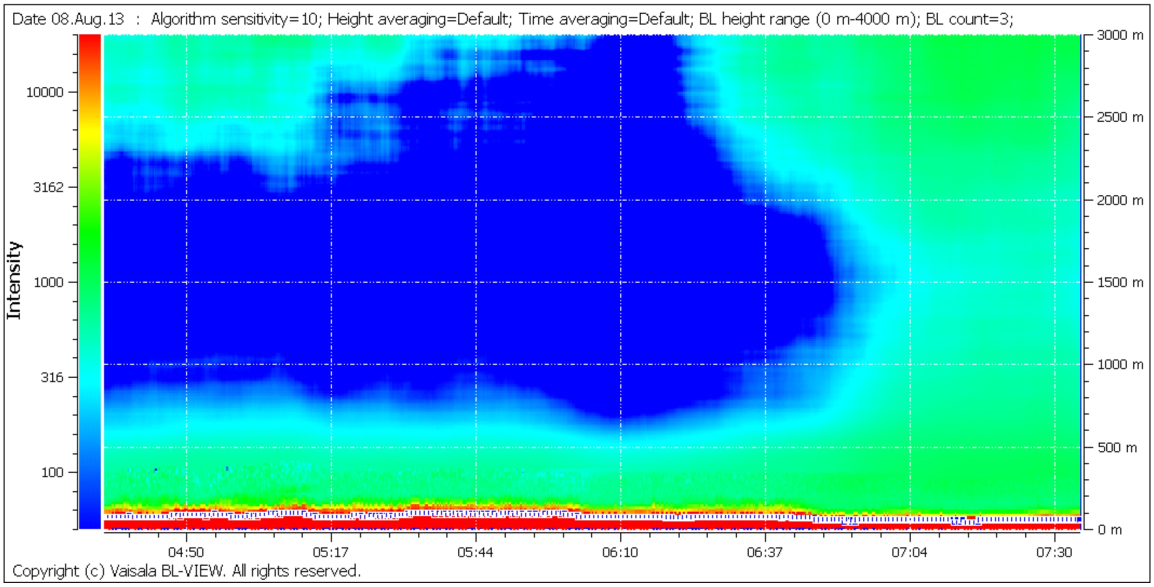
Sigrid Salo (NOAA,PMEL)

PMEL/NOAA measured weather parameters with three instruments. We continuously measured cloud layers and boundary level height with a Vaisala CL31 ceilometer, deployed 45 radiosondes (weather balloons), and monitored incoming short-wave radiation with an Epply short-wave radiometer. The radiometer data are being transmitted back to PMEL via the ARGOS satellite system and internally recorded, but I will not see the data during the cruise.

Ceilometer data

Ceilometers use LIDAR technology; they send out a laser pulse every 2 seconds and measure the backscatter to determine the presence of clouds and to calculate cloud base heights and boundary level height as well. The CL31 backscatter profile contains 770 10-m bins. Unfortunately, dense fog interferes with some of the ceilometer calculations; primarily the ones giving boundary layer heights because so much of the energy is absorbed in the near-surface layer. Since fog is common in the summer in the Arctic that will present problems in our assessment of the data.

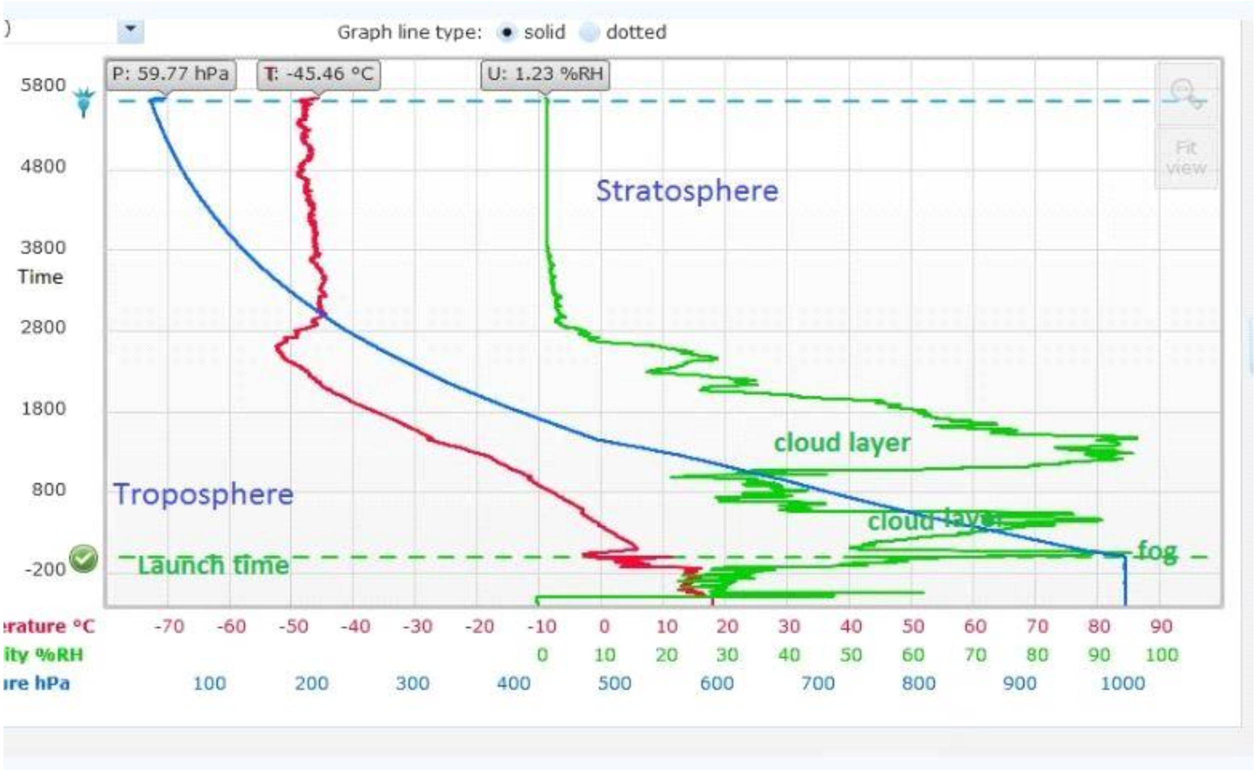
An example of a few hours of ceilometer data is shown below. The right hand axis shows the height. The colors of the plot indicate the intensity of the reflection - which increases with the cloud density. A fog layer - the red high-scatter layer at the base of the plot - is obvious in the image, although the ceilometer is also receiving reflections from moisture in clouds above the fog layer.



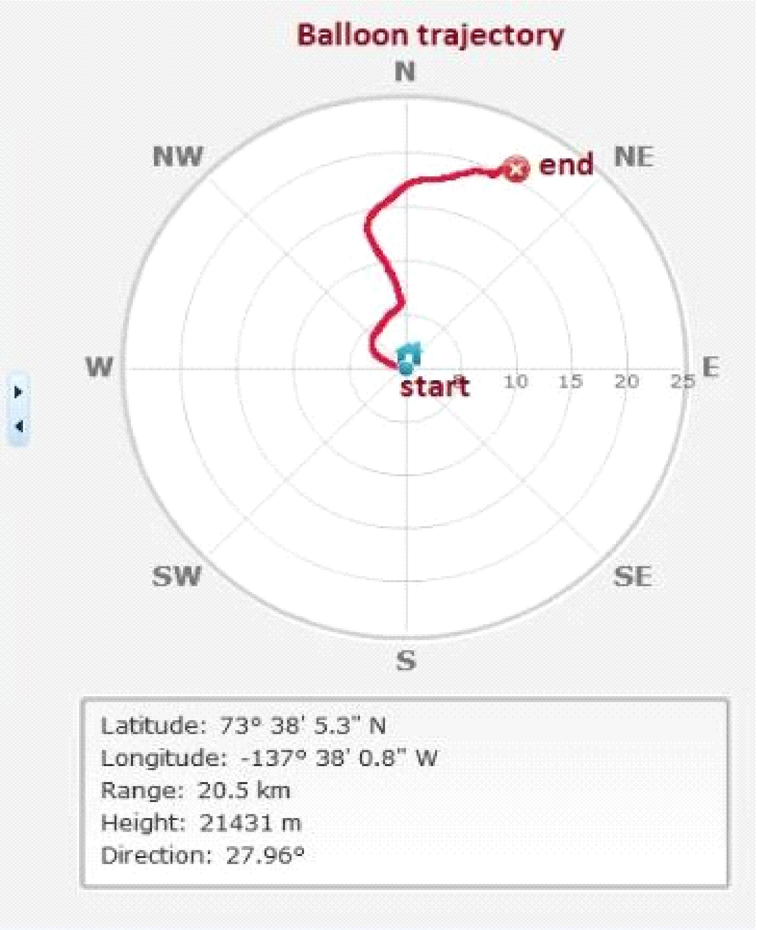
Radiosondes

The weather balloons used RS92-SGP radiosondes, with Vaisala's MW41 program to track the ballons and process the data. We measured pressure, temperature, relative humidity, and winds calculated from the radiosondes' GPS positions. All but two radiosondes reached an altitude of 20-25km before the balloon burst. Most of the weather balloons were launched at CTD positions, but in our final transect we added additional soundings between CTDs for better coverage of the marginal ice zone.

An example of a radiosonde, one taken on August 28 at CB22 is shown below. MW41 is a new program, so it does not yet have the capability to create skew-T plots or plots with pressure as the vertical axis. In this plot, of pressure, temperature, and relative humidity as a function of time, you see a fog layer under a thin temperature inversion near the surface. Two other cloud layers are centered at 850 mb and 500 mb.


Graph line type: ● solid ○ dotted

The balloon whose measurements are described above was blown to the northwest in the surface layer, and then to the northwest, NNW and finally ENE as it ascended. Few of the balloons showed this much variation in wind direction and most of them had larger horizontal displacements as they rose; it will be interesting to see the weather maps for the time of this sounding.



Latitude: 73° 38' 5.3" N
Longitude: -137° 38' 0.8" W
Range: 20.5 km
Height: 21431 m
Direction: 27.96°

Unlike the CTD survey, the ceilometer and radiosonde measurements taken over the course of a month are not synoptic so we cannot create atmospheric "snapshots" to match the oceanic transects and surface plots. However, I do plan to plot up a transect for the final day's work, when we passed from CB22, within the ice, through the marginal ice zone, and then south to open water.

The ceilometer and radiosonde data provide information on cloud extent, density, and thickness, as well as the temperature structure of the atmosphere and its winds (both near the surface and aloft). These are important parameters for heat and momentum transfer between the air, ice and ocean.

The radiosonde data, which are point-source data will be used to corroborate or fine-tune the ceilometer data, which will then give us "line-source" data as well as providing temperature and wind data of their own. However, in order to go from our point-source and line-source measurements to a more general description of the atmospheric conditions in the Canadian Basin we are going to have to combine our data with weather charts and satellite measurements. I'm not the PI who will be deciding how we assess this data, but since I do much of the data processing and programming for them, I think I'm going to have a busy winter learning about new types of data..

Table of Radiosondes

1	AG5	August 5, 2013	0041	70.56	122.92
2	CB1	August 6, 2013	0143	71.77	131.86
3	C31b	August 6, 2013	1416	72.33	133.90
4	CB23a	August 6, 2013	2349	72.87	135.87
5	CB22	August 7, 2013	0931	73.44	137.94
6*	CB21	August 8, 2013	0227	74.02	139.99
7	CB19	August 9, 2013	0530	74.30	143.26
8	CBS	August 10, 2013	0834	73.53	144.86
9	StnA	August 10, 2013	1634	72.63	144.76
10#	BL8	August 11, 2013	0501	71.95	150.28
11#	BL1	August 11, 2013	1904	71.39	151.78
12	CB2A	August 12, 2013	0552	72.49	150.07
13	CB3	August 12, 2013	1908	74.00	150.02
14	XCTD48	August 13, 2013	2058	75.30	150.00
15	CB7	August 14, 2013	0312	75.94	149.98
16	CB4	August 14, 2013	1447	75.01	149.99
17	CBW	August 16, 2013	1321	74.48	155.07
18	CB5	August 16, 2013	2138	75.28	153.34
19	RS4	August 17, 2013	0603	75.64	156.14
20	RS1	August 17, 2013	1111	75.73	157.02
21	Tu_1	August 17, 2013	2025	76.00	160.14
22#	TU_2	August 18, 2013	1716	77.01	169.99
23	CB10A	August 19, 2013	2338	78.30	154.34
24	CB11	August 21, 2013	1022	78.87	149.93
25	CB9	August 21, 2013	2155	78.02	150.11
26	CB8	August 22, 2013	1129	77.05	150.07
27	CB13	August 23, 2013	1048	77.29	143.78
28	CB16	August 23, 2013	2226	77.94	140.20
29	CB15	August 24, 2013	1150	77.07	139.94
30#	PP7	August 25, 2013	1321	76.54	135.47
31	PP6	August 25, 2013	2302	76.29	132.84
32	CB17	August 26, 2013	1302	76.03	139.43
33	CBC2	August 27, 2013	0541	75.52	142.83
34	CB18	August 27, 2013	1953	75.00	140.03
35	CB40	August 28, 2013	0549	74.51	135.60
36	CB51	August 28, 2013	2300	73.63	131.43
37	CB50	August 29, 2013	0917	73.50	133.97
38	CB22	August 29, 2013	1823	73.47	137.94
39	CB27	August 30, 2013	0117	73.01	139.94
40	CB27+	August 30, 2013	0520	72.75	140.00
41	CB29-	August 30, 2013	0732	72.41	140.01
42	CB29	August 30, 2013	1050	72.00	139.99
43	MK6	August 30, 2013	1501	71.58	139.97
44	CB28B	August 30, 2013	1907	71.00	139.99

45	MK2	August 31, 2013	0236	70.40	140.00

Information in this table is from the soundings logs which are initiated at the time the radiosonde is ground-checked. The actual release generally occurs about 5 minutes later.

The thermistor on radiosonde 6 failed soon after launch. In addition, radiosondes 10,11 and 30 did not acquire GPS and therefore did not calculate winds. Radiosondes 40 and 41 were not at CTD sites, but were between CB 27 and CB29.

APPENDIX A: Participants

Table 1. Cruise Participants

Name	Affiliation	Role
Bill Williams	DFO-IOS	Chief Scientist, UCTD
Sarah Zimmermann	DFO-IOS	Lead CTD Watchstander, Data Analyst, ADCP
Kristina Brown	DFO-IOS	Lead CTD Watchstander (bongos), Ammonium Analyst, Dispatch
David Spear	DFO-IOS	CTD Watchstander (bongos), Salinity Analyst
Edmand Fok	DFO-IOS	CTD Watchstander, IT, Underway System
Kenny Scozzafava	DFO-IOS	Oxygen Analyst
Linda White	DFO-IOS	Nutrient Analyst, Lab Supervisor, GPS ice-drifters
Sarah-Ann Quesnel	DFO-IOS	Nutrient Analyst, QA / QC
Marty Davelaar	DFO-IOS	DIC / Alkalinity Analyst
Michiyo Yamamoto-Kawai	TUMSAT	SF6 / CFC12, Moored water sampler
Yusuke Ogiwara	TUMSAT	CTD Watchstander, SF6 / CFC12, Moored water sampler
Scott Rose	DFO-IOS	CTD Watchstander (bongos), Salinity Analyst
Yasuhiro Tanaka	KIT	Ice Observations, XCTD

Sigrid Salo	NOAA-PMEL	CTD Watchstander, Radiosondes
Paul Dainard	Trent U	CTD Watchstander, Bacteria and CDOM
Adam Monier	U Laval	Microbial Diversity, Foredeck CTD
Deo Florence Onda	U Laval	Microbial Diversity, Foredeck CTD
Cory Beatty	U Montana	CO2 Underway and under ice, Moorings / Buoys
Peter Peterson	UAF	O-Buoys
Brice Griffith Loose	URI	Ra / Rn Isotopes, Foredeck CTD, UAV Arducopter
Roger (Pat) Kelly	URI	Ra / Rn Isotopes, Foredeck CTD
Judy Twedt	UW	Ice Observations, GPS ice-drifters
Rick Krishfield	WHOI	Lead Moorings / Buoys
Brian Hogue	WHOI	Moorings / Buoys
Jim Ryder	WHOI	Moorings / Buoys
Kris Newhall	WHOI	Moorings / Buoys
Zoe Sandwith	WHOI	CTD Watchstander, O2 / Ar and TOI
Genki Sagawa	WNI	Ice Observations, on-ice EM-31 sensor

Table 2. Principal Investigators not on-board ship

Name	Affiliation	Program
Mike Degrandpre	UMontana	CO2, pCO2, pH on moorings, buoys and underway measurements
Martin Dople	LOV	Wave Buoys
Champika Gallage	EC	IMBB Buoy
Christopher Guay	PMST	Barium
Celine Gueguen	Trent U.	CDOM, DOC, Underway measurements
Jennifer Hutchings	OSU (formerly IARC)	Ice Observations, GPS ice-drifters
Motoyo Itoh	JAMSTEC	XCTD
Peter Lavrentyev	UAkron	Micro-zooplankton
Rainer Lohmann	URI	Persistant Organic Pollutants (Polyfluoroalkyl Compounds (PFCs))
Connie Lovejoy	ULaval	Bacteria, Microbial Diversity (DNA / RNA)
Roxane Maranger	UMontreal	N2O
Patricia Matrai	BLOS	O-Buoys
John Nelson	DFO-IOS	Zooplankton net tows
Don Perovich	CRREL	Ice Mass-Balance Buoy
Andrey Proshutinsky	WHOI	BGOS Moorings, ITP Buoys, XCTD

Koji Shimada	TUMSAT	GAM Moorings, XCTD
John Smith	DFO-BIO	CTD / Rosette, I-129
Rachel Stanley	WHOI	O2 / Ar and TOI
Tim Stanton	NPS	Arctic Ocean Flux Buoy
Mike Steele	UW-APL	UpTempO Buoys
Kazutaka Tateyama	KIT	On-ice Observations, Underway ice thickness measurements
Mary-Louise Timmermans	Yale U.	Moorings, Ice Beacon Buoys
John Toole	WHOI	ITP Buoys
Svein Vagle	DFO-IOS	Ship-side ADCP, Underway measurements
	NOAA-PMEL	Radiosonde, Ceilometer, Radiometer (incoming shortwave radiation)
	UW	AWAC on BGOS moorings

Table 3. Affiliation Abbreviation

BLOS	Bigelow Laboratory for Ocean Sciences, Maine, USA
CRREL	Cold Regions Research Laboratory, New Hampshire, USA
DFO-BIO	Bedford Institute of Oceanography, Dartmouth, NS Department of Fisheries and Oceans, Canada
DFO-IOS	Institute of Ocean Sciences, Sidney BC, Department of Fisheries and Oceans, Canada
EC	Environment Canada
IARC	International Arctic Research Center, University of Alaska Fairbanks, Alaska, USA
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Yokosuka, Kanagawa, Japan
KIT	Kitami Institute of Technology, Kitami, Hokkaidō, Japan
LOV	Laboratoire d’Océanographie de Villefranche, Villefranche-sur-Mer, France
NOAA-PMEL	Pacific Marine Environmental Laboratory / National Oceanic and Atmospheric Administration, Seattle, Washington, USA
NPS	Naval Postgraduate School, Monterey, California, USA
OSU	Oregon State University, Corvallis, Oregon USA
PMST	Pacific Marine Sciences and Technology LLC, California, Oakland, USA
Trent U.	Trent University, Peterborough, Ontario, Canada
TUMSAT	Tokyo University of Marine Science and Technology, Tokyo, Japan
UAF	University of Alaska Fairbanks, Alaska, USA
UAkron	University of Akron, Akron, Ohio, USA
UBC	University of British Columbia, Vancouver, British Columbia, Canada
ULaval	University of Laval, Quebec City, Quebec, Canada
UMontana	University of Montana, Missoula, Montana, USA
UMontreal	University of Montreal, Montreal, Quebec, Canada
URI	University of Rhode Island, Kingston, Rhode Island, USA
UVIC	University of Victoria, Victoria, British Columbia, Canada
UW	University of Washington, Seattle, Washington, USA
UW-APL	Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
WHOI	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
WNI	Weathernews Inc., Mihama, Chiba, Japan
Yale U.	Yale University, New Haven, Connecticut, USA

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

1.1 Rosette / CTD casts

Table 1. CTD/Rosette cast for 2013-04

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample Numbers	Comments
4	AG5-DNA	04/08/2013 15:05	70.5563	122.9050	650	641	1-16	Team DNA cast.
5	AG5	04/08/2013 16:38	70.5570	122.9087	650	640	17-36	Main CTD cast.
6	CB1	05/08/2013 16:46	71.7727	131.8662	1134	1106	37-60	Ice caught CTD wire twice. To clear CTD wire of ice, we stopped foredeck activities after first bongo.
7	CB31b	06/08/2013 5:18	72.3367	133.9220	2055	2035	61-84	
8	CB23a	06/08/2013 14:39	72.8783	135.8648	2720	2711	85-108	tested mooring releases. Hung on CTD frame and triggered at 2650m. They all worked.
9	CB22	07/08/2013 0:39	73.4355	137.9208	3113	3106	109-132	
10	CB21	07/08/2013 18:15	74.0147	139.9653	3497	3508	133-156	
11	CB21-cal	08/08/2013 4:03	73.9907	139.9762	3489	601	157-178	Calibration cast; RBR sensor is 1.4 m above CTD sensors though discover afterward the RBR was not turned on; have 11 yo-yo stop bottles; high definition nutrient sampling between 150 and 250 m.
12	CB19	08/08/2013 21:48	74.2972	143.2550	3685	3692	179-202	around 1000m, winch operator mistakenly accelerated, but correct right away.
13	CBS	10/08/2013 0:13	73.5260	144.8585	3491	1000	203-221	
14	StaA	10/08/2013 8:17	72.6247	144.7285	3442	3437	222-245	Two WHOI releases on frame for test. Paused at 3245 on upcast for test; Eddies with low transmisson at 159-242 and 800-1100 m; nothing obvious in T-S from seasave trace; same features are seen in upcast; transmissometer #993 was replaced by #1025 after StnA (Dave Spear).

15	BL8	10/08/2013 21:37	71.9457	150.2830	2970	2944	246-269	The con file has NOT been updated after the transmissometer swap; 2941+10->2951, adjust sound speed from 1477 to 1470.
16	BL6	11/08/2013 2:49	71.6815	151.1187	2099	2088	270-293	
17	BL4	11/08/2013 7:02	71.5490	151.5112	1444	1449	294-316	
18	BL2	11/08/2013 10:35	71.3810	151.7993	166	150	317-339	Effluent coming out just aft of CTD wire during cast; we pulled ahead at ~ 1knot to get into clean water (will affect ADCP); Rosette accidently came out of water instead of stopping at 5 m for the last 3 bottles. CTD sent down to 5 m, wait 30 sec , then tripped last 3 bottles.
19	BL1	11/08/2013 12:34	71.3460	151.7863	96	86	340-347	
20	CB2a	11/08/2013 20:19	72.4883	150.0312	3824	3714	348-371	
21	CB2	12/08/2013 2:14	72.9998	150.0000	3816	3742	372-395	
22	CB3	12/08/2013 11:22	74.0030	150.0043	3827	3816	396-419	
23	CB6	12/08/2013 21:36	74.6665	146.8502	3785	3780	420-443	
24	CB7	13/08/2013 19:30	75.9413	149.9827	3830	3824	444-467	BOT Display and GPS on server needs to cloes/open to work again.
25	CB4	14/08/2013 5:26	75.0098	149.9885	3828	3817	468-491	
26	CBW	16/08/2013 5:55	74.4778	155.0703	3854	1000	492-510	Not a full profile, just for upper water properties in SW corner of Beaufort Gyre. No bongos or Foredeck work
27	CB5	16/08/2013 14:18	75.2760	153.3423	3847	3835	511-534	ISUS sensor is back on Foredeck Rosette for CB5. PAR sensor is not as it is currently not working.
28	RS4	16/08/2013 22:52	75.6430	156.1410	1910	1909	535-556	
29	RS1	17/08/2013 3:06	75.7482	157.0352	1073	1048	557-575	
30	TU1	17/08/2013 13:21	75.9908	160.1075	2111	2080	576-599	
31	TU2	18/08/2013 9:33	77.0100	169.9807	2214	2204	600 - 623	
32	CB10a	19/08/2013 16:26	78.3072	154.2493	899	883	624-643	
33	CB10	20/08/2013 0:26	78.2987	153.2448	2240	2462	644-667	
34	CB11	21/08/2013 1:15	78.8677	149.9555	3827	3811	668-691	Styrofoam cup shrink cast; winch making a 'chunk-a-chunk' sound for last ~100 m; but not on upcast.
35	CB9	21/08/2013 14:36	78.0232	150.1078	3825	3814	692-715	con files shows 2013-04-00034.xmlcon instead of 2013-04-0034.xmlcon; need adjustment for next cast
36	CB8	22/08/2013 3:08	77.0482	150.0632	3828	3816	716-739	

37	CB12	22/08/2013 14:21	77.5160	147.8198	3821	3811	740-763	
38	CB13	23/08/2013 2:33	77.2960	143.7750	3789	3780	764-787	
39	CB16	23/08/2013 16:06	77.9265	140.1597	3753	3746	788-811	Bottle 24 - ROS was up to surface, then went back down to 5 m to trip the last bottle.
40	CB15	24/08/2013 3:38	77.0702	139.9635	3734	3722	812-835	10 sample numbers were skipped between cast #40 and #41.
41	PP7	25/08/2013 5:09	76.5445	135.4925	3580	3563	846-869	Notice AVOS is not writing to SCS on 25th
42	PP6	25/08/2013 15:33	76.2953	132.8422	3150	3126	870-893	
43	CB17	26/08/2013 11:47	75.9870	139.6998	3686	3675	894-917	
44	CBC2	26/08/2013 21:44	75.5220	142.8503	3751	1004	918-936	ISUS sensor ON
45	CB18	27/08/2013 10:34	75.0052	140.0342	3635	3620	937-960	Actual depth is 3628 m; adjust sound speed to 1476
46	CB40	27/08/2013 22:34	74.5142	135.6005	3284	3264	961-984	
47	CB51	28/08/2013 15:42	73.6318	131.4302	2671	2646	985-1008	
48	CB50	29/08/2013 1:04	73.4998	133.9532	2849	2840	1009-1032	
49	CB22	29/08/2013 10:36	73.4723	137.9305	3134	3125	1033-1056	Bottle 2 not fired, error message from Seasave: unsupported message 06 2D 06 from SBE carrousel.
50	CB27	29/08/2013 18:34	73.0090	139.9442	3226	3208	1057-1080	
51	CB29	30/08/2013 2:43	71.9977	139.9985	2681	2670	1081-1104	
52	MK6	30/08/2013 6:56	71.5845	139.9897	2491	2479	1105-1128	Grey/green surface waters at 10 m instead of 30 m. Rosette bottle firing problems, first two bottom bottles didn't close; tried to fire with deck unit but also had problems. Deck unit was re-started and bottle 4 to 24 were closed with deck unit. See logbook for more details
53	CB28b	30/08/2013 12:02	71.0005	139.9805	2088	2067	1129-1152	Cleaned cable connections between pylon & CTD before cast. Still had problems: bottle 1 wouldn't fire (at 2067 m). We swapped out deck units and restarted new file for upcast but problem persisted; went to 1500 m, tried firing bottle 2, but didn't work; tried with deck unit at 1400 m and bottle 1 closed; bottle 2 closed using software and for the rest of the cast worked fine. Swapped deck unit "system 2003" to "system 2004".

54	MK3'	30/08/2013 16:29	70.6610	139.9888	1346	633	1154-1176	No sample #1153 as bottle 1 wouldn’t fire; tried firing many times before it starting to functionproperly again.
55	MK2	30/08/2013 19:20	70.3975	139.9930	502	490	1177-1196	Rosette misfired

1.2 XCTD

Table 3. XCTD cast deployment locations for 2013-04.

Locations are from cruise track based on deployment time. Latitude and longitude of all XCTD deployments was obtained from underway GPGGA GPS data. Filename is of format 2013-03-XCTDXXX.RAW, where XXX is the cast number (kept previous leg's naming system, did not change to 2013-04).

XCTD 068, 069, 092 and 103 were not deployed correctly so there is not data collected for them. Also – file numbers 30, 35, 52, 62, 75, 81, 82, 110 and 121 do not exist (failed probe? Skipped sample number?)

Cast number	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)
021	06/08/2013 6:58	72.03588	132.80605	1349	1100
022	06/08/2013 18:06	72.60382	134.92735	2459	1100
023	07/08/2013 4:00	73.18768	137.03688	2973	1093
024	07/08/2013 15:32	73.61452	136.45863	3121	1100
025	07/08/2013 19:08	73.7803	138.01135	3332	1100
026	08/08/2013 7:30	74.3791	139.99775	3332	1100
027	09/08/2013 1:00	74.15275	141.74375	3628	1100
028	10/08/2013 0:48	73.82502	141.66788	3590	1100
029	10/08/2013 3:51	73.6621	143.34432	3656	1100
031	10/08/2013 11:51	73.06667	144.87253	3564	1100
032	10/08/2013 20:40	72.4506	145.96483	3476	1100
033	10/08/2013 23:20	72.30603	147.28617	3535	1100
034	11/08/2013 1:50	72.1239	148.78122	3587	1100
036	11/08/2013 7:55	71.82527	150.74125	2579	1100
037	11/08/2013 12:14	71.5924	151.3655	1578	1100
038	11/08/2013 16:05	71.45853	151.81162	450	449
039	11/08/2013 16:12	71.45688	151.81317	Unknown	450
040	12/08/2013 0:54	72.25265	150.3968	3485	1100
041	12/08/2013 7:22	72.7426	150.00668	3730	1100
042	12/08/2013 13:58	73.34217	149.99538	3785	1100
043	12/08/2013 16:01	73.65625	150.01008	3819	1100
044	12/08/2013 23:27	74.25957	148.89525	3794	1100
045	13/08/2013 1:56	74.50657	147.66337	3782	1100
046	13/08/2013 8:59	74.80178	147.76618	3792	1100
047	13/08/2013 11:14	74.90883	148.94162	3808	1100
048	13/08/2013 21:00	75.33402	149.99535	3820	1100
049	13/08/2013 23:24	75.66625	150.00683	3823	1100
050	14/08/2013 22:09	74.68555	150.66788	3821	1062
051	15/08/2013 0:04	74.38182	151.22653	3788	1100
053	15/08/2013 2:04	74.06763	151.88662	3831	1100
054	15/08/2013 3:30	73.8252	152.47438	3840	1100

055	15/08/2013 5:13	73.53412	153.06983	3842	1100
056	15/08/2013 6:53	73.24295	153.68232	3843	1100
057	15/08/2013 8:29	72.9246	154.30723	3594	1100
058	15/08/2013 10:00	72.64625	154.82463	3011	1100
059	15/08/2013 11:22	72.37338	155.32792	1732	1096
060	16/08/2013 1:57	72.8168	158.16562	839	795
062	16/08/2013 3:36	73.1133	157.64063	2422	1063
063	16/08/2013 5:03	73.39418	157.15648	3319	1089
064	16/08/2013 7:01	73.68618	156.65492	3592	1100
065	16/08/2013 9:13	74.0013	156.03833	3844	1100
066	16/08/2013 11:26	74.2955	155.48757	3851	1100
067	16/08/2013 14:53	74.60808	154.7978	3836	1100
070	16/08/2013 17:41	74.92278	154.12022	3841	1100
071	16/08/2013 19:53	75.20082	153.54993	3839	1100
072	17/08/2013 1:57	75.4437	154.4475	3838	1031
073	17/08/2013 3:58	75.56337	155.42635	3843	1100
074	17/08/2013 5:04	75.62903	155.92883	2533	1100
076	17/08/2013 8:19	75.67865	156.35048	1391	1100
077	17/08/2013 8:47	75.69563	156.51077	1479	1100
078	17/08/2013 13:21	75.86918	158.56277	585	516
079	18/08/2013 0:03	76.15107	161.36763	unknown	1100
080	18/08/2013 2:01	76.30498	162.65338	2051	1100
083	18/08/2013 3:53	76.46045	164.0359	1158	583
084	18/08/2013 5:31	76.58757	165.28158	1028	992
085	18/08/2013 7:31	76.72212	166.60872	670	660
086	18/08/2013 9:26	76.84347	168.08785	1729	1100
087	18/08/2013 10:41	76.92	168.99955	2134	1100
088	18/08/2013 21:26	77.16608	168.65178	1266	1100
089	18/08/2013 23:30	77.31728	167.30347	593	573
090	19/08/2013 1:37	77.44805	166.00797	514	521
091	19/08/2013 4:02	77.60317	164.5003	319	395
093	19/08/2013 6:50	77.72403	163.03603	410	406
094	19/08/2013 8:40	77.81865	161.97312	2217	1100
095	19/08/2013 11:25	77.95187	160.21148	2495	1100
096	19/08/2013 14:05	78.05438	158.76145	3817	1100
097	19/08/2013 17:00	78.14755	157.09988	1761	806
098	19/08/2013 20:03	78.24198	155.54363	1416	1100
099	20/08/2013 6:06	78.33878	153.48538	2045	1100
100	20/08/2013 11:36	78.15732	151.67197	3769	1100
101	21/08/2013 4:34	78.51282	150.01638	3815	1100
102	22/08/2013 4:54	77.51677	150.00193	3817	1039

104	22/08/2013 17:00	77.38958	148.44525	3812	1100
105	23/08/2013 4:42	77.40855	145.56305	3792	1100
106	23/08/2013 18:13	77.62155	141.7459	3762	1100
107	24/08/2013 6:19	77.4574	139.9364	3728	1100
108	25/08/2013 6:44	76.71013	137.27042	3652	1100
109	25/08/2013 18:37	76.39547	134.02413	3380	1100
111	26/08/2013 9:28	76.07593	137.67732	unknown	1100
112	27/08/2013 1:36	75.75278	141.37432	3721	1088
113	27/08/2013 8:44	75.26363	141.50998	3703	1100
114	28/08/2013 1:07	74.76293	137.65678	3448	1100
115	28/08/2013 13:13	74.15545	133.84375	3434	851
116	28/08/2013 18:27	73.83882	132.3302	3448	1100
117	29/08/2013 4:32	73.5769	132.90577	3289	1097
118	29/08/2013 22:45	73.22343	139.0447	2641	1100
119	30/08/2013 6:36	72.52468	139.99943	2999	1100
120	30/08/2013 21:41	70.82135	140.00822	1732	1100
122	31/08/2013 14:23	71.17647	134.03048	620.8	619

1.3 UCTD

Table 4. UCTD cast deployment locations for 2013-04.
Location is from cruise track based on deployment time. Cast Number taken from file name. Only one cast was deployed as the only fully open water we found in our sampling region was at the southern end of our 140W line.

Cast number	DATE	TIME (UTC)	Latitude (N)	Longitude (W)	MAX DEPTH	COMMENTS
1	30/08/2013	17:29	71.26	140.00	650	The rewinder broke before the 2nd cast

1.4 ADCP

Table 5. ADCP cast locations for 2013-04.
Filename is of format ADCPXXX_000000.LOG, where XXX is the cast number.

File Name	STATION	Date (DD/MM/YEAR)	Start Time (UTC)	End time (UTC)	Comments
150	AG5	04/08/2013	0:00		
151	CB1	05/08/2013	0:06		Retied lines. Lots of stern wash.
152	CB31b	06/08/2013		14:12	Not so much stern wash this time, but did get caught on ice a couple of times.

153	CB23a	06/08/2013		22:21	Pulled up early due to large ice nearby.
154	CB22	07/08/2013		8:52	See that nmea data was not coming through properly…will fix for next cast
155	CB21	08/08/2013	0:00		
156	CB19	09/08/2013	4:58		after the station looked at GPSGATE again: GPGGA was closed but is now opened. The other two instances called GPRMC and HEHDT have been open and running, at least for last cast onwards.
159	CBS	10/08/2013	???		
160	STAA	10/08/2013	???		
172	BL8	11/08/2013		6:14	FIRST ADCP WITH GPS FEED!!!
173	BL6	12/08/2013	9:55		
173	BL6	12/08/2013		11:11	
174	BL4	12/08/2013	14:13		
174	BL4	12/08/2013		15:13	
175	BL2	12/08/2013	17:58		
175	BL2	12/08/2013	18:03		
176	BL1	12/08/2013	19:40		
177	CB2a	12/08/2013	0:03		
178	CB2	12/08/2013	0:09		
179	CB3	12/08/2013	18:25		
180	CB6	13/08/2013	4:40		
181	CB7	14/08/2013	2:42		GPS initially not working; NAV IO error didn't fix once Edmond reset GPS, still looks like it was logging fine though?
182	CB4	14/08/2013	12:35		
182	CBW	16/08/2013	13:30	13:34	New station this year
186	CB5	16/08/2013	21:20		NAV IO Error
187	CB5	16/08/2013	22:23		NAV IO Error
188	CB5	16/08/2013		23:31	Edmand fixed NAV IO Error problem; GPSgate problem on server
189	RS4	17/08/2013	5:55	6:52	Pulled up early due to large ice nearby.
190	RS1	17/08/2013	10:14		Forgot to turn off for quite a while. On deck about 11:15 but actually turned off at 18:37.
191	TU1	17/08/2013	20:23		
192	TU2	18/08/2013	16:42	17:57	
193	CB10a	19/08/2013	23:29	0:01	
194	CB10	20/08/2013	7:28	8:55	
195	CB11	21/08/2013	8:19	11:01	
196	CB9	21/08/2013	21:41	23:55	
197	CB8	22/08/2013	10:11	12:18	
198	CB13	23/08/2013	9:39	11:45	

199	CB16	23/08/2013	23:09	1:18	
200					accident …
201	CB15	24/08/2013	10:43	12:13	ran for 26 hours?
201	PP7	25/08/2013	12:14	14:19	
203	PP6	25/08/2013	22:33	0:20	
204	CBC2	27/08/2013	4:47		
205	CB40	28/08/2013	5:37	14:33	Ran in air for several hours after cast
206	CB51	28/08/2013	22:37		go pro :)
207	CB50	29/08/2013	8:11	9:48	
208	CB22	29/08/2013	17:41	19:24	Repeat of cast at beginning of cruise
209	CB27	30/08/2013	1:39	3:25	
210	CB29	30/08/2013	9:49	11:20	
213	MK6	30/08/2013	14:03	15:56	Finger trouble with opening file so closed and restarted. Yes, file is now #213. Water is a lot less clear than it has been.
214	MK5	30/08/2013	19:05	20:31	
215	MK3'	30/08/2013	23:31	0:28	
216	MK2	31/08/2013	2:21	3:07	

1.5 Zooplankton – Vertical Bongo Net Hauls

Table 5. Zooplankton vertical bongo net hauls.
Summary of the number of samples taken at each station, based on net mesh size (53, 150 or 236µm) and tow depth (100, 500m or bottom - 10m).

Station	Net number	Depth (m)	236	150	53	Total	Comment
CB1	NET1	79.3	1	1	1	3	Stopped between net 1 and 2 for foreward rosette and CTD/Rosette and working out some kinks. Location recorded from CTD rather than from the nets. Originally recorded flow end as 50271.8 but must have been "0" for first digit.
	NET2	77.5	1	1	1	3	
CB31b	NET1	80.6	1	1	1	3	Flow values are probably wrong. Delay in getting seawater for rinsing.
	NET2	80.3	1	1	1	3	
CB23a	NET1	80.5	1	1	1	3	All 4 cod ends sat on deck for ~ 1 hr while ship maneovered in ice.
	NET2	81.0	1	1	1	3	
CB22	NET1	81.0	1	1	1	3	Nets at previous stations: winch counter shows linear offset by 1.2x CTD depth; need to correct values by 1.2 (all casts so far likely only to 80m depth). Refer to RBR for true depth.
	NET2	81.4	1	1	1	3	
CB21	NET1	94.3	1	1	1	3	Started making a correction for winch counter offset (x1.2); target depth now 120m. Everything before this is shallower than expected because of winch counter. Note: The winch counter was reading only 80% of what it should and the correct target should be x 1.25 rather than 1.2. The two watches implemented this change differently, so there will be
	NET2	98.7	1	1	1	3	

	NET3	482.9	1	1	1	3	some discrepency with actual depths.
CB19	NET1	79.8	1	1	1	3	The winch correction was not applied to the first cast; at CB19, thus the 82 meter depth.
	NET2	96.2	1	1	1	3	
CBS	NET1	97.0	1	1	1	3	
	NET2	95.6	1	1	1	3	
Sta-A	NET1	95.5	1	1	1	3	
	NET2	94.1	1	1	1	3	
BL8	NET1	100.5	1	1	1	3	
	NET2	100.9	1	1	1	3	
BL6	NET1	96.7	1	1	1	3	
	NET2	94.8	1	1	1	3	
BL4	NET1	95.3	1	1	1	3	
	NET2	99.5	1	1	1	3	
CB2a	NET1	100.7	1	1	1	3	
	NET2	98.5	1	1	1	3	
CB2	NET1	97.5	1	1	1	3	
	NET2	99.8	1	1	1	3	
CB3	NET1	95.5	1	1	1	3	
	NET2	107.9	1	1	1	3	
CB6	NET1	100.7	1	1	1	3	Switched out the 53 cod ends on net 1
	NET2	93.4	1	1	1	3	
CB7	NET1	115.7	1	1	1	3	
	NET2	115.8	1	1	1	3	
CB4	NET1	112.5	1	1	1	3	The 150 µm sample accidentally got dumped into the 236 µm sample and sieved with the 236 µm sample, so they couldn't be separated.
	NET2	98.2	1	1	1	3	
CB5	NET1	100.3	1	1	1	3	Net flipped over at mid-descent, sample was discarded and net repeated
	NET2	100.2	1	1	1	3	
RS4	NET1	97.3	1	1	1	3	I noticed the cod end was coming off between the first and second net, so there was a delay while I fixed it and checked the others. They all needed to be tightened at the very least.The frozen sample was put in the freezer quite late at 10:25 UTC.
	NET2	96.7	1	1	1	3	
RS1	NET1	97.7	1	1	1	3	The pickling of net 2 samples was delayed
	NET2	96.5	1	1	1	3	
TU1	NET1	98.2	1	1	1	3	
	NET2	98.1	1	1	1	3	
TU2	NET1	98.8	1	1	1	3	
	NET2	98.0	1	1	1	3	
CB11	NET1	97.8	1	1	1	3	Flow meter stuck
	NET2	96.8	1	1	1	3	
CB9	NET1	101.0	1	1	1	3	Flow meter not working
	NET2	103.8	1	1	1	3	
CB8	NET1	95.4	1	1	1	3	
	NET2	94.2	1	1	1	3	
CB12	NET1	100.6	1	1	1	3	
	NET2	100.5	1	1	1	3	

CB13	NET1	97.4	1	1	1	3	Flow meter frozen
	NET2	96.6	1	1	1	3	
CB16	NET1	81.1	1	1	1	3	Flow meter -this first reading is questionable
	NET2	89.0	1	1	1	3	
CB15	NET1	85.7	1	1	1	3	
	NET2	71.7	1	1	1	3	
PP7	NET1	96.3	1	1	1	3	
	NET2	95.1	1	1	1	3	
PP6	NET1	100.6	1	1	1	3	
	NET2	101.0	1	1	1	3	
CB17	NET1	104.5	1	1	1	3	
	NET2	106.0	1	1	1	3	
CBC2	NET1	100.4	1	1	1	3	
	NET2	103.9	1	1	1	3	
CB18	NET1	104.8	1	1	1	3	
	NET2	104.5	1	1	1	3	
CB40	NET1	100.1	1	1	1	3	
	NET2	103.4	1	1	1	3	
CB51	NET1	100.7	1	1	1	3	
	NET2	100.7	1	1	1	3	
CB50	NET1	101.0	1	1	1	3	frozen
	NET2	101.1	1	1	1	3	
CB22	NET1	99.5	1	1	1	3	
	NET2	99.3	1	1	1	3	
CB27	NET1	100.4	1	1	1	3	
	NET2	100.4	1	1	1	3	
CB29	NET1	98.0	1	1	1	3	
	NET2	100.1	1	1	1	3	
MK6	NET1	98.7	1	1	1	3	
	NET2	97.6	1	1	1	3	
MK5	NET1	100.0	1	1	1	3	
	NET2	99.6	1	1	1	3	
MK3'	NET1	99.9	1	1	1	3	
	NET2	100.5	1	1	1	3	
MK2	NET1	97.3	1	1	1	3	
	NET2	100.0	1	1	1	3	
All Stations			**89**	**89**	**89**	**267**	

1.6 Foredeck Rosette Cast locations

Table 6. Locations of microbial diversity stations.
At each station, 6 to 8 depths were sampled and were defined as either: surface (usually ~ 6 m), bottom mixed layer, temperature minimum, above subsurface chlorophyll maximum, subsurface chlorophyll maximum, below subsurface chlorophyll maximum, bottom (usually 100 m), isocline or high transmissivity. The stations that have an * next to cast depth had an additional sample which was from the deep water niskin bottle from the main deck rosette.

Station	Cast #	Start Date and Time (UTC	Location	Bottom depth (m)	Cast depth (m)	Sample #	Comments
AG-5	4	04/08/2013 22:10	70° 33.35' N 122° 54.36' W	640	640*	1-8	Main rosette Sunny, no waves
CB31b	301	06/08/2013	72° 20.01' N 133° 54.24 W		100	9-14	Foggy, no waves
CB22	302	07/08/2013 2:15	72° 52.2' N 135° 52.2' W	3110	100	15-20	Foggy, no waves
CB21	303	08/08/2013 12:47	74° 1.35' N 139° 59.61' W	3508	100	21-26	Foggy, no waves
StnA	304	10/08/2013 17:54	72° 37.77' N 144° 46.38' W	3446	168	27-33	Foggy, strong
BL8	305	10/08/2013	71° 56.85' N 150° 17.29' W	2945	100	34-39	Foggy, no waves
BL2	18	11/08/2013 17:35	71° 23.00' N 151° 47.75' W	166	150	40-45	Main rosette Sunny, no waves
CB2	306	12/08/2013 10:25	72° 59.93' N 150° 0.76' W	3751	100	46-51	Foggy, windy, scattered rain
CB3	307	12/08/2013 17:30	74° 0.27' N 150° 1.13' W	3824	100	52-57	Foggy, windy, string surface current
CB6	308	12/08/2013 5:48	74° 40.00' N 146° 52.18' W	3785	100	58-63	foggy, windy, scattered rain
CB5	309	15/08/2013 22:40	75° 16.51' N 153° 20.19' W	3847	100	64-69	Foggy, windy, strong surface current
TU1	310	16/08/2013 21:10	75° 59.30' N 160° 5.38' W	2079	100	70-75	Foggy, windy, string surface current
CB10	311 / 33	20/08/2013 9:15	78° 17.91' N 153° 13.29' W	2260	100	77-81	* Main rosette
CB11	312	21/08/2013 8:50	78° 51. 86' N 149° 55.69' W	3827	100*	82-89	Windy, temperature below 0, grease ice below 0, grease ice
CB9	313	21/08/2013 22:31	78° 1.33' N 140° 6.38' W	3822	100	90-95	Cold, icy and just finished snowing
CB12	314	22/08/2013 22:50	77° 31.05' N 147° 50.45' W	3809	100*	96-102	Windy, surface water icy, foggy
CB16	315	24/08/2013	77° 55.46' N	3744	100*	103-109	Windy, foggy, icy

		1:50	140° 8.68' W				
PP6	316	25/08/2013 23:30	76° 17.63' N 132° 50.78' W	3150	100	110-115	Foggy, chilly, lots of grease snow
CB40	317	28/08/2013 6:20	74° 30.88' N 135° 35.94' W	3284	100	116-121	outside temp negative
CB50	318	29/08/2013 9:00	73° 29.91' N 133° 58.13' W	1100	100	122-127	Temperature below 0
MK6	319	30/08/2013 14:42	71° 34.94' N 139° 58.21' W	2490	100	128-133	Less ice but chilly
MK2	320	31/08/2013	70° 23.74' N 159° 59.33' W	504	100	134-139	Raining
IBO1	1A 1B	24/08/2013 15:46	76° 55.4' N 138° 50.9' W			140-145	
IBO2	2A 2B	26/08/2013 17:34	75° 59.0' N 139° 43.1' W			146-151	

1.7 UpTempO buoy deployments

Table 7. Location of UpTempO buoy deployments

IMEI: International Mobile Equipment Identity

Buoy Type	Manufact.	Deployment Date	Latitude (N)	Longitude (W)	Notes
Iridium (IMEI: 300234060456740)	Pacific Gyre	12/8/2013	74.01	150.08	2013-5 deployed in open water near station CB3
Iridium (IMEI: 300243011242970	Marlin-Yug	17/8/2013	75.98	160.06	2013-7 deployed in open water near station TU1
Iridium (IMEI: 300243060451580)	Pacific Gyre	18/8/2013	77.01	170.02	2013-8 deployed in open water near station TU2
Iridium (IMEI: 300243011242840	Marlin-Yug	22/8/2013	77.52	147.84	2013-9 deployed on-ice at IBO-1
Iridium (IMEI: 300243011241960	Marlin-Yug	26/8/2013	76	139.75	2013-10 deployed on-ice at IBO-3

1.8 Location of Drift Bottle drops

Table 8. Drift bottle deployments

STATION	DATE	TIME (UTC)	Latitude (N)	Longitude (W)	SAMPLE NUMBERS
Sta-A (approx)	10-Aug-13		72.1718	147.8600	75 to 100
TU2	18-Aug-13	18:15	77.0235	170.0119	1 to 25
CB51	28-Aug-13		73.6330	131.4361	51 to 75
18 miles east of Cape Chidley (Lab Sea)	14-Nov-13	19:00	60.4410	63.8121	26 to 50 and 101 to 125