Joint Ocean Ice Study (JOIS) 2014
Cruise Report

Photo credit: Sam Thomas

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,* September 21 to October 17, 2014 IOS Cruise ID 2014-11

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2014 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 2014, 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.
- 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.
- Purdue University, West Lafayette, IN, USA

Canada:
- Environment Canada

- Trent University, Peterborough, Ontario, Canada.
- Université Laval, Québec City, Québec, Canada.
- University of Ottawa, Ottawa, Ontario, Canada
- Vancouver Aquarium, Vancouver, Canada

Switzerland:
-ETH Zurich, Switzerland

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 September 21st and finished October 17th, 2014. The research was conducted in the Canada Basin from the Beaufort Slope in the south to 79°N by a research team of 30 people. Full depth CTD casts with water samples were conducted, measuring biological, geochemical and physical properties of the seawater. The deployment of underway 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.

Different from previous years' programs, we did not take stations from the south-western Beaufort slope and shelf due to scheduling constraints of a shorter program.

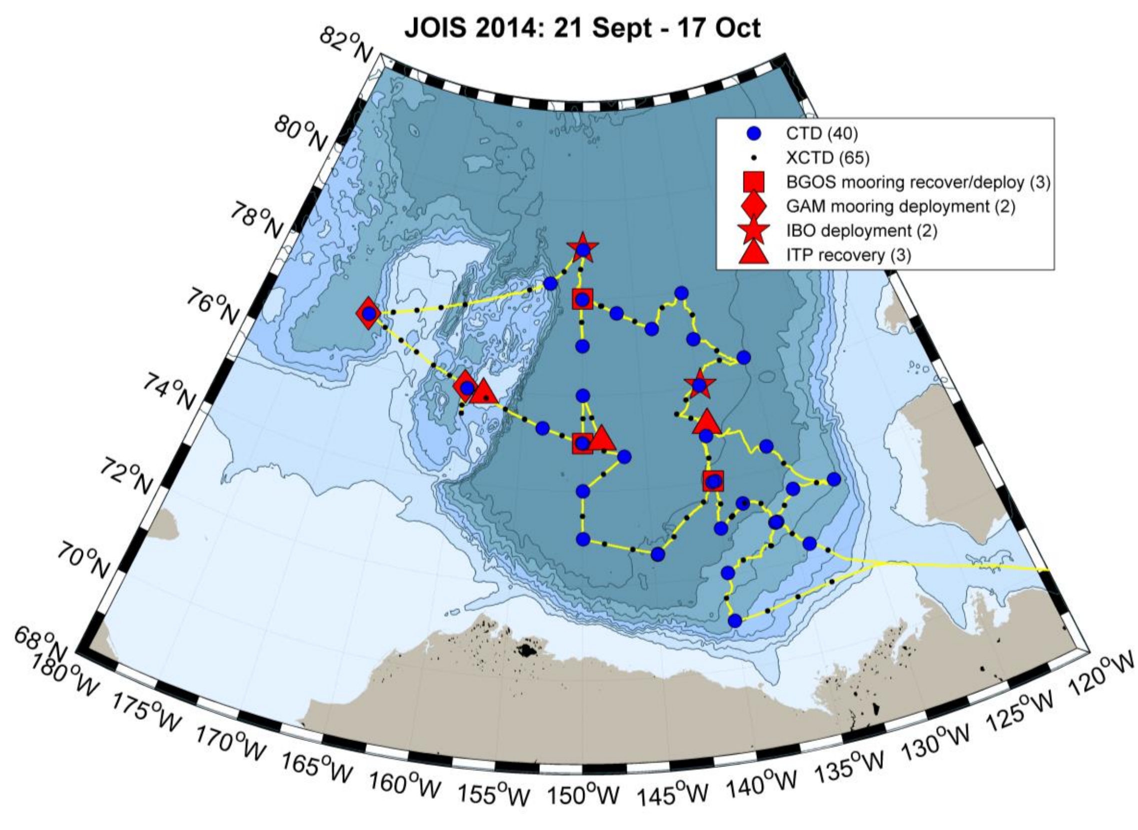

Figure 1.The JOIS-2014 cruise track showing the location of science stations.

2.1 Program Components

Measurements:

- At CTD/Rosette Stations:
  - 40 CTD/Rosette Casts at 32 Stations (DFO) with 912 water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (DFO, TrentU, TUMSAT, WHOI, ULaval, UMontreal, URI, ETH Zurich, UOttawa, Vancouver Aquarium)
    - At all full depth stations: Salinity, Oxygen, Nutrients, Barium, ^{18}O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a, and O_2/Ar (also called Triple Oxygen Isotope)
    - At selected stations: water for microbial diversity studies, ^{129}I, ^{137}Cs, ^{236}U, CFC/SF_6, pCO_2, ^2H (deuterium), and microplastics
  - Upper ocean current measurements from Acoustic Doppler Current Profiler during most CTD casts (DFO)
  - 20 Vertical Net Casts at 10 select Rosette stations typically with one cast each to 100m and 500m per stations. Mesh size is 50, 150 and 236 µm. (DFO)
  - 16 stations using a submersible pump, sampled 6-8 depths in the upper 94m for $^{222}Rn/^{226}Ra$ isotopic ratio profiles. In addition 200L of surface water was collected at each of these sites for ^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra measurements.

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

- Mooring and buoy operations
  - 3 Mooring Recoveries (3 deep basin (WHOI)
  - 5 Mooring Deployments (3 deep basin (WHOI), 2 in the Chukchi and Northwind Abyssal Plains (TUMSAT , NIPR, performed by WHOI)
  - 2 Ice-Based Observatories (IBO, WHOI)
    - the first consisting of:
      - 1 Ice-Tethered Profiler (ITP85, WHOI)
      - 1 Ice Mass Balance Buoy (IMBB, Environment Canada)
      - 1 O-buoy (OBuoy11, BLOS)
    - the second:
      - 1 Ice-Tethered Profiler (ITP84, WHOI, UMontana)
      - 1 S-Ice Mass Balance Buoy (S-IMBB, CRREL)
      - 1 O-buoy (OBuoy12, BLOS)
  - 3 Ice-Tethered Profiler Recoveries (ITP71,ITP77,ITP79, WHOI)

- Ice Observations (OSU/KIT)

  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) and an electromagnetic inductive sensor (EM31-ICE).

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.
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, microdiversity and microplastics.
On-ice observations of spectral albedo of ice and snow cover using an ASD FieldSpecPro and melt pond study.

- Cloud and weather observations:
  - 37 radiosondes (weather balloons) deployments at 0000 and 1200UTC daily.
  - Continuous cloud presence, cloud base height and base level measurements using a ceilometer.

- Underway collection of meteorological, depth, and navigation data, photosynthetically active radiation (PAR), and near-surface seawater measurements of salinity, temperature, chlorophyll-a fluorescence, CDOM fluorescence as well as pCO2 using oxygen sensor and a gas tension device (DFO).
  A combined 60 water samples were collected from the underway seawater loop for Salinity (DFO), CDOM (TrentU) and D2O (ETH Zurich).
  In addition, a second system was set up to continuously measure partial pressure of CO2 (pCO2) and pH (UMontana) from the surface seawater.

- Daily dispatches to the web (WHOI)

- Drift bottles launched at 1 location (DFO)

3. COMMENTS ON OPERATION

3.1 Ice conditions

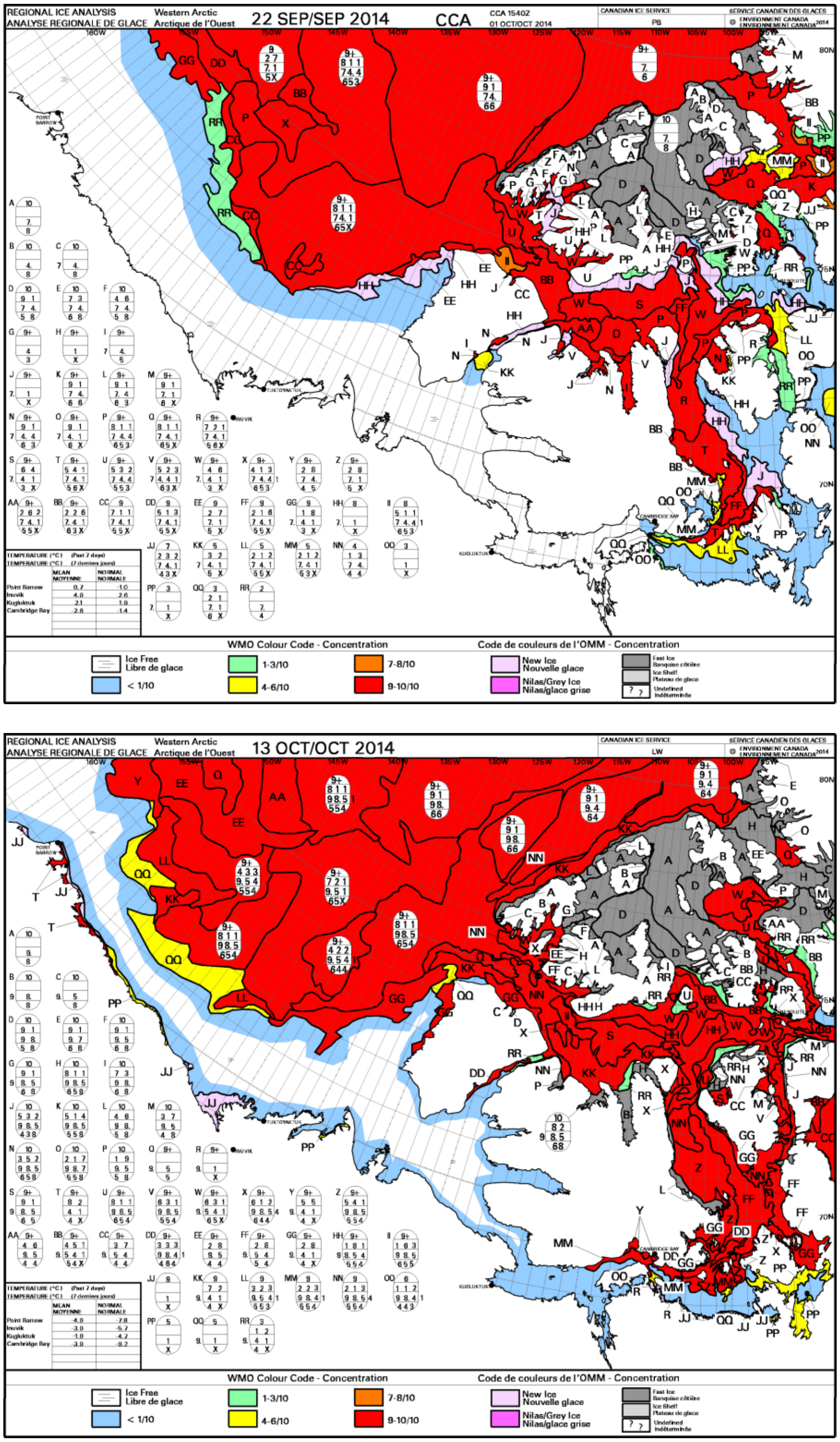

Figure 2: Canadian Ice Service ice concentration charts from the beginning and end of the cruise.

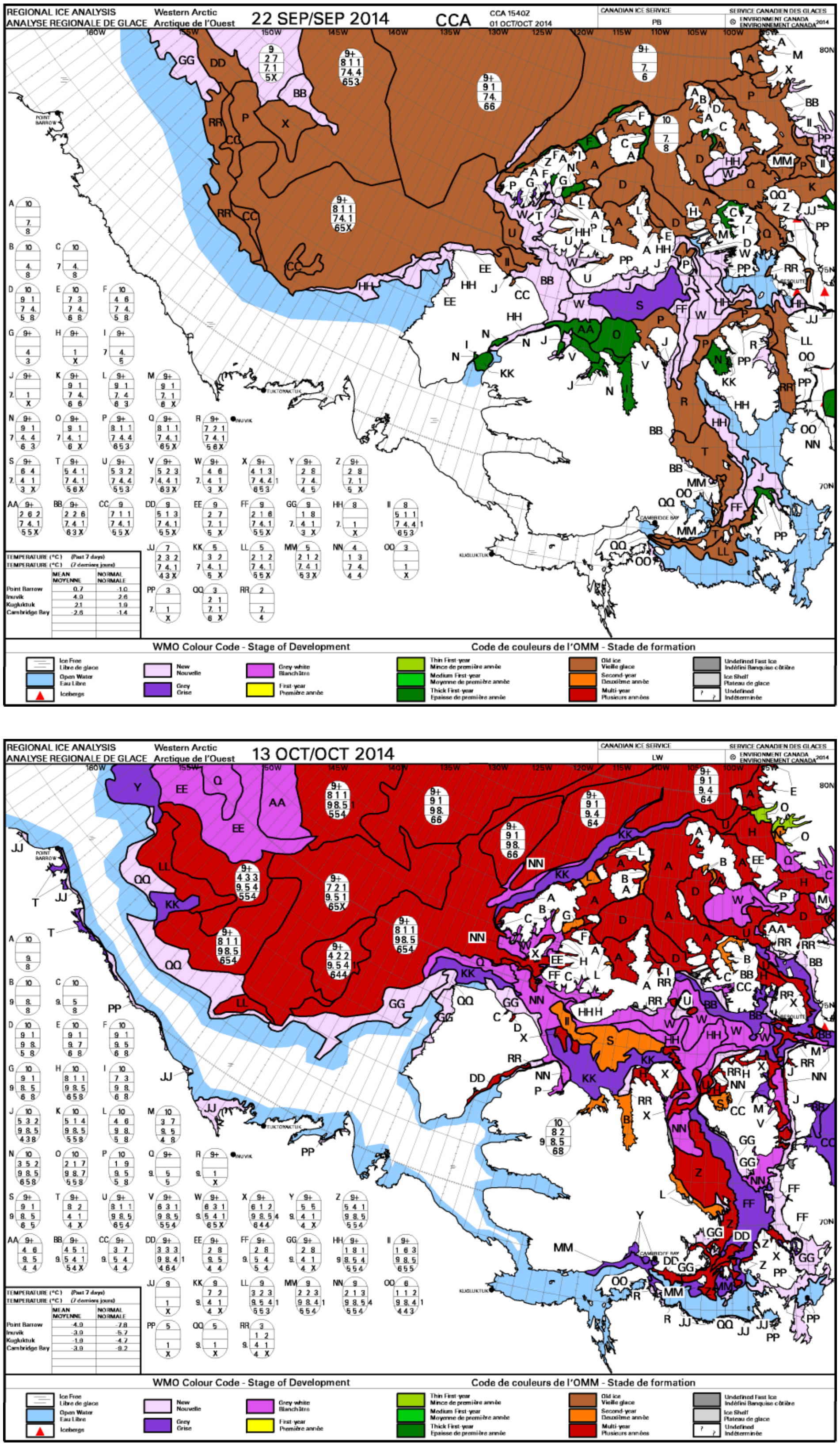

Figure 3. Canadian Ice Service ice stage for beginning and end of cruise. Note on Oct 1st the ice 'ages' increase by a year.

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. Two days of ship time was initially lost during the offloading/onloading for the start of the program due to poor weather closing the runways in Kugluktuk requiring a change of port to Cambridge Bay for both the LSSL and the fueling barge. However, the cruise was extended to compensate for these lost days. Two stations were dropped due to concerns of time shortages naturally occurring from at-sea ice and weather delays. As time was regained, we were able to add ITP buoy recoveries and a few stations at the end of the cruise.

Our primary goals were met during this successful 27-day program. We would like to note:
a) The efficiency and multitasking of Captain and crew in their support of science.
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 core science stations, and removing the Beaufort shelf and slope stations
- iii) Planning for overnight turnarounds of all moorings being re-deployed

4. ACKNOWLEDGMENTS

The science team would like to thank Captains Marc Rothwell and Tony Potts and 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 on-board 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 Lebus traction winch, the rosette lab door, container labs drainage and plumbing, installation of the -80°C freezer. We would also like to thank the deck crew for installing a new rosette deck and the IT technician for assistance with the NOAA server and connectivity issues that we encountered. It was a pleasure to work with helicopter pilot Chris Swannell and mechanic Steve Lloyd for their valuable help with support on the ice, and transport. Importantly, we'd like to acknowledge DFO, NSF, NIPR and JAMSTEC for their continued support of this program.

This was the program's 12th annual expedition and the exciting and valuable results are a direct result of working with such an experienced, well trained and professional crew.

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 0724, 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 V7.23.2 acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, dissolved oxygen sensor, fluorometer, transmissometer, CDOM fluorometer, cosine PAR and altimeter. In addition, an ISUS nitrate sensor was used for casts shallower than 1000 m and on select early casts a Biospherical QSP2300 PAR sensor with a 2000m limit was used. A reference surface PAR sensor was integrated into the CTD data stream startin on cast #3. In addition, a continuous PAR data were collected for the whole cruise as part of the underway suite of measurements. These 1-minute averaged data are reported with the underway suite of sensors.

This year, fast response temperature sensors were mounted on the top and bottom of the rosette frame to measure turbulence. For more information, see report below.

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 and 500m respectively at select stations Due to the colder conditions of this fall cruise, the foredeck rosette was not set up this year. For the samples collected using foredeck rosette last year, the microbial diversity water was collected using additional casts of the main rosette and the Radon/Radium samples were collected through a submersible pump and hose lowered in the same region as the ADCP, after the ADCP was in the water. The ADCP was recovered prior to the main CTD. Please see the individual reports for more information on the ADCP, bongo, and pump. Once on deck the rosette was brought into the double wide container lab for sampling.

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. If two or more bottles were being closed, the rosette would be stopped for 30 seconds before closing the bottles. During a “calibration cast”, 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 goal of the calibration cast is to have the water in the Niskins and at the CTD sensors as similar as possible at the expense of mixing the local water.

Air temperatures were below freezing for almost the entire cruise. This meant ice was forming on the block, wire and under the rosette deck. The use of a pneumatic-air wire-blower (the “ice chummy”) was used for all casts where the air temperature was below -3C or new ice formation on the surface was evident. At the start of the upcast, a hose with pressurized air was attached to the CTD wire outboard of the ship about 5m off the water. By continuously blowing air on the wire, seawater was removed which greatly reduced the build-up of frozen seawater on the sheave and drum.

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.

The acquisition configuration files (xmlcon file) changed during the cruise to reflect the different sensors swapped onto the CTD. Note that all the configuration files include the ISUS even though it was used on only a few of the casts. The data fields are to be ignored for those casts when the sensor was not installed.

The Niskin o-rings (end caps, valves and spigots) were new and baked in August 2013. This year they were wiped down at the start of the cruise to reduce any contamination for the CFC/SF6 sampling but they were not replaced.

5.1.1 Chemisty Sampling

The table below shows what properties were sampled and at what stations.

Table. Water Sample Summary for Main CTD/Rosette.

Parameter	**Canada Basin Casts**	**Depths (m)**	**Analyzed**	**Investigator**
CFC/SF_6	5, 9-10, 12-14, 16-17, 21, 23, 25-26, 31, 33-35, 37, 39	155-255 m	Shore lab	Michiyo Yamamoto-Kawai (TUMSAT)
	17	3000 m		
Dissolved Oxygen	All (except short casts)	Full depth	Onboard	Bill Williams (IOS)
pCO_2	34	Full depth	Shore lab	Debbie Ianson (DFO-IOS) and xxxx
Ar/O_2 and TOI	2, 10, 19, 21, 27, 35-37, 40	5-650 m	Shore lab	Rachel Stanley (WHOI)

	3-5, 9, 13-17, 23-26, 29-34, 38-39	5 and ~70 m		
	6 and 12	Full depth		
DIC/alkalinity	All (except short casts)	5-400 m	Onboard	Bill Williams (IOS)
	6, 16, 27, 31-32, 34, 39-40	Full depth		
CDOM	All (except short casts)	5-1000 m	Shore lab	Celine Gueguen (Utrent)
	6	Full depth		
Chl-*a*	All (except short casts)	5-180 m	Shore lab	Bill Williams (IOS)
	6	Full depth		
Bacteria	All (except short casts)	Full depth	Shore lab	Connie Lovejoy (Ulaval)
Nutrients	All (except short casts)	Full depth	Onboard and Shore lab	Bill Williams (IOS)
Salinity	All	Full depth	Onboard and Shore lab	Bill Williams (IOS)
$\delta^{18}O$	All (except short casts)	5-400 m	Shore lab	Bill Williams (IOS)
	6, 12, 27, 31-32, 34, 39-40	Full depth		
Barium	All (except short casts)	5-400 m	Shore lab	Christopher Guay (PMST)
	6, 12, 27, 31-32, 34, 39-40	Full depth		
Iodine-129	11, 24, 29, 32-34	Full depth	Shore lab	John Smith (DFO-BIO) and Jack Cornett (UOttawa)
Cesium-137	20, 22	5-250 m	Shore lab	John Smith (DFO-BIO) and Jack Cornett (UOttawa)
	11	Full depth		
Uranium-236	11, 24, 29, 32-34	Full depth	Shore lab	Jack Cornett (UOttawa)
Deuterium	10, 16, 27, 33, 40	Full depth	Shore lab	Tim Eglinton (ETH-Zurich)
Microplastics	8, 18, 28	5-1000 m	Shore lab	Peter Ross (Vaquarium)

Microbial Diversity	1, 4, 6-8, 11, 13-14, 17-20, 22, 24-25, 28-29, 31-35, 39-40	5-250 m	Shore lab	Connie Lovejoy (Ulaval)

5.1.2 CTD operation performance notes

The SBE9+ CTD overall performance was good except for the fluorometer and transmissometer. 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 CDOM and Chlorophyll-a water samples were collected and can be used for calibration at the user's discretion.

The rosette frame was modified before this cruise with an addition of a high ring mounted above the plyon and Niskins. The Niskin lanyards are run over the ring to the pylon, increasing the lanyard's angle from earlier years. The lanyards were lengthened to match the new desigh. The change to the rosette improved the problem from earlier years of the Niskins not always closing at the triggered depth as indicated by the seawater samples after analysis.

NMEA data: Casts 11+, the NMEA time was added to all scans.

Oxygen: DO sensor s/n 435 had noise issues at the beginning of the cruise. Cleaning the connectors initially cleared the problem. Later the sensor appeared to have an offset and was swapped for s/n 1489 after cast 23. Noise re-occurred and was persistent on the DO channel. The new DO/Altimeter Y cable for 2014 was then swapped out. It is suspected that there is a high pressure leak in the potted splice. This cable and a similar failure during BREA were fabricated by Specialty Cables of Calgary this year. They will be returned to the manufacturer and checked for possible warranty replacement. It is possible that the potting compound is too hard and does not bind sufficiently to the neoprene jacket of the cable under pressure underwater..
Oxygen sensor 435 casts 1 to 23
Oxygen sensor 1489 casts 24 to 40

Chl-a Flurometer: There were some issues with fluorometers. Initially there were small noise issues that were fixed by cleaning connectors. The noise returned and the Seapoint SCF fluorometer s/n 3652 was changed for s/n 3653 after cast 29. These 2 fluorometers are new this year and have the MCBH/MCIL connector instead of the AG206 connector that has flooded often in the past. Unfortunately 3653 appeared to have a 1.6 V clear water offset and 3652 was swapped back in after cast 30. The offset problem disappeared after the fluorometer and transmissometer 'Y" cable was changed for cast 35. SCF3653 should go back to Seapoint for warranty consideration
Cast 28: Bad data at 200m when values jump to higher concentration.
Cast 29: Bad data at 800m when values jump to higher concentration.

Cast 30: Bad Flr except for downcast top 200m? At surface value pegged at 1.6v. Sensor replaced.
Cast 34: Bad Flr, though upcast might be OK.
Cast 35: New Y cable made for this cast
SCF sn 3652 Casts 1 to 29, 31 to 40
SCF sn 3653 Cast 30
Configuration file unchanged as coeff's do not change between sensors.

Transmissomeneter: A problem with transmissometer drift was encountered with CSTAR s/n 1052. The transmissivity below 1000m appeared to decrease with subsequent casts. This may be an offset in the upper 1000m as well, but harder to tell with the large gradients and range of signal. Cleaning of connectors did not clear the problem and ultimately the transmissometer was changed for 993 (MCBH/MCIL connectors) after cast 34.
The transmissometer was mounted in a new place this year, horizontally along a lower bar padded with rubber.
Cast 30: Bad data with false low readings that do not match between up and down cast. Transmissometer repositioned after cast (had rotated slightly downwards on bar) and cable connectors checked.
Cast 34: Bad data.
Cast 35: Sensor changed. New Y cable made for this cast.
SN 1052 Casts 1 to 34
SN 993 Casts 35 to 40

CDOM: No data for casts 1 to 3. Cable was found to have been installed backwards. Correction was made and cable marked to avoid this easy confusion in the future.

PAR: This year a new Satlantic Cosine PAR (SATPAR) sensor s/n 517 was used for much of the cruise. The advantage to this sensor is that it is deep rated (7000m) and can be left on for all casts in the Canada Basin. The Biospherical QSP2300 s/n 70123 was removed once the casts were deeper than its 2000 m rating. Further analysis will determine the usefulness of the new sensors planar light collector. The previous Biospherical sensor had a spherical 4 Pi collector that measured irradiance from above and below including reflected backscatter.
Cast 1 to 4 or 5 Biospherical PAR QSP-2300 sn70123
Casts 5 to 40 Satlantic Cosine PAR LOG sn0517

SPAR:
Cast 1 and 2: Not installed
Cast 3 to 40: Installed and cleaned daily

ISUS nitrate: Sn 121. Batteries changed after Cast 2. Not used for many casts due to its limited depth range. On for Casts 1,2 20, 22, 28. There is often a small signal on this channel even when ISUS not attached to CTD. This should be ignored. This was fixed for Cast 38 by cleaning all connectors and swapping in a new 4 socket dummy for the "ISUS" extension cable on the Y cable used for ISUS/PAR.

Summary of configuration files applied to at-sea preliminary 1-db averaged data (different than files used in acquisition)
SBE9plus_724_v2014-10-03a Cast 1 to 5
SBE9plus_724_v2014-10-03b Cast 6 to 10 Change to Cosine PAR
SBE9plus_724_v2014-10-03c Cast 11 to 23 NMEA added to every scan
SBE9plus_724_v2014-10-04 Cast 24 to 34 Change Oxygen sensor
SBE9plus_724_v2014-10-12 Cast 35 to 40 Change Transmissometer sensor

Pylon: The pylon trigger release mechanisms was swapped out with the spare every week (pylons s/n #452 and #498), washing and rinsing well before reinstalling. There were a few problem latches and the cleaning helped improve their performance.
SN 498 used for casts 1 to 20
SN 452 used for casts 21 to 25
SN 498 used for casts 26 to 38
SN 452 used for casts 38 to 40

Hawboldt winch: Although wire has been greased, the wire looked rusty on the first use. Spooling worked well. Although in past years there has been some worrying noises from the winch in cold weather, this year there was only some clunking during pay out near the bottom on deep casts. There was no clunking during the upcast.

Block: Performed well except for period of freezing where out-going wire was bouncing on the wheel likely due to ice buildup. When ice built up on the sheave during the downcast, the counter was observed to under count the amount of wire out. Sometimes this under counting was as large as 100m on a 3800 m cast. During the upcast, the ice is worn out of the sheave by the CTD wire.
The "chummy" was a constant source of concern. This model had not been on the LSSL before and was worn badly due to inappropriate rigging. Once the rigging was made right, it worked well. It did however wear out one inner piece and notched all other plastic parts. The design should be improved to hang straighter on the wire and wear better.
One recurring small problem concerned the dry cabling for the BOT IMS interface. There is a split cable running from the lab control box to the two computers in the CTD lab. The connector to the CTD computer broke and required fixing. Later, on several occasions, the CTD serial feed to the display was lost or garbled. Re-seating of the serial connectors and re-starting program seemed to fix the problem.

5.1.3 CTD Sensor Configuration:

Table 1. CTD Accuracy for Seabird SBE911plus CTD systems used during 2014-11

SBE9-0724 (All Casts)				
Sensor (s/n)	**Accuracy**	**Lab Calibration**	**Correction to Lab Calibration**	**Comment**
Pressure (90559)		27 May 2009		
Temperature, Primary (SBE3 4397)		28 Dec 2013		Primary pump 3615
Temperature, Secondary (SBE3 4402)		28 Dec 2013		Secondary pump 3610
Conductivity, Primary (SBE4 2992)		31 Dec 2013		

Conductivity, Secondary (SBE4 2984)		31 Dec 2013		
SBE9-0756 Backup not used				
Sensor (s/n)	**Accuracy**	**Lab Calibration**	**Correction to Lab Calibration**	**Comment**
Pressure (91164)		9 Feb 2010		
Temperature, Primary (SBE3 4322)		4 Jan 2012		Used once since new calibration
Temperature, Secondary (SBE3 4239)		4 Jan 2012		Used once since new calibration
Conductivity, Primary (SBE4 2809)		4 Jan 2012		Used once since new calibration
Conductivity, Secondary (SBE4 2810)		4 Jan 2012		Used once since new calibration
Other Sensors (All casts)				
Salinity calculated, Primary		NA		
Salinity calculated, Secondary		NA		
Oxygen (SBE 43 435)		14 Jan 2014		Plumbed with primary sensors. Casts 1 to 23.
Oxygen (SBE 43 1489)		July 2014		Plumbed with primary sensors. Casts 24 to 40.
Transmission (Wetlabs CST-1052DR)		18 Jun 2014 (bench calibration)		Casts 1 to 34.
Fluorescence (Seapoint SCF 3652 with 30x gain)		May 2014		Plumbed with secondary sensors. All casts except 30.
Fluorescence (Seapoint SCF 3653 with 30x gain)		May 2014		Plumbed with secondary sensors. Cast 30.
Altimeter (Benthos Datasonics PSA-916D 1161)		31 Mar 2005		
Nitrate (Satlantic ISUS v3 #121)		June 2014 (bench validation)		
CDOM (Wetlabs FLCDRTD-1076)		6 Nov 2006		
PAR (Biospherical QSP2300 70123)		31 Aug 2009		Casts 1 to 5.
PAR (Satlantic Cosine PAR LOG sn0517)				Casts 6 to 40.
SPAR (QSR2200 sn20281)		9 Apr 2007		Typically on SWL
Pylon sn 498				Trigger mech swapped btw 498 and spare 452
Deck Unit sn 0680				

5.2 Chi-Pod and RBR Data

June Marion (OSU)
PI: Jonathon Naxh (OSU)

Summary

Oregon State University Ocean Mixing Group measured the ocean temperature microstructure with two new instruments mounted on the rosette. Chipods are fast rate thermistors that measure the temperature and the time derivative of temperature over the full depth of the water column. Additionally, x and z accelerations are measured. One RBR pressure and temperature sensor measured the pressure and temperature during casts. The data was collected manually through a USB connection approximatly every 12 hours-2 days depending on the quality of the data. The Chipod data can be used as an analog for turbulent mixing. This type of data over the full water column has never been collected in the arctic before.

Chipod Setup

The photos below show the Chipods mounted on the rosette. The two uplooking sensors are mounted approximatly 25 cm above the top of the rosette frame and the downlooking sensor is mounted approximatly 6 cm above the bottom of the frame. The RBR pressure and temperature sensor is on the endcap housing of the right uplooker inside the rosette frame. Uplooking sensors have the least obstructed view of the water column during the up cast while the down looking sensor is less obstructed on the down cast. There is some concern that a bow wave could be induced by flow distortion around the rosette and contaminate the downlooking sensor measuremnts. The advantage of the downlooker is that it is located closest to the CTD intake and measurs similar waters at similar times as the CTD.

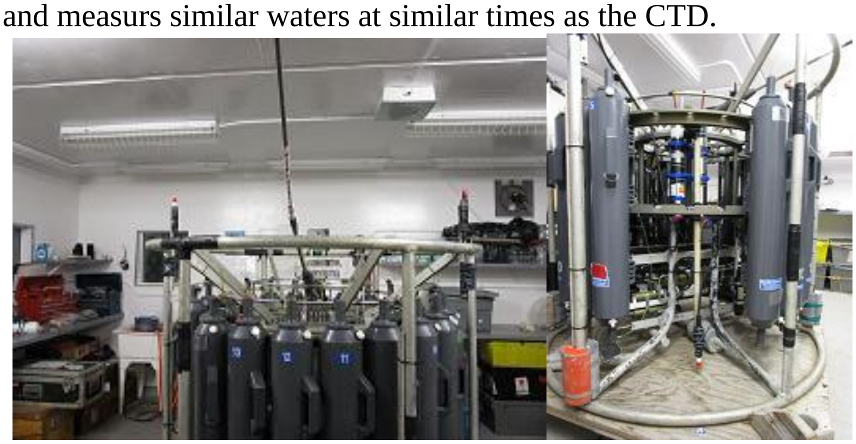

Figure 2 Chipods mounted on the rosette.

Chipod data

Chipods use glass tipped thermistors to measure the voltage from 0-4.096 V at 100 Hz that can be calibrated using the CTD temperature (at 24 Hz resolution). The derivative signal is a standard analog differentiator circuit. Turbulence can be deduced from the derivative signal since even small but fast changes in temperature can indicate shear layers and/or turbulent mixing. Temperature is not as effective at deducing turbulence within the mixed layer because the water temperature is nearly constant with depth through the layer.

An example of a full Chipod cast is shown in Figure 2. The x-axis is time, the units on the top plot are minutes and the bottom two plots are hours, and the y axes are, from top to bottom, Voltage, dV/dt, and m/s^2 . The top panel in Figure 2 shows the voltage which will be calibrated with the CTD tepmerature during post processing when I return to OSU. The flat section at the beginning and end of the cast is the mixed layer in which temperature does not vary a lot with depth. The small pointy peaks are the Pacific Summer Water, and the large peaks containing Tmax are Atlantic Water. The relatively constant section is deep water. This data is raw and plotted as a time series. The Chipod data will be processed upon retuning to Oregon State University at the enf of the cruise.

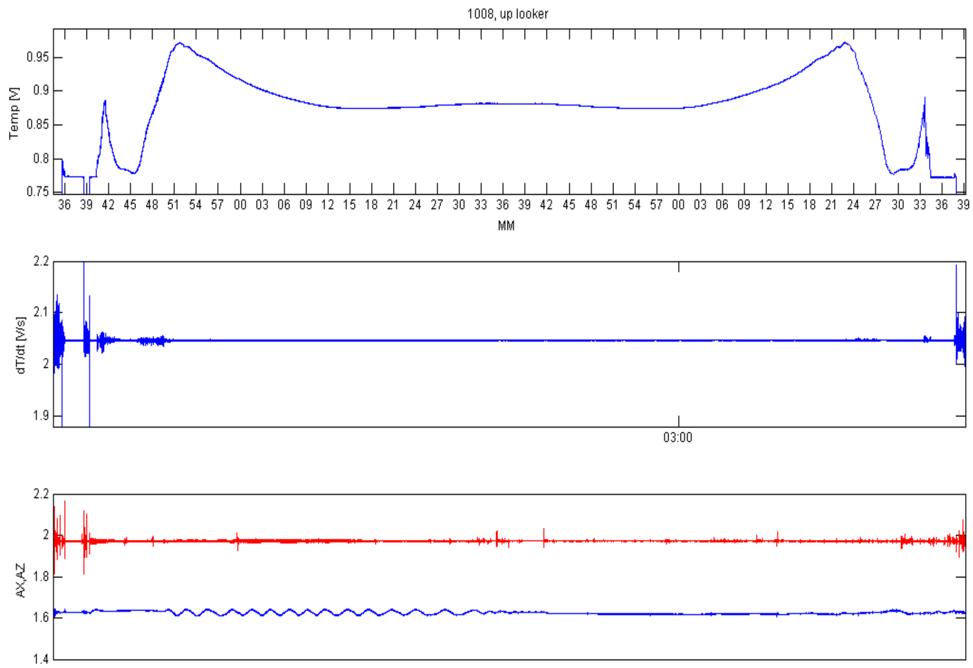

Figure 3 Full cast.

Figure 3 shows an example of turbulece in the Pacific Summer Water as seen in the upcast.

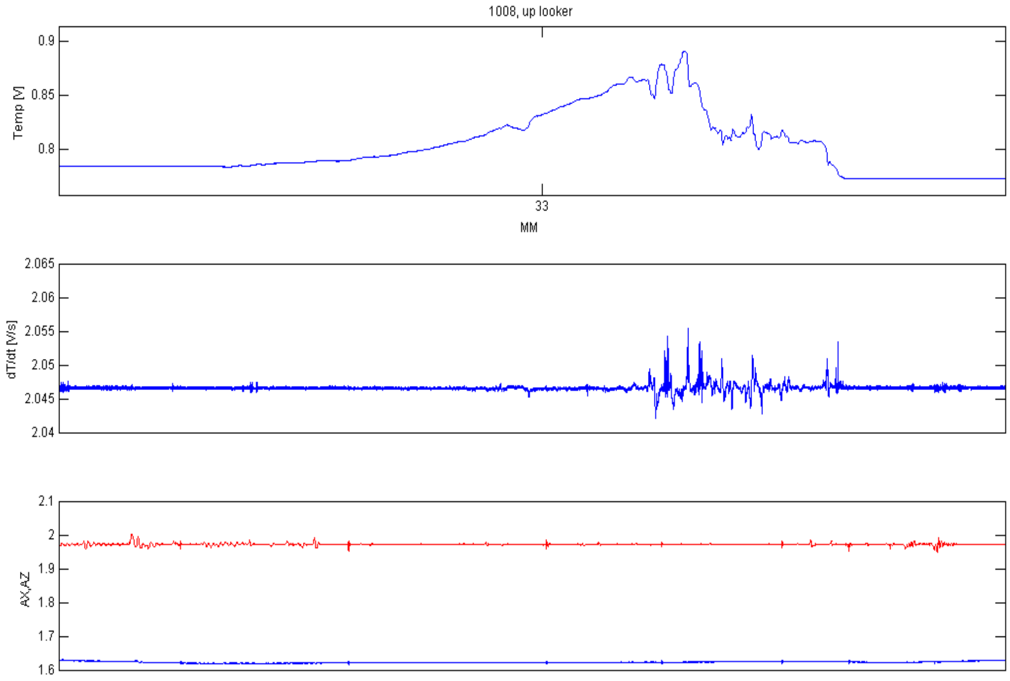

Figure 4 Pacific Summer Water

The Excell sheet named ChipodsFinal has a list of the cast, station name, time and date for each cast. For each sensor location (ie, downlooker, uplooker, uplooker+RBR) the electronics card number, sensor number and file name are listed. There is a loose smile/frown face system to indicate the visual inspection of the data at first glance; it was mostly for my diagnostic usage.

5.3 Side-of-ship ADCP

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

Figure 5. 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.

Data collected

In 2014, the over the side ADCP was used at 36 stations. Generally the ADCP was left in for the duration of the cast and deployments vary from 30 to 140 minutes. Brice Loose's in situ pump was run often at the same time by passing the hose over the ADCP frame and rigging. Some ADCP deployments were shortened due to conflicts with ice or other over the side gear and was recovered early.

During ***ADCP228_000000*** collected during Station CB2, CTD cast 13, the power/data cord was pulled and the connector may have been stressed. Following the cast, the connector was cleaned, the connector pins rebent and the cable redressed onto the Kevlar line with slack.

No detailed analysis of the collected data was made on board. Due to the clarity of the water and low current structure, the percentage good returns and current vectors appeared low. The data collected is not only for current measurement. Some of the data collected although incomplete for current speed information is still valuable for analyzing the backscatter for plankton studies.

5.4 XCTD Profiles

Operators: Yasuhiro Tanaka (KIT), Seita Hoshino (KIT), Sam Thomas (OSU), Alek Petty (OSU)
PIs: PIs: Koji Shimada (TUMSAT), Motoyo Itoh (JAMSTEC), Andrey Proshutinsky (WHOI), Rick Krishfield (WHOI), Bill Williams (DFO), (Yasuhiro Tanaka (KIT))

XCTD (Expendable Conductivity, Temperature and Depth profiler, Tsurumi-Seiki Co., Ltd. And Sippican) probes provided by JAMSTEC, WHOI, TUMSAT and DFO 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, Lockheed Martin WinMK-21 was used for XCTD deployment and for data conversion from raw binary to ascii data. Salinity, density and sound speed were automatically calculated during the data conversion. The types of XCTD probes used 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, 53 XCTDs were successfully launched, and 12 failed. Some of the working XCTDs had shortened profiles presumably due to broken wires. A large number of the failed probes were from a single carton and a recently passed expiration date, likely indicating the whole carton was suspect.

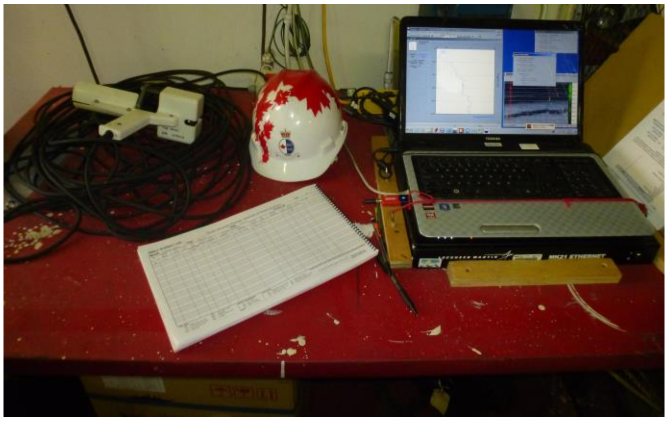

Figure 1: XCTD probe deployment from the ship's stern (2011) and XCTD setup showing launcher, log book, and laptop sitting on top of data converter Win MK-21.

5.5 Zooplankton Vertical Net Haul.

Mike Dempsey (DFO-IOS)
PI: John Nelson (Stantec)
Day Watch: Hugh Maclean (IOS), Sarah-Ann Quesnel (IOS),
Night Watch: Mike Dempsey (IOS), Sigrid Salo (NOAA)

A total of 20 bongo net hauls were completed at 10 stations. Bongos were deployed on the foredeck using a Swann 310 hydraulic winch and 3/16" wire through the forward starboard A frame. The sampling strategy was changed for 2014 given the late season sampling. Most of the adult zooplankton population was expected to have entered diaphase in deeper water than earlier in the year. Also due to the shortened duration of the cruise and past experience in sampling the JOIS grid, zooplankton plankton sampling was omitted from many stations. Sampling therefore was reduced to single 500m and 100m vertical net tows at 10 stations.
Samples were preserved as follows:

Cast 1 (500m):
- 236 µm

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

Cast 2 (100m):
- 236 µm into 95% ethanol
- 150 µm into buffered formalin (10%)
- both 53 µm combined to single be buffered formalin (10%) sample

See Appendix for table of samples and stations.

5.6 Microbial Community Structure and Dynamics

Deo Florence Onda, Robyn Edgar (ULaval)

P.I.: Connie Lovejoy (ULaval)

Introduction and objectives

The Canada Basin lost a significant extent of its multiyear sea ice cover over the summer of 2012, which resulted in stronger stratification especially in the surface, but also resulted in creating new waters in the northern Canada Basin. Arctic physical oceanography is a complex system and is strongly coupled with meteorological drivers. This coupling influences chemical and biological dynamics at different regional scales (McLaughlin and Carmack 2010; Nishino et al. 2011). Although the fate of the water masses entering the region and making up most of the Arctic waters has been seemingly studied and understood (Steele 2004; Proshutinsky et al. 2009; Yamamoto-Kawai et al. 2009), the consequences of such events on microbial communities have not been investigated. For example, it is currently not fully known how local conditions greatly affect or modify the diversity of microbial communities associated with a specific/certain water mass (e.g. Pacific water) as it moves from one region to another (i.e. Chuckchi sea to Canada Basin) and its implications to overall microbial community functions. With the rapid changes occurring in the Arctic right now, many ecological and biological questions still need to be resolved particularly in the field of microbial oceanography.

Past JOIS expeditions have provided opportunities to investigate eukaryotic microbial community structures in the unstudied northern sector of the Canada Basin. Samples collected on ice-free (2012) and ice-covered (2013) years provide contrasting views, which can be used to predict how microbial communities might change in response to the various ice scenarios. The use of high throughput sequencing technology coupled with bioinformatics analysis provides information on species diversity, composition, activity and community structure. This information can then be put into ecological context using correlations with relevant environmental factors.

In line with these, our objective for this year is to collect samples on the same sites visited in the past years to add an element of temporal/seasonal variation to further understand microbial dynamics. We also extended our sampling depth to the core of the Pacific Winter Water (PWW) in connection with recent field campaigns done in the western Arctic Ocean (USCG Healy) during the spring of 2014. This work will provide information on how local conditions influence local diversity within the same water mass by looking at overall community composition, possible perseverance with inactivity (dormancy) and potential survivability of the community.

Methodology

Samples were collected at stations that were mostly visited in 2012 and 2013 with the addition of the core of the Pacific Winter Water (Table 1). Samples were collected at 4-8 depths per station to increase vertical resolution in investigating genetic variation and possible community niche partitioning. Additional samples from deep waters (~3800 m) and ice cores were also collected for other possible investigations.

Sampled depths were selected based on water column characteristics profiled by the downcast of the CTD of the maindeck rosette. Typical depths include surface (~6 m), mixed layer (~20-30 m), subsurface chlorophyll maximum (SCM), below SCM (SCM + 10m), 100m-depth and the PWW characterized by 33.1 psu. DNA/RNA, DAPI, FISH, FCM and chlorophyll samples were collected at all depths while FNU samples only targeted the surface and SCM samples.

DNA and RNA

DNA/RNA samples from large (>3 µm) and small (0.22 -3 µm) fractions were collected by filtering 6L of seawater at room temperature, first through a 3.0 µm polycarbonate filter, then through a 0.22 µm Sterivex unit (Millipore). Large fraction samples were placed in 2-mL microfuge tubes. All filter samples were immersed in RNAlater solution (Ambio) and left for at least 15 minutes at room temperature before being stored at -80°C.

Fractionated Chlorophyll-a

Samples were collected for phototrophic biomass estimate using chlorophyll-*a* as the proxy. The total fraction chl-*a* samples were obtained by filtering 500 mL of seawater at each station and depth sampled through 0.7 µm GF/F filters (Millipore). The 0.7-3µm fraction chl-*a* samples were obtained by pre-filtering 500 mL of seawater through 3 µm polycarbonate filters before filtering through 0.7 µm GF/F filters. All samples were wrapped in foil, labelled and stored at -80°C until ethanol extracted for chl-*a* analysis onshore (ULaval).

Epifluorescent Microscopy

Samples for biovolume estimation, abundance and gross taxonomic classification by microscopy were collected and preserved as described by Thaler and Lovejoy (2014) at each station and depth sampled. In summary, 100 mL seawater is fixed in 1% glutaraldehyde (final concentration), filtered onto a 25 mm, 0.8 µm black polycarbonate filter (AMD manufacturing), stained with DAPI (1 mg/ml, final concentration) and mounted on a glass slide with oil. Slides are stored in opaque boxes and kept frozen until analysis at ULaval.

Fluorescent in situ Hybridization (FISH)

FISH is a technique that uses fluorescent-labelled nucleic acid probes to identify specific phylogenetic group 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 % (final concentration) formaldehyde (Sigma-Adrich) and processed within 1-6 hours after sampling. For eukaryotic organisms, 100 mL of fixed sample was filtered onto a 0.8 µm polycarbonate filters (AMDM) and for bacteria, 25 mL was filtered onto 0.2 µm polycarbonate filters (AMDM). Filters were air-dried and stored at -80ºC until analysis in the laboratory.

Conventional Light Microscopy

At each station, at the surface and SCM, 225 mL of seawater was collected and 25 mL FNU, a mixture of glutaraldehyde and formaldehyde with adjusted pH prepared before the cruise, was added as the fixative. Samples were stored in 4ºC refrigerator and in the dark until further analysis. Larger organisms, such as diatoms and dinoflagellates, will be identified to the highest possible taxonomic level using a sedimentation technique in an inverted microscope at ULaval.

Live culture and single-cell genetics

We also attempted to collect and maintain live cultures of phytoplankton and fixed samples for single-cell genetics, particularly the larger species such as dinoflagellates and some ciliates. Two liters of samples from the SCM and PWW were gravity filtered through 3 µm polycarbonate filters, and then the filters were re-suspended in 350 mL of 0.2 µm filtered nutricline water. The samples were first grown in PWW seawater for a few days to prevent rapid enrichment of unwanted species. Then 1 mL of 10x f/2 solution was added in cultures grown in clear culture bottles after a few days. Live samples were stored on 4°C walk-in cold room illuminated with fluorescent lights in a 12:12 light-dark cycle. Samples were transported immediately to ULaval right after the campaign.

Large cell fractions (>3 µm) were also collected and fixed following the same procedure described above, but filters were suspended in 5 mL 0.2 µm filtered seawater and added with 1 mL TE-glycerol stock. Samples were incubated for at least 30 minutes with the preservative at room temperature before being stored at -80ºC. Cells preserved in this manner will be singularly picked and be used for genetics/genomic studies.

Bacterial and pico-nanoeukaryote cell count

Cell counts of both prokaryotic (<2 μm) and photosynthetic pico-nanoeukaryotes (2-10 μm) will also be estimated by flow cytometry. An aliquot from each sample were fist collected in 50 mL falcon tubes, then under the hood, 1.8 mL seawater were added to 200 μl 10% glutaraldehyde in 2 mL cryogenic vials. Samples were first incubated in room temperature for at least 30 minutes and then flash frozen in liquid nitrogen before being finally stored in -80ºC until transportation to ULaval. Before counting, bacterial nuclear material is stained with Sybr Green I (Life Sciences) while photosynthetic eukaryotic cells are detected by chlorophyll autofluorescence.

Summary

A total of 141 samples from different depths at 23 stations including ice cores were collected during this expedition. With more depths and samples, a higher resolution investigation microbial community partitioning and diversification can be carried out.

Locations of microbial diversity stations. – See Appendix

At each station, 3-8 depths were sampled and were defined as either: surface (usually ~ 5 m), mixed layer (~25 m), subsurface chlorophyll maximum, below SCM (SCM - 10 m), 100m-depth and the core of the Pacific Winter Water (33.1 psu).

Issues

In previous years, the ULaval team has been provided with a 12-bottle rosette deployed in the foredeck dedicated to the needs of the program. However, the later date of the campaign this year as compared to previous years limited the possibility of foredeck work due to harsh conditions. Thus, as agreed with the IOS group, we were given some dedicated bottles (2-3) in the maindeck rosette during full-depth casts and a short cast on our own as time permits in our selected target stations. However, the 2-3 bottles corresponding to 2-3 depths were only half the number of our target depths. To partially resolve the issue, we tried to collect excess waters on other bottles that were on the same depth as ours (i.e. surface, ML, below SCM). The volume of water however was not enough to fill in the needs of the program. For example, to perform all the protocols described above, ~9.0 l of water is needed, however, we were only able to collect 3.5 to 6L in some bottles. The protocols for microscopy were always performed along with DNA but due to water shortages, we needed to skip Chl a protocols for some depths in some stations. The volume of 6L usually needed for the DNA/RNA application is due to the low amount of nuclear material available. The viability of samples collected for DNA/RNA using a lesser volume of water will be tested once samples are already in the laboratory.

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Nishino, S., Kikuchi, T., Yamamoto-Kawai, M., Kawaguchi, Y., Hirawake, T., & Itoh, M. (2011a). Enhancement/reduction of biological pump depends on ocean circulation in the sea-ice reduction regions of the Arctic Ocean. *Journal of Oceanography*, 67:305–314.

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Please see full report for list of stations sampled and depths

5.7 ^{222}Rn and Ra sampling aboard JOIS 2014

B. Loose, R.P. Kelly (University of Rhode Island)

Motivation:

We are trying to determine the gas transfer velocity (k) as a function of 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. 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.

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.

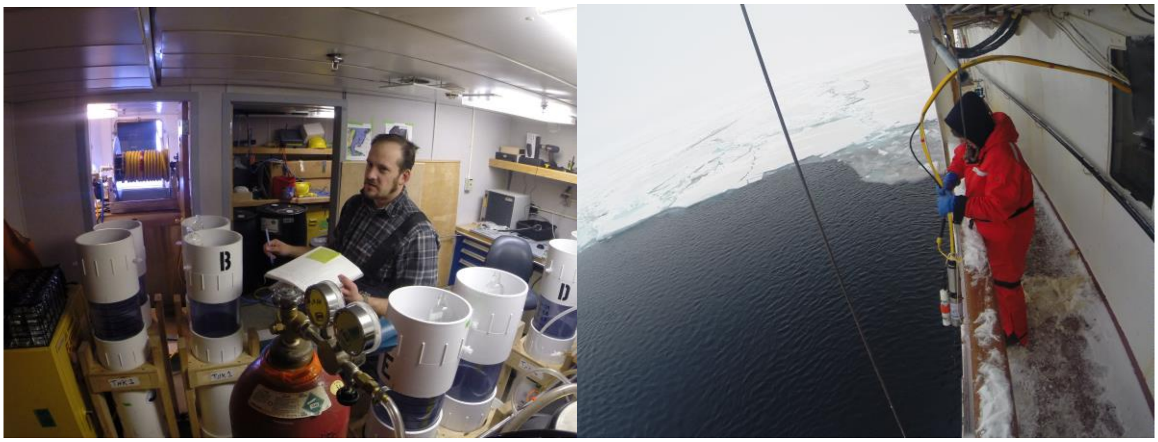


Figure 6. Scenes from the radon extraction lab – labs C, D and E, near the nurse's station.

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 PVC hose, attached to a mechanical hose reel that was mounted in Lab C. The sample pump was lowered out the wind of the lab and over the side using a PVC roller (See Figure 6). 200 L of surface water were collected in barrel containers at each station.

Analysis

The ~200L seawater sample 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

Approximately 26 L 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 94 m of the ocean surface layer. Rn/Ra profiles were collected at the following hydrographic stations: CB-31b, CB-27, STA-A, CB-6, CB-7, CB-5, TU-1, TU-2, CB-8, CB-13, PP-07, CB-17, CB-40, CB-50, CB-29, and CB-28b. Water samples for salinity were also collected at each depth where a Keybler was filled.

It is common for the ship to use 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. We attempted to avoid sampling the surface just after bubbling and notes were taken at each station to indicate whether any bubbling had taken place in close proximity to our sampling. The bubblers were not used as much in 2014 as in 2013, in part because the ship found it easy to rest against the ice and hold position by having the wind blow the ship against the ice. 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.

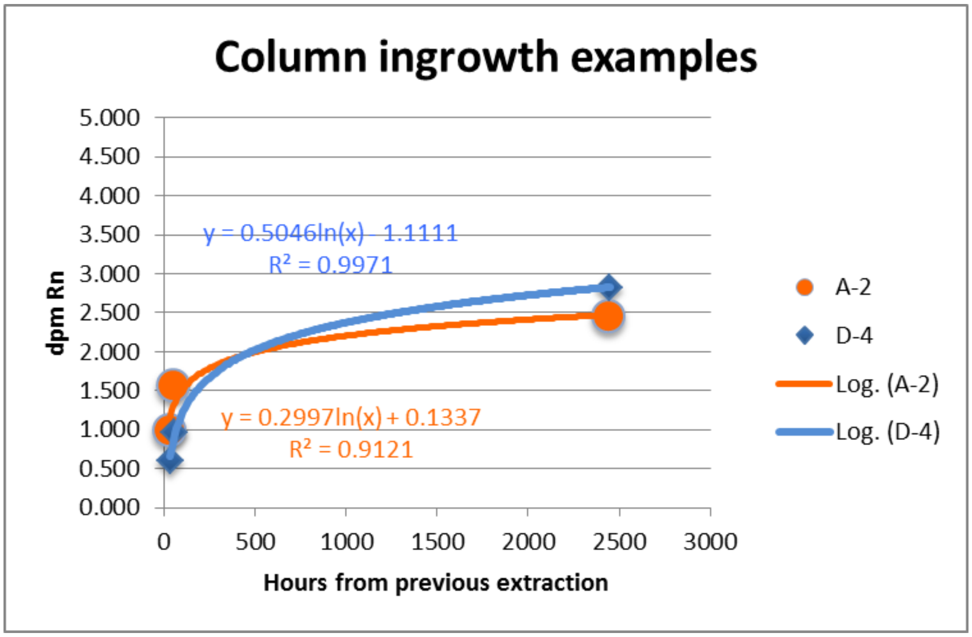


Figure 7. The background on the radon extraction and measurement system, plotted as a function of time to reflect radon ingrowth on charcoal containing radium.

Problems and Solutions

During the course of laboratory analysis of 2013 Radium data, R. Kelly discovered that the most significant source of background radon appears to originate from the charcoal material that is used to cold trap the radon. Consequently, the radon accumulates on the trap as a function of the time between the current extraction and the previous extraction. To attempt to constrain this ingrowth of background, we performed an extraction of ingrown radon at three time periods - immediately once we got on the ship, which corresponded to an ingrowth period of 3000 hours, at 24 and at 48 hours. These backgrounds follow an an empirical logarithmic ingrowth equation which stabilizes at an equilibrium values within 500 hours of the last extraction (see Figure 6). Occasionally, a Keybler will leak or air will be introduced to the system. We were concerned with knowing if the lab air is a source of radon. If not, lab air can be treated as a carrier gas and used just as helium is. To determine the radon content in lab air we evacuated 4 Keyblers and then filled them with lab air. After filling with lab air we performed a typical two hour extraction, recirculating the air through the charcoal columns in the propanol + dry ice slurry for 120 minutes. This resulted in 0 to 1.7 dpm/100 L of air. In the worst case, a maximum of 6L of air can leak into the tank, and increase the total radon in the tank by at most ca. 2%.

Preliminary Data

Ice samples at Ice Station 1.

At the first ice station, duplicate sea ice cores were collected for Rn/Ra analyses. We are interested in knowing what the Rn and Ra content is in typical sea ice cores. The expectation, because of low gas diffusion through sea ice, we expect radon and radium to be in equilibrium within sea ice. We don't have the radium sample analysis completed yet, but the radon results indicated that activity was 3.5 and 3.3 dpm/100L of melted ice. This is approximately. The salinity of these melted water samples were 11 and 16 psu, which is a little high for sea ice, indicating that some slush may have been included in our samples. If we assume that the average activity in the mixed layer beneath the ice was 10 dpm/100L, we observe that activity is reduced to 1/3 water column activity and this is consistent with what we expect from solute rejection.

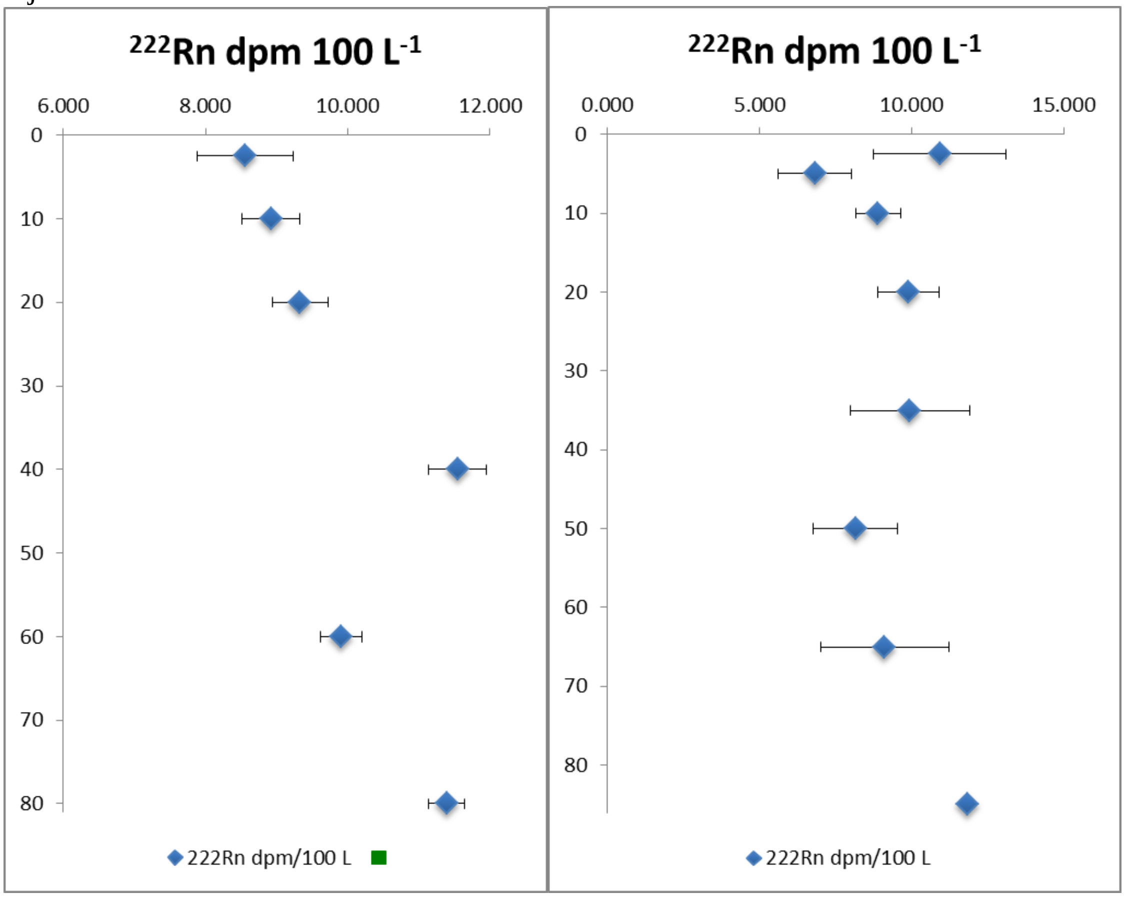


Figure 8. Profiles of radon-222 from station CB-17 (left side) and CB-27 (right side). The ice cover at CB-17 was approximately 90% or more, but with many fractures and recent wind. Ice cover at CB-27 was greater than 90%, with recent ice growth. The recent ice growth appears to produce an excess of radon in the near surface layer, possibly as a result of brine rejection. Both stations may need to be corrected for recent mixed layer deepening and possible sea ice formation, which affect the radon concentration and produce an "artificial" excesses.

5.8 Microplastics sampling

Sarah-Ann Quesnel (DFO-IOS)
P.I.: Peter Ross (Vancouver Aquarium)

Summary

Plastic debris are now ubiquitous in our marine environments. They are separated in two main categories: macroplastics (> 5 mm) and microplastics (< 5 mm). Larger, macroplastic debris distribution and threat to the marine biota are fairly well documented. On the other hand, less is known on the distribution and possible detrimental effects on the marine biota.

The scope of this sampling effort during the JOIS 2014 expedition is to define the spatial distribution of microplastics at the surface (0-10 m) in the Arctic Canada Basin, and obtain a few depth profiles and ice cores, if logistics permit.

In total, 16 samples were collected from 3 stations, CB-21, CB-4, CB-9, in the Canada Basin for depth profiles (Table 1). An additional 6 samples were collected from the seawater loop system at 6 stations, AG-5, CB-1, CB-6, CB-4, TU-1 and TU-2 for surface distribution (Table 2). Finally, 10 samples were collected from 2 ice cores at 2 Ice-Based Observatory (IBO, Table 3).

Sampling method

For depth profile samples, 2 to 4 niskin bottles from the CTD/Rosette, fired at the same depth, were collected together through a brass #230 mesh sieve (pore size = 0.0625 μm, Hogentogler & Co Inc.). To confirm at which depth the bottles were tripped, a salinity sample was collected from every niskin prior to microplastic sampling, which took roughly 300 mL of sample water from each niskin. The sieve was then washed with filtered seawater to decant the particulate material > 0.0625 μm into a 20 mL scintillation vial with the help of a glass funnel, giving a total sieved volume of 20.36-40.72 L per sample. The average volume ± standard deviation of the niskin bottles minus the salinity sample volume was estimated to be 10.18 ± 0.14 L, by filling 4 of them with water, taking a pseudo salinity sample from each, and then measuring the remaining volume from each with a graduated cylinder.

For seawater loop (surface) samples, seawater from the CDOM sensor line was sieved onto #230 mesh sieve, for approximately 20 minutes, either coming onto or leaving station, giving a total sieved volume of ~67-78 L per sample. The engine room control was advised so they could turn off the sewage discharge during sample collection. The particulate matter collected on the sieve's mesh was transferred to 20 mL scintillation vials as described above. Flow rate of the CDOM sensor line outflow was measured after each sample collection using a graduated 20 L bucket and a stopwatch.

Two ice cores (1 per IBO) were collected for microplastic samples. Each core was cut in smaller pieces for easier transport and melting, with each piece resulting in one sample. The samples can either be analyzed individually to determine microplastic vertical distribution within the ice floe or combined by ice core to determine if microplastics concentrate in sea ice. Each core piece was melted in either stainless steel pot (+ rinsed ziplock for cover) or simply in the rinsed ziplock it was collected in on the ice stations. Melting of each piece took ~ 24 hours, after which the sample water was sieved through #230 mesh sieve. The sieved water was collected in a tote to measure its temperature and the water was then poured into a graduated cylinder to measure volume. The stainless pot and/or ziplock bags were then rinsed 3 times with filtered seawater and sieved through the #230 mesh. The particulate matter collected onto the mesh was then transferred to 20 mL scintillation vials as described for the depth profile samples. Three blanks were prepared to account for plastic particles that could originate from the plastic ziplock.

All samples were collected by Sarah-Ann Quesnel (DFO-IOS) and stored in the dark, in the 4°C walk-in cooler until the ship arrived in St-John's, where the samples were shipped back to IOS (Sidney, BC).

See Appendix for sample location.

5.9 Underway Measurements

Sarah Zimmermann (DFO-IOS)

P.I.s: Bill Williams, Svein Vagle (DFO-IOS), Celine Gueguen (TrentU)

Underway measurements summary:

- The seawater loop system:
  a. Electronic measurements of salinity, temperature (inlet and lab), fluorescence for Chlorophyll-a, fluorescence for CDOM, gas tension, and oxygen concentration. *Please see pCO_2 section by Cory Beatty (UMontana) for underway measurements of pCO2.*
  b. Water samples were drawn for salinity, CDOM, d2H, microplastics, DIC and alkalinity.
- 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 9 m 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, a small lab just off the main lab where a manifold distributes the seaweater to instruments and sampling locations (Figure 1). 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.

Figure 9. Seawater loop system
The seawater loop provides 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.

Autonomous measurements

- ***SBE38: Inlet Temperature s/n 0319:*** the 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 sensor, 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 sensors. 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, GTD) 40 seconds 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-IOS).
- ***SBE48: Hull Temperature:*** This sensor was installed below waterline on the inside of the ship's hull. No thermo-coupling grease was used when it was mounted onto the hull's painted surface. Temperatures are an approximation of sea-surface temperatures.

The flow rate was set to maintain a pressure of 18 PSI with safety shut off at 35% to protect the pump (ie pressure at pump should not be more than 35% higher than 18 PSI). Readings of the manifold were typically 18 PSI and 25% output on open water and light ice. In thick snow covered ice the pump would regularly shut itself off maxing out at 35%.

A flow meter was repositioned this year, installed on the line running to the blue cooler. The flow was typically fast enough to be measured by the flowmeter however there was a period where there was flow above the threshold level but the flow meter read zero flow, appearing stuck.

Discrete water samples were collected for salinity, CDOM, d2O, microplastics, and DIC/alkalinity at select locations. The salinity and DIC/alkalinity are to calibrate the corresponding sensors.

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 (S/N 10350, calibration date 2/27/2007), was mounted on the 05 deck, above where the rosette operations are performed (03 deck). The sensor was located directly next to the surface reference PAR connected to the CTD deck unit. The view is unobstructed approximately 300deg. The blocked areas are due to the ship's crane, approximately 50 feet aft and inboard of the sensors and the ship's smoke stack approximately 50 feet forward and inboard. Both PAR sensors were cleaned once a day at approximately 0800 local. Data was sampled at 1/5 second intervals but averaged and recorded at 1 minute intervals.

Issues with the underway system and 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 and 48 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.

- Due to sea-ice conditions the seawater pump often lost flow 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. Once restarted it takes approximately 10minutes for the lab TSG to stabilize.

5.10 Moorings and Buoys

Rick Krishfield (P.I., WHOI), John Kemp, Jeff O'Brien, Meaghan Donohue (WHOI) and Cory Beatty (UMontana).
P.I.s not in attendance: Andrey Proshutinsky, John Toole (both WHOI) and Mary-Louise Timmermanns (YaleU)

Summary

As part of the Beaufort Gyre Observing System (BGOS; www.whoi.edu/ beaufortgyre), three bottom-tethered moorings deployed in 2013 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in September 2014 from the *CCGS Louis S. St. Laurent* during the JOIS 2014-11 Expedition. Furthermore, two similar moorings (labeled GAM-1 and GAM-2) which were recovered to the west of our array in 2013 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 redeployed this cruise. Two (out of three planned) Ice-Tethered Profiler (ITP; www.whoi.edu/itp) buoys were deployed on ice floes with Ice Mass Balance (IMBB) and atmospheric chemistry O-Buoys, and three ITPs with MAVS current probes were also recovered. A summary of moorings and buoys deployed and serviced are listed in Tables 1 to 3.

Table 2. Mooring recovery and deployment summary.

Mooring Name	Bottom Depth (m)	2013 Location	2014 Recovery	2014 Deployment	2014 Location
BGOS-A	3830	74° 59.5738' N 149° 58.8354' W	30-Sep 16:39 UTC	1-Oct 22:21 UTC	75° 0.137' N 149° 57.322' W
BGOS-B	3830	77° 59.5161' N 150° 3.2380' W	7-Oct 20:18 UTC	9-Oct 00:28 UTC	78° 0.6177' N 149° 59.8203' W
BGOS-D	3530	73° 59.7817' N 139° 57.3017' W	26-Sep 20:01 UTC	27-Sep 21:20 UTC	74° 1.853' N 140° 3.741' W
GAM-1	2103			3-Oct 22:39 UTC	76° 0.145' N 160° 8.749' W
GAM-2	2222			4-Oct 21:45 UTC	77° 0.031' N 170° 3.051' W

Table 3. Ice-Based Observatory buoy deployment summary.

IBO	ITP / Buoy System	Date	Location
1	ITP85 / IMBB/ O-Buoy11	7-Oct 23:29	79° 2.1' N 149° 58.5' W
2	ITP84 / S-IMBB / O-Buoy12	11-Oct 1:15	76° 1.9' N 139° 48.7' W

Table 3. Ice-Tethered Profiler buoy recovery summary.

Recovery	ITP	Date	Location
1	ITP79	30-Sep 23:30	75° 2.6' N 148° 28.2' W
2	ITP77	2-Oct 18:33	75° 53.1' N 158° 28.7' W
3	ITP71	12-Oct 18:07	75° 10.9’ N 139° 47.3’ 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 BGOS 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 incorporated an acoustic wave and current profiler (AWAC) provided by the University of Washington (only one was redeployed on mooring D). On redeployment, assorted

Microcat CTDs, SAMI-CO_2, SAMI-pH, and McLane Remote Access Samplers (RAS) were added to moorings A and B, while only MIcrocats were added to mooring D.

Eleven years of data have been acquired by the mooring systems, which document the state of the ocean and ice cover in the Beaufort Gyre. The seasonal and interannual variability of the ice draft, ocean temperature, salinity, 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 recovered 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. After refurbishment over the winter, these moorings were redeployed this 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 2 Ice-Tethered Profiler buoys (or ITPs), and assisted with the deployments of one Environment Canada IMBB, one US Army CRREL Seasonal IMBB, and two O-Buoys. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).

The centerpiece ITPs obtain profiles of seawater temperature and salinity from 7 to 760 m twice each day and broadcast that information back by satellite telephone. The 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 (Table 4).

Table 4. Project websites

Project	Website Address
Beaufort Gyre Observing System	www.whoi.edu/beaufortgyre
Beaufort Gyre Observing System dispatches	www.whoi.edu/beaufortgyre/2014-dispatches
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	http://imb.crrel.usace.army.mil/
O-buoy Project	www.o-buoy.org

The acquired CTD profile data from ITPs documents interesting spatial variations in the major water masses of the Canada Basin, shows the double-diffusive thermohaline staircase that lies above the warm, salty Atlantic layer, measures seasonal surface mixed-layer deepening, and documents 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. On the first mooring (D), faulty releases prevented a complete survey of the anchors, but were able to release the moorings when commanded. 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 (upward looking sonar), all ADCPs, one AWACS (acoustic wave and current profiler), every BPR (bottom pressure recorder), and all three sediment traps collected samples for the duration of the deployment. One AWACS obtained only a partial year record due to a faulty cable. Four out of five MMPs were recovered with full year-long profiler data records (although one system had intermittent velocity measurements), the fifth MMP profiled until November when it succumbed to a hardware fault.

The GAM mooring deployment operations were conducted in the same manner as the BGOS mooring deployments, but consumed only 2-3 hours as the mooring systems are half a long as the BGOS systems. During the first GAM deployment, the mooring was released in water too shallow so that the top sphere was only 5-10 m from the surface. An attempt to hook the mooring was unsuccessful, so the following day, this mooring was recovered completely undamaged and intact, and redeployed at the proper depth with the spare anchor.

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 6-7 hours each including transportation of gear and personnel each way to the site. Ice analyses were also performed by others in the science party while the IBO deployment operations took place. At one site, the ship's gangplank was able to be lowered onto the ice to allow the personnel to walk down to the floe instead of requiring helicopter transport. Three ITP systems (with MAVS current probes) were also recovered this cruise, and one Acoustic Navigation System (ANS). The recoveries were conducted using the ship's A-frame to haul out the instrumentation after the icefloes containing the buoys had been strategically smashed and the systems released into the open water.

Other

Dispatches documenting all aspects of the expedition were posted in near real time on the WHOI website at: www.whoi.edu/beaufortgyre/2014-dispatches

5.11 pCO2 and pH

Cory Beatty (UMontana)
P.I.: Mike DeGrandpre (UMontana)

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

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 (ITPs). Placed on the ITP cable just under the ice, the sensors will send their data via satellite using the WHOI ITP interface.

Figure 10. SAMI-CO_2-SAMI-pH and Seabird Microcat w/ dissolved Oxygen deployed on ITP 85 during the first ice station.

Cruise Objectives

1. Deploy 3 pCO_2 and 1 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 Seabird Microcat equipped with a dissolved oxygen sensor on each ITP.
4. Deploy 1 SAMI pH on the BGOS-A mooring and 1 SAMI-CO_2 on the BGOS-B mooring.
5. Assist with other shipboard research activities and to interact with ocean scientists from other institutions.

Cruise Accomplishments

We deployed a SAMI-CO_2 -SAMI-pH sensor pair as well as a Seabird Microcat equipped with a dissolved Oxygen sensor on ITP 85 at the first ice station (Figure 1) and the second SAMI-CO_2 & Seabird Microcat with dissolved Oxygen sensor at the second ice station. Due to time restraints, the third ITP was not deployed, so the third SAMI-CO_2/Microcat combo was not deployed. We collected underway pCO_2 data using an infrared equilibrator-based system (SUPER-CO_2, Sunburst Sensors). The instrument was connected to the ship's seawater loop line manifold located in the TSG laboratory. We also deployed a SAMI-pH on the BGOS-A mooring and a SAMI-CO_2 on the BGOS-B mooring. The sensor data collection is summarized in Table 1 below.

Table 5. pCO_2 and pH sensor data collection summary

Measurement system	Instrument IDs	Location	Duration
underway infrared-equilibrator pCO_2	SUPER (Sunburst Sensors)	Entire cruise track (see IOS report in this document)	9/24/14-10/16/14
ITP SAMI-CO_2 & ITP SAMI-pH including PAR, Seabird Microcat w/ DO sensor	WHOI ITP #85, SAMI-CO2 C87, SAMI-pH P130	First Ice station, pH ~6 m depth CO2 ~ 9 m depth, Microcat ~ 8 m depth (see WHOI cruise report in this document)	10/6/14-present
ITP SAMI-CO_2 including PAR & Seabird Microcat w/ DO	WHOI ITP #84, SAMI-CO2 C88	Second ice station CO2 ~6.5 m depth, Microcat ~ 8m depth (see WHOI cruise report in this document)	10/11/14 – present
SAMI-pH	S47	BGOS-A mooring	9/30/14 – present
SAMI-CO2	C38	BGOS-B mooring	10/8/14 - present

5.12 O-buoy Deployment and Recovery

John W. Halfacre
PI: Paul Shepson (Purdue University)

Pre-deployment Assembly and Testing of OB11 and OB12 (24 September-10 October 2014)

Mast was assembled on top of the hangar. Lifting of the instrument tube out of the crate was scheduled with the boatswain. The lifting of the tube out of the crate was immediately followed by attaching the flotation collar. The mast was then assembled by attaching instrument sensors / intakes, and connections were made from mast cables to the instrument tube. The buoy was turned on for testing. As the buoy shipped with the rechargeable lead-acid batteries fully charged, the buoys were allowed to stay powered until ~ a couple days before deployment (7 days for OB11, 12 days for OB12). The O-Buoy team remotely verified function of all instruments. Two days prior to probable deployment, the mast was disconnected and the plywood cover put on the instrument tray. For OB11, the 250 pound ballast was attached at this time (Figure 1). For OB12, the ballast and seawater module were attached on the ice (discussed below in Sect. 1.1.1.3.

Figure 1. OB11 deployment
Ballast (new style) was attached on the ship pre-deployment.

OB11 Deployment on 6 October 2014

Figure 2. OB11 deployment

Left: John Halfacre (Purdue) and John Kemp (WHOI) drilling the O-Buoy hole in the ice. Right: O-Buoy body is guided into position by Leo Rose (CCG).

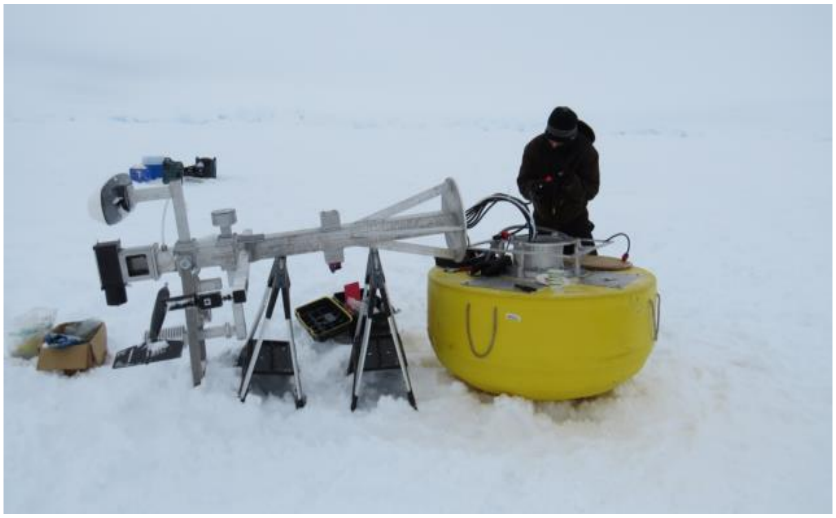
Location: 79 N 150 W

Weather: Overcast. occasional wind gusts, and temps around -10°C.

2100 UTC: We, with the assistance of the WHOI team, prepped the site for deployment of the O-buoy by auguring a 22 inch hole with the Little Beaver auger. Ice thickness was 2.7 m. The buoy was then slung out to the floe via helicopter and guided into position with help from Leo Rose (CCG), Rick Krishfield (WHOI), and Cory Beatty (WHOI).

2230 UTC: The assembled mast and solar panel box were slung out separately. The first step was to set the mast up next to the deployment site on sawhorse, make the mast connections, attach the DOAS scanhead, and bolt the mast to the buoy body with the assistance of Mike Dempsey (IOS) and June Marion (Oregon State). Next, the solar panels were installed and attached to the charge controller. Power connections were made and the buoy turned on at 0130 UTC. Pictures of the mast were taken.

Figure 3. OB11 deployment



Left: John Halfacre (Purdue) making connections from mast sensors to tube.

0300 UTC: Returned to the ship via gangplank. 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.

OB12 Deployment on 11 October 2014

Location: 76 N 140 W

Weather: Overcast. Calm winds. Snowy. Temps around -10°C.

1900 UTC: We, with the assistance of the WHOI team, prepped the site for deployment of the O-buoy by auguring a 22 inch hole with the Little Beaver auger. Ice thickness was slightly less than 1 m. The buoy tube and flotation collar were then slung out to the floe via helicopter, laid on the ice sideways, and disconnected from the helicopter. The seawater module connections were made to the buoy tube, and the module was attached via carabiner. Care was taken to blow snow out of the seawater module inlet tubing. The ballast was attached by running a clip through the eye-bolt attached to the ballast. The ballast was then slid into the auger hole, followed by the seawater module. The seawater module was held ~1 minute underwater to purge it of air before it stayed underwater on its own. The buoy tube was then pushed as close to the hole as possible with help from Leo Rose (CCG). When the helicopter returned, the tube was re-slung and slowly lifted, such that it could be guided into the hole with minimal movement.

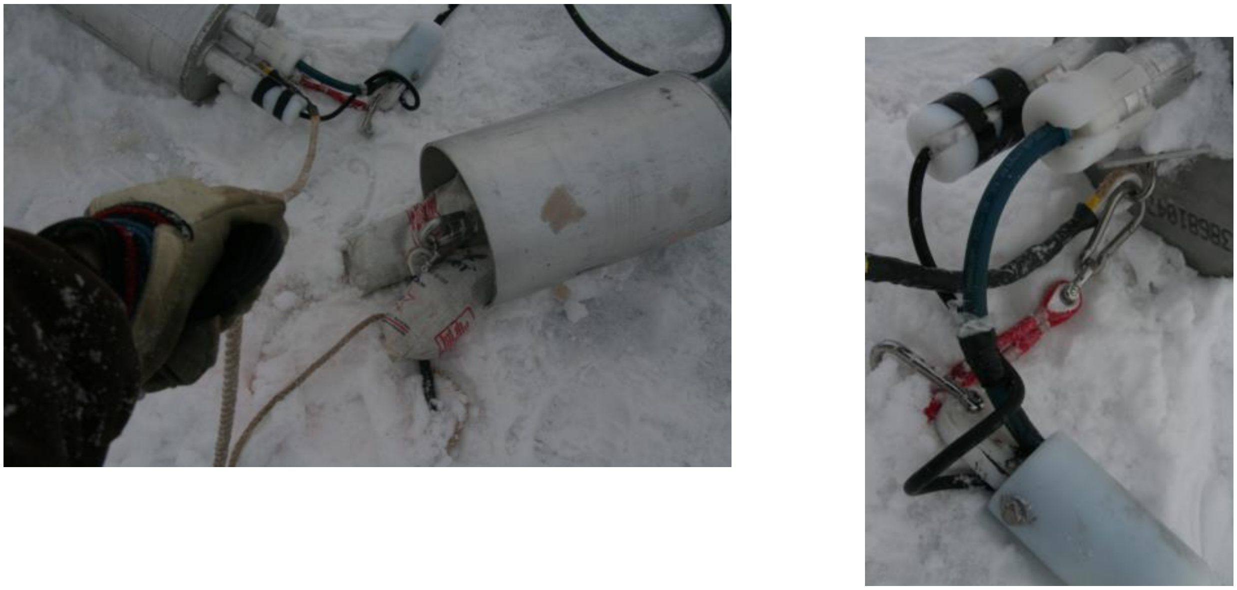


Figure 4. OB12 deployment

Left: Connections made from buoy tube to both seawater unit and ballast. Right: Alternate angle.

<u>2030 UTC:</u> Once installed in the ice, buoy assembly occurred as before. The assembled mast and solar panel box were slung out separately. The first step was to set the mast up next to the deployment site on sawhorse, make the mast connections, attach the DOAS scanhead, and bolt the mast to the buoy body with the assistance of June Marion (Oregon State) and Mike Dempsey (IOS). Next, the solar panels were installed and attached to the charge controller. Power connections were made and the buoy turned on at 2230 UTC. Picture of the mast was taken and a bearing verified in the direction of the GPS arrow with a handheld GPS.

Figure 5. OB12 deployment

June Marion (Oregon State University) and Mike Dempsey (IOS) assisting with solar panel array assembly.

2300 UTC: Returned to the ship via helicopter. 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.

Figure 6. OB11/12 deployment

Left: Complete OB11. Right: Complete OB12.

5.13 RAS (Remote Access sampler) deployment

Representative: Yusuke Ogiwara (Tokyo University of Marine Science and Technology)
PI: Michiyo Yamamoto-Kawai (Tokyo University of Marine Science and Technology)
Contact to us ; michiyo@kaiyodai.ac.jp

Summary

A Remote Access Sampler (RAS) was installed on two of BGOS mooring arrays and deployed at BGOS-A and BGOS-B stations to collect discrete water samples over a year. These samples will be used to for the study of seasonal variations of surface ocean acidification and nutrients (nitrate) cycles.

Each RAS was installed with 48 sample bags and was set to collect 450mL of seawater at 8 days intervals. The RAS will be recovered during the JOIS 2015 cruise and the samples will be analyzed for $\delta^{18}O$, nutrients, salinity, DIC and Total Alkalinity. Additionally, RAS deployed at BGOS-B was installed with 2 devices. One is WQM: Water Quality Monitor (Wet Lab.).This equipment has sensors for conductivity, temperature, pressure, dissolved oxygen, fluorescence and turbidity. Other one is SUNA-V2, a nitrate sensor (SATLANTIC). These sensors will collect data at 12 hours intervals.

Equipment and sampling details

RAS is a time-series sampler that autonomously collects up to 48 individual max 500ml in situ water samples. Figure 1 illustrate the major components and mechanical design of the RAS.

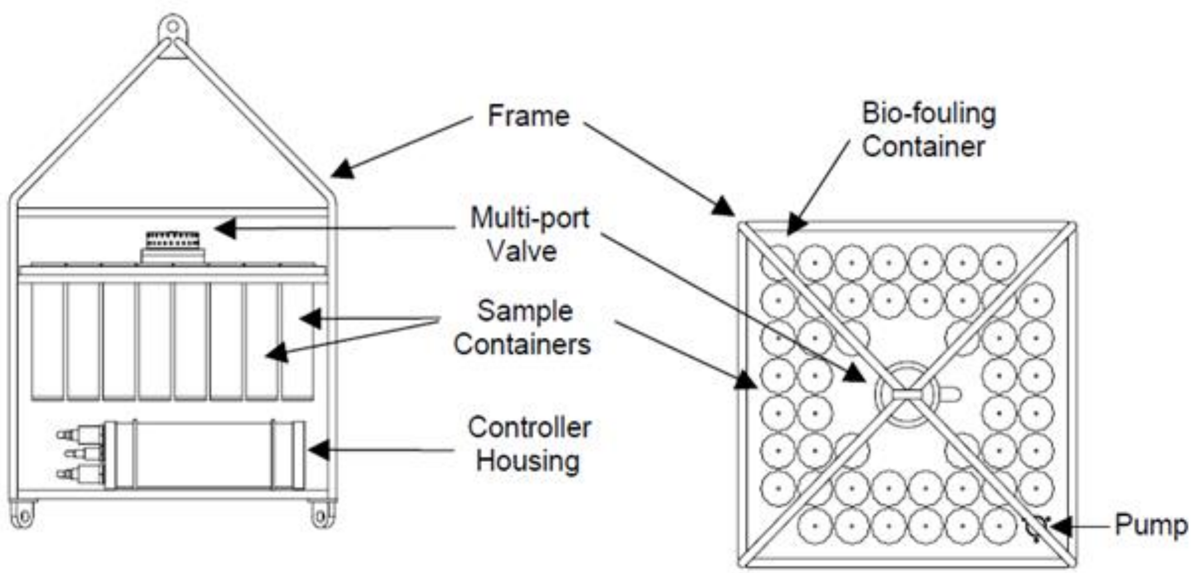


Fig.1-1 RAS Line Drawing –Overall View

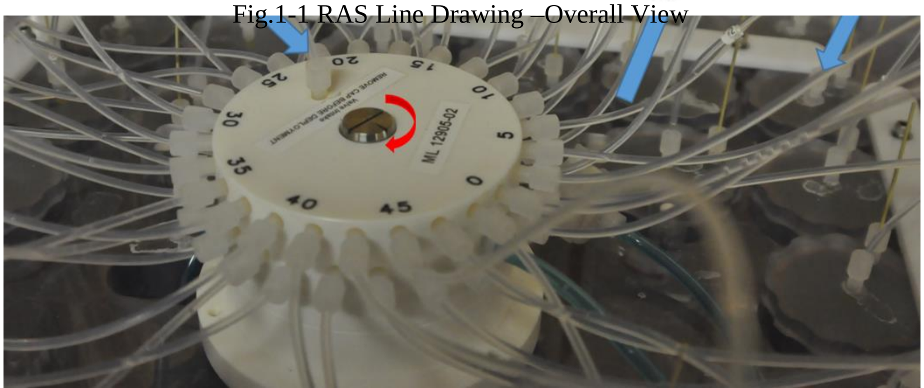


Fig.1-2 seawater pass ways into sample bags from sampling tube

The RAS setting is summarized in Tables 1 and 2. Each RAS was set to collect 48 of 450 mL seawater samples at 8 days intervals. 400 µL of saturated $HgCl_2$ was added to each sample bag before the deployment. Sampling tubes between the multi-port valve and sample bags are filled with salty water made of DMQ with NaCl to have salinity of ~40 and poisoned with $HgCl_2$ ($HgCl_2$ concentration is 0.05%). Before adding $HgCl_2$, this water was sampled for $\delta^{18}O$ and salinity analysis for the correction to make after the recovery of RASs.

RAS (BGOS-B)	
sirial No.	ML12905-02
sampling start date	UTC /Oct/2014 UTC 2:00
sampling interval time	8days
sample bags	48
sample volume	450ml
filter	none

Table.1 RAS(BGOS-A) setting

For BGOS-B, a filter (GF/F) was installed for each sample bag and the 2 devices, SUNA and WQM were mounted on RAS frame.

RAS (BGOS-B)	
Sirial No.	ML12905-01
sampling start date	UTC 08/Oct/2014 UTC 4:00
sampling interval time	8days
sample bags	48
sample volume	450ml
filter	GF/F

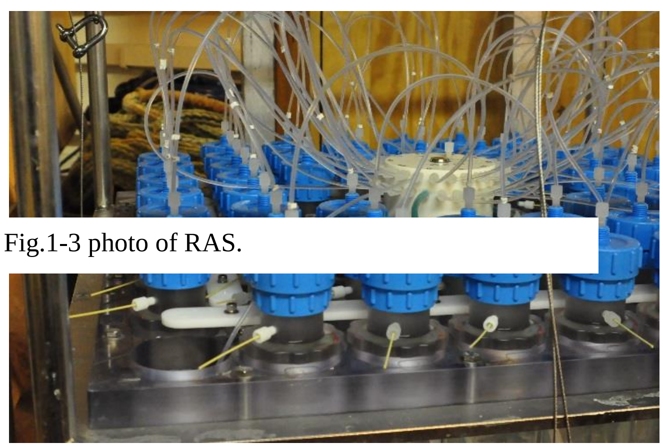


Fig.1-3 photo of RAS.

Table.2 RAS(BGOS-B) setting

Fig.2 Set up filters on sampling bottles.

SUNA (Submersible Ultraviolet Nitrate Analyzer)

SUNA is a chemical-free nitrate sensor. It is based on the ISUS (In Situ Ultraviolet Spectroscopy) technology developed at MBARI (Kenneth., et al.2005). The setting of SUNA-

V2 at the deployment is shown in Table 3.

Table.3 SUNA-V2 setting.

SUNA V-2	
Sirial No.	SUNA-06
starting date	UTC 08/Oct/2014 UTC 5:30
interval time	12 hours
light frame	120 seconds
intagrated waiper	ON

WQM (Water Quality Monitor)

WQM is a monitoring device equipped with conductivity, temperature, pressure, dissolved oxygen, chlorophyll fluoresce and turbidity sensors. The setting of WQM at the deployment is shown in Table 4.

Table.4 WQM setting list.

WQM	
Sirial No.	WQM-406
starting date	UTC 08/Oct/2014 UTC 3:50
interval time	12 hours
sampling time	5 minutes
collect data	conductivity, salinity, temperature, pressure, dissolved oxygen (ml/l), Oxygen saturation(%) and Chlorophyll


(a) (b) (c)

Fig.3 BGOS-B RAS photos a) SUNA-V2 b) WQM c) RAS deployment

References

Kenneth S. Johnson, Luke J. Coletti, In situ ultraviolet spectrophotometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean, Deep-Sea Research I 49 (2002) 1291–1305).

5.14 Ice Observation Program Cruise Report 2014

Alek Petty (NOAA/UMD), Sam Thomas (UCL)
P.I.: Jennifer Hutchings (OSU)

Background and summary

This year's program consisted of multiple activities: hourly ice observations from the bridge, imaging of ice conditions, and on-ice stations collecting cores and carrying out ice thickness transects.

Ice observers Alek Petty (NOAA/UMD), Sam Thomas (UCL), Yasuhiro Tanaka and Seita Hoshina (KITAMI) took hourly observations from the bridge and recorded the data using the ASSIST (Arctic Shipborne Sea Ice Standardization Tool) software. ASSIST is a product of UAF's IARC sea ice group and GINA software programming department, based on the input of members from the international sea ice community. The project is sponsored by the Climate and Cryosphere Group of the Word Climate Research Programme.

As in previous years, the ice observations recorded during the JOIS 2014-11 cruise will provide information regarding the local ice conditions. These data provide crucial added-value to the broader analysis of sea ice conditions of the Beaufort Sea obtained from other datasets (e.g. satellite/airborne imagery), which lack the detailed descriptions possible through direct visual observations. Our objective was to identify the sea ice variability observed throughout the Beaufort Sea for the region (1km radius) surrounding this year's cruise track.

Our on-going participation in the JOIS cruises has been vital in working towards a satellite validation project and the development of the ASSIST ice-observing program. The observations collected since 2006 provide a valuable 9-year dataset of Beaufort Sea ice characterisation, complimenting existing sea ice datasets.

This year's cruise spanned 21st September – 17th October 2014, covering the first month of freeze-up in the Arctic autumn immediately after the annual minimum sea ice extent. Since the Ice Watch team began its participation, JOIS cruises have been scheduled at various times throughout the summer/autumn season. Attention should be given when comparing 2014 data to the results from previous cruises, which were usually (although not always) earlier in the year (see Figure 1).

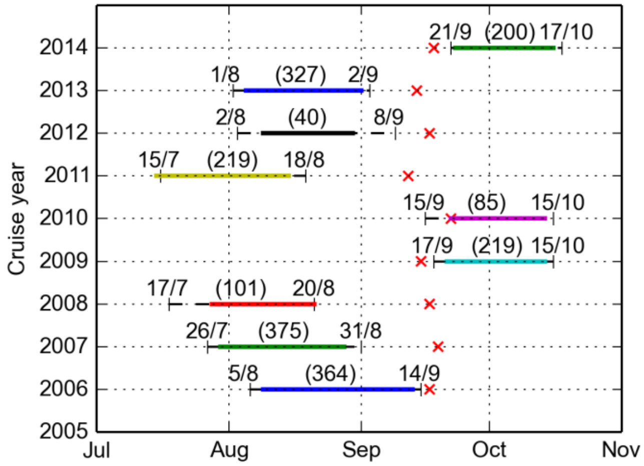


Figure 1: 2006-2014 JOIS cruise dates (black lines and numbered dates). The colored lines indicate the start and end of the Ice Watch observations while the number in brackets gives the number of observations recorded that year. The red crosses indicate the date of the Arctic sea ice minimum extent for each year.

We would like to extend our gratitude to Captain Marc Rothwell and the entire crew of the CCGS Louis S. St-Laurent for making this work possible. In addition, we thank Chief Scientist Bill Williams and rest of the science team for their support and assistance, especially with the on-ice work we carried out.

Observations from the Bridge

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 concentration within 1km of the ship (or as far as was visible), the types of ice present and the state of open water. For the primary, secondary, and tertiary ice types we recorded the relative concentration, thickness, flow size, topography, snow type, snow thickness and stage of melt for each ice type. Other types of ice present that were at lower concentrations than the three main types were also documented. Also recorded was basic meteorological information such as visibility and precipitation, as well as air temperature, pressure and humidity from the ship's AVOS system.

The program aimed to take hourly observations throughout the 24-hour cycle each. Observations were suspended when the ship was on station for rosette or mooring operations, unless ice drift was sufficient to produce a significant change in conditions. At night, the frequency of observations was reduced due to the usually poor

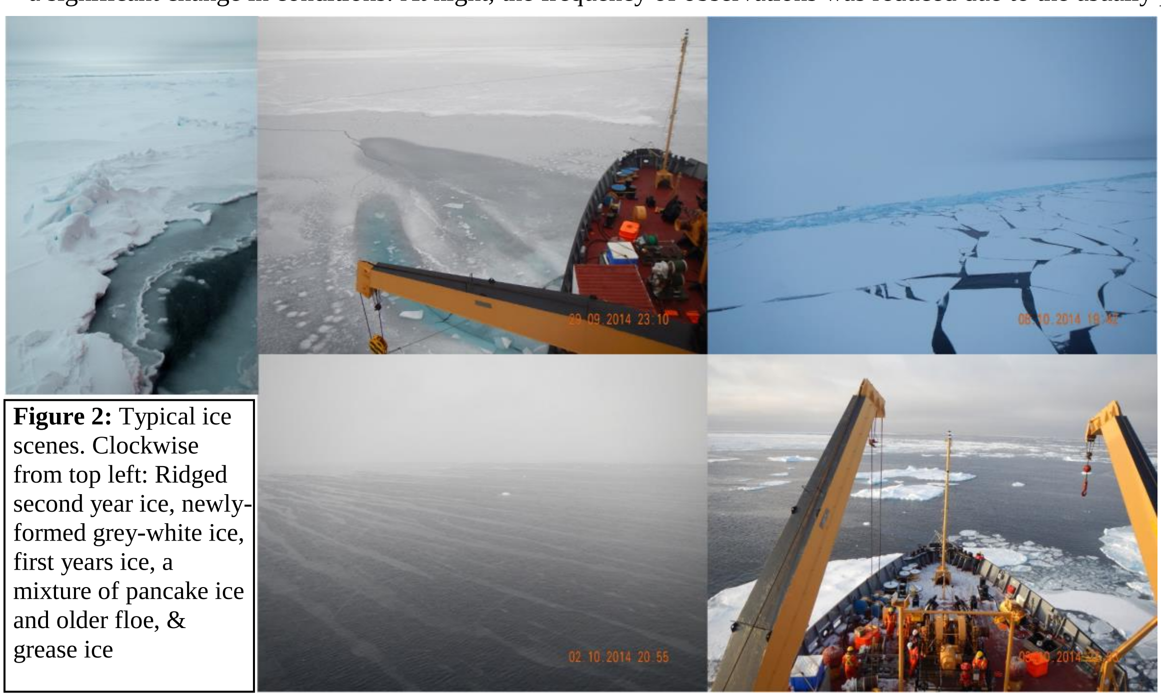


Figure 2: Typical ice scenes. Clockwise from top left: Ridged second year ice, newly-formed grey-white ice, first years ice, a mixture of pancake ice and older floe, & grease ice

(<200m) visibility and slower speed of the ship. Time atop was limited to reduce exposure to RF radiation, and in rough conditions (heavy icebreaking or large swell) access to the monkey's island was coordinated through the officer of the watch.

Observations were assisted by the two webcams placed on the monkey's island. The downward-facing camera was useful for estimating thickness, as it views newly broken ice overturning as it passed the ship's hull. In addition, we took periodic photographs with a handheld camera for consistency checks and to capture specific features of the ice.

Webcam Imagery

Webcams have been positioned atop the rail of monkey island for multiple seasons. The images supplement the hourly visual observations made from the bridge.

Camera 1 faces forward, looking out across the bow. It provides an overall picture of ice conditions.

Camera 2 faces downward and slightly aft on the port side. It views ice overturning as it is broken by the ship. This exposes a cross-section of the ice, allowing thickness & freeboard to be estimated. The ice thickness pole (marked in 10cm gradations) is visible in the camera's field of view, which assists with thickness estimates.

Figure 3: (left) Downward facing NetCam on the port side of the ship. (right) Example image from the NetCam showing the measuring stick (the colors indicate 10/50 cm intervals) which is often used to estimate ice thickness

The cameras are connected via power-over-ethernet (POE) connections, which run from the monkey's island into the ice office/radio room via the window.

The cameras are accessible on the ship's science network, and are set to use static IP addresses. Camera 1 is available at 10.1.20.33, while camera 2 is available at 10.1.20.31. In the event of the IP addresses changing unexpectedly (e.g. due to DHCP), they may be "discovered" using Stardot's supplied Netcam software. Camera 1's MAC address is 00:30:F4:C9:01:6F, while Camera 2's MAC address is 00:30:F4:C8:01:F6.

The cameras are set to automatically save an image to the ship's NOAA server every 10 minutes, via FTP. This is currently available at \\lslnoaa\IceCamera or 10.1.20.10.

This year, the downward-facing camera was replaced with an improved "XL" model of camera, providing improved frame rate and image quality.

The forward-facing camera had suffered image difficulties earlier in the year. After some testing, the problem was determined to be due to the camera's "auto iris" system not properly adjusting the aperture, causing the sensor to be overexposed when in direct view of the sun. Permanent damage to the sensor may have occurred when the camera was directly pointed towards the sun. As a temporary fix, the lens + iris system was replaced with the manual lens from the old downward-facing camera and the aperture set to minimum (around f/11). However, it proved impossible to fully focus the replacement lens, causing some blur in the images.

Additional documents on the set up and configuration of the NetCams are available on the NOAA server: LSLNOAA/ScienceNet/2014-11-JOIS/Setup Documents/ICE CAMERA SET-UP.

The cameras are mounted in outdoor cases, but are otherwise fully exposed to the Arctic elements. It is common for freezing rain and snow to accumulate on the camera window – this icing can be easily removed with a sponge soaked in hot water.

On-ice Measurements

On-ice measurements were carried out during the deployment of ice-tethered profilers (ITPs) and other buoys. These on-ice stations were planned well in advance, in concert with WHOI and the other scientists who had volunteered their help to coordinate the logistics and designate separate working areas on the floe.

The on-ice stations consisted of two main efforts: ice transects and ice coring. The layout of the ice measurement area was planned prior to deployment. On arrival at the floe, the transect lines were measured and marked out. The on-ice team (consisting of the 4 Ice Watch team members and several volunteers) split up into their respective teams and began work.

1. *Ice Transects*

Transects involve linear profiling of the ice floe (up to 100m), revealing the small-scale variations in ice thickness, freeboard and snow depth.

Snow depth measurements were recorded every 1 metre (using a meter ruler), and ice holes were drilled every 10 metres. Drilling was carried out using a 2-inch auger mounted on a 130V hand drill, powered by a gas generator. Ice thickness and freeboard were measured and recorded at the drill sites using toggle tape. Ice Station 1 involved a single 100 m transect line.

After drilling was completed, an EM-31 instrument mounted on a sled was used to measure ice thickness (calculated using the snow depth measurements). The EM records ice thickness every second (although this can be changed) as it is pulled along the transect line. This was the first time this EM was used so the results presented are very much preliminary. The results provided an encouraging validation of the EM sensor, a much quicker and higher resolution approach to ice thickness profiling. This work also complimented the EM sensing (along the same transect line) carried out by the Kitami team who had their own EM sensor they used out on the ice. Results from the first transect are shown in Figure 4.

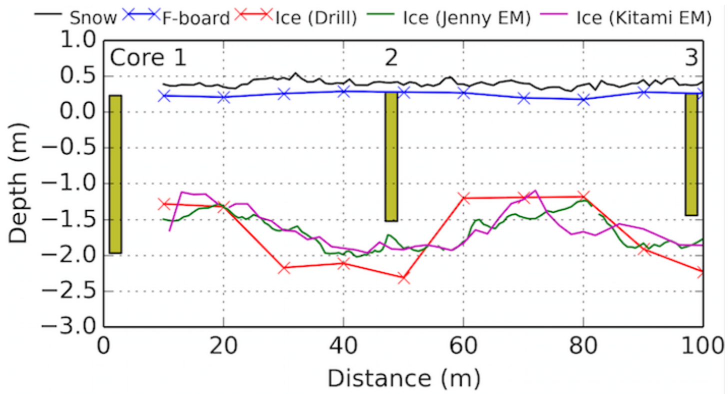


Figure 4: Example transect from Ice Station 1. Black line is snow depth (every 1m), red crosses are the drilled ice thickness, blue crosses are the freeboard depth and the green and blue lines are the thicknesses obtained from two different EM sensors pulled along the transect line. The data was converted into depth using the snow and freeboard data. Raw data is available on the ScienceNet server.

At Ice Station 2, a 50 m x 20 m transect grid was laid out. Due to the time constraints, holes were drilled along only the two 50 m sides of the grid. The EM sensor was then pulled along lines within the grid, showing the spatial variation in ice thickness one can expect on such a small spatial scale. The EM sensor has a portable GPS, providing the latitude and longitude of the EM sensor as it traverses the ice. Due to the motion of the ice floe, the position data has to be corrected accordingly (using the start and end lon/lat), taken from the ship's own position logging (the ship moved along with the ice).

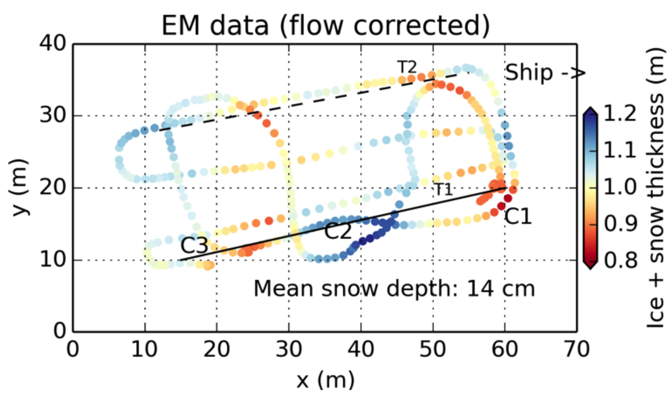


Figure 5: ice (plus snow) thickness profile from the EM-31 sensor. C1/C2/C3 indicate the three coring sites, while T1/T2 indicate the two principle transect lines.

All the data and analysis of the transect lines have been stored on the ScienceNet server (LSLNOAA/ScienceNet/2014-11-JOIS/Data/IceData).

2. Ice Cores

Coring was carried out at sites along the transect lines, using a 10 cm ice auger powered by a 4 stroke engine. At each site, snow depth was measured multiple times to give an average value for the site. Snow was then cleared away to give a working area of bare ice.

Two types of core were taken: those for salinity & temperature analysis by the Ice Watch team, and those for biological/chemical analysis by other members of the JOIS science team.

The salinity/temperature cores required processing on the ice. Each 1 m core section was drilled at 10 cm intervals and measured for temperature, before being cut into 10 cm sections. Each section was measured for thickness with calipers before being placed into pre-marked pots or bags. This was repeated for every section of the core as drilled. On return to the ship, the samples were allowed to melt and the volume, conductivity and temperature were measured. This data was used to calculate salinity and density, allowing depth profiles of each core to be created.

The other cores generally did not require processing on the ice. These were placed into plastic bags and labelled, identifying the core and the piece or section. In addition, the orientation of the pieces was recorded by marking the tops with coloured tape. These core pieces were stored in coolboxes for return to the ship. Some cores, such as those for microplastic analysis, required special handling such as gloves and pre-cleaned bags.

At the first ice station (CB11), 3 cores were collected for the Ice Watch team. In addition, 8 cores were collected for other science team members. At the second ice station (between PP7 & CB17), a further 3 Ice Watch cores were collected as well as 7 other cores for science team members.

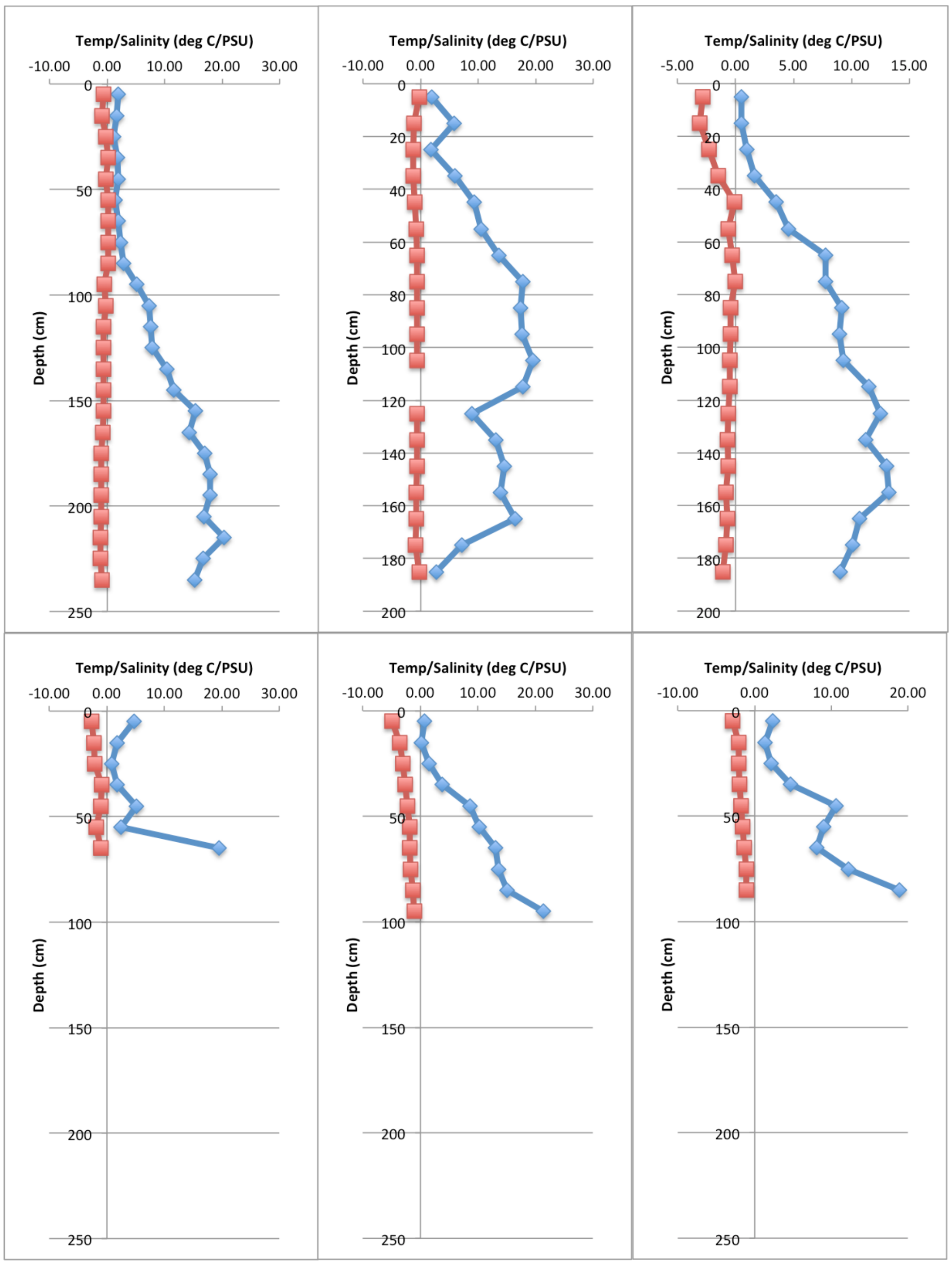


Figure 6: Temperature (red)/Salinity (blue) profiles for the sampled cores. Top row: IBO 1, Cores 1-3 (left to right), bottom row: IBO 2, Cores 1-3 (left to right)

We would like to thank all the volunteers from the science team who assisted us in demanding work on the ice, as well as the ship's crew for making ice operations possible.

Synopsis of Ice Types along Cruise Track

We first hit ice on the 24th September, around 72S/134W. This was generally thin, new ice (of various types). The ice continued to remain thin (<1 m) for several days, with medium floes of white first year ice interspersed with newly forming (grease/grey/grey-white) ice. Due to the southern (clockwise) route taken, there were occasional days in open water, around 29th September and again around 4th October. Once back into the ice pack, we rarely encountered periods of open water longer than an hour.

From the 5th October we started to encounter ice in higher concentrations and, in general, greater thickness. This period of thicker ice coincided roughly with the start and end of the Ice Stations. During this time, we encountered significant fractions of old (second or multi-year) ice. However this was not observed to be continuous, which could either be due to a lack of older ice or the ship preferring to travel in leads – thus often avoiding the heaviest and oldest ice. This "bias" in the ship's course is a complication when assessing the overall multi-year ice fraction.

Due to the late timing of the cruise, the leads that the ship travelled mainly in were often refrozen, albeit with very thin, new (nilas, grease, grey) ice.

General comments:

We were somewhat surprised by the lack of visible refrozen melt ponds on the surface of ice floes throughout this cruise. The lack of unfrozen ponds was likely due to the late timing of this year's cruise, while continually overcast (cloudy and sometimes foggy) conditions potentially made it harder to spot refrozen ponds, especially at distances greater than 100-200 m away from the ship. This made it quite difficult to differentiate second year ice from older multi-year ice, meaning we had to base our decisions mainly on the weathering of ridges and estimations of ice thickness from either the freeboard or visible overturning.

In general, the Ice Watch data does not log continuous period of open water. Observations were also discontinued when the ship was on station, unless drift was sufficient to change the local ice conditions. These periods could last from a few hours up to almost an entire day during mooring operations. At night, observations were hampered by the lack of ambient light. Observations were made where possible, however in sparse or new ice (which does not reflect the ship's spotlights well) it was not possible to make accurate observations. Users of the data should be aware of these reductions in observation rate.

Ice Program Data Locations

Ice watch observations: www.icewatch.gina.alaska.edu, csv files at: LSLNOAA/ScienceNet/ASSIST_observations
Ice Camera photos: LSLNOAA/IceCamera/2014CamX
Ice station data: LSLNOAA/ScienceNet/2014-11-JOIS/Data/IceData
Instrument set-up: LSLNOAA/ScienceNet/2014-11-JOIS/Setup documents

Just a note of a couple of other additional sampling on the Ice Station –

Contact: Michiyo Yamamoto-Kawai
Onboard: Yusuke Ogiwara

Iron in Ice:
Ice cores (summarized by ice team) were collected for analysis of iron at Ice station 1 and 2 . These cores are for Jun Nishioka, University of Hokkaido, who will be processing the samples at IOS.

Pollutants:
For the measurement of PFAS (a type of persistent pollutant) and black carbon, samples were collected from the snow, ice and surface seawater at the two ice stations. These samples were melted into 1L volumes and brought back to |Japan for analysis.
Station 1: snow sample, and surface seawater sample from the ship's seawater loop.
Station 2: snow sample, top ~30cm of an ice core , and surface seawater from the ship's seawater loop.

5.15 Ice Observations

PI: Kazutaka Tateyama, Kitami Institute of Technology, Japan
Students on ship: Yasuhiro Tanaka, Kitami Institute of Technology, Japan
With Seita Hoshino, Kitami Institute of Technology, Japan

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)
Seita Hoshino (KIT)

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 Alek Petty and Sam Thomas, OSU. 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.

Sea Ice thickness is inaccurate because of Laser distance meter (LD90) that set in the EM case is broken. The relationship between LD90 and EM is referring to ‘EM ice thickness profiles and PMR observation’.

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

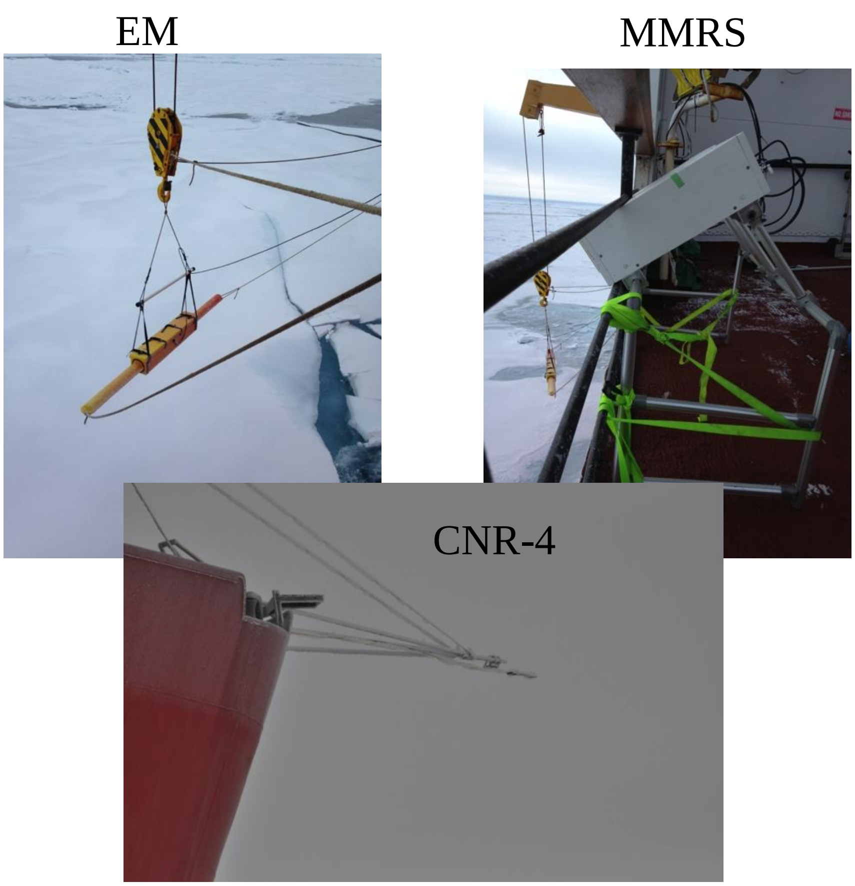


Figure 2. Pictures of EM, PMR, CNR-4.

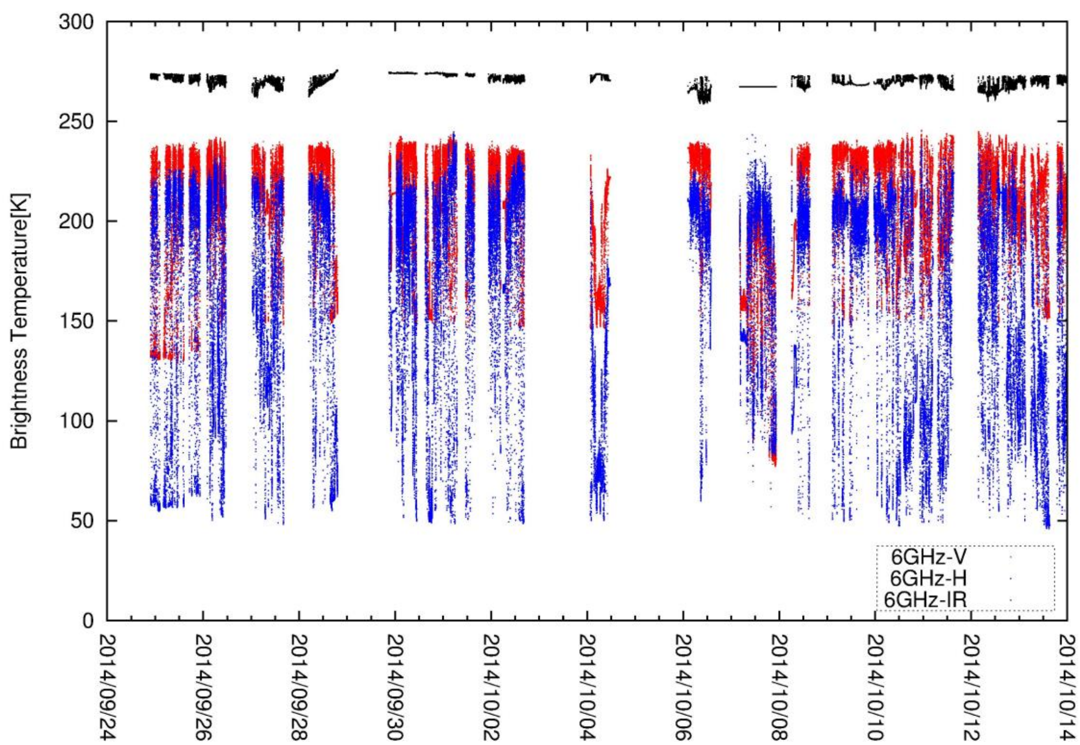
EM ice thickness profiles and PMR observation

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 and 36GHz, the horizontally polarized 6GHz and 36GHz with radiation thermometers and CCD cameras (36Ghz). 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 25th September-14th October. The total distance of 1 profiles are 3745.6 km.

Please see Appendix for list of transects.



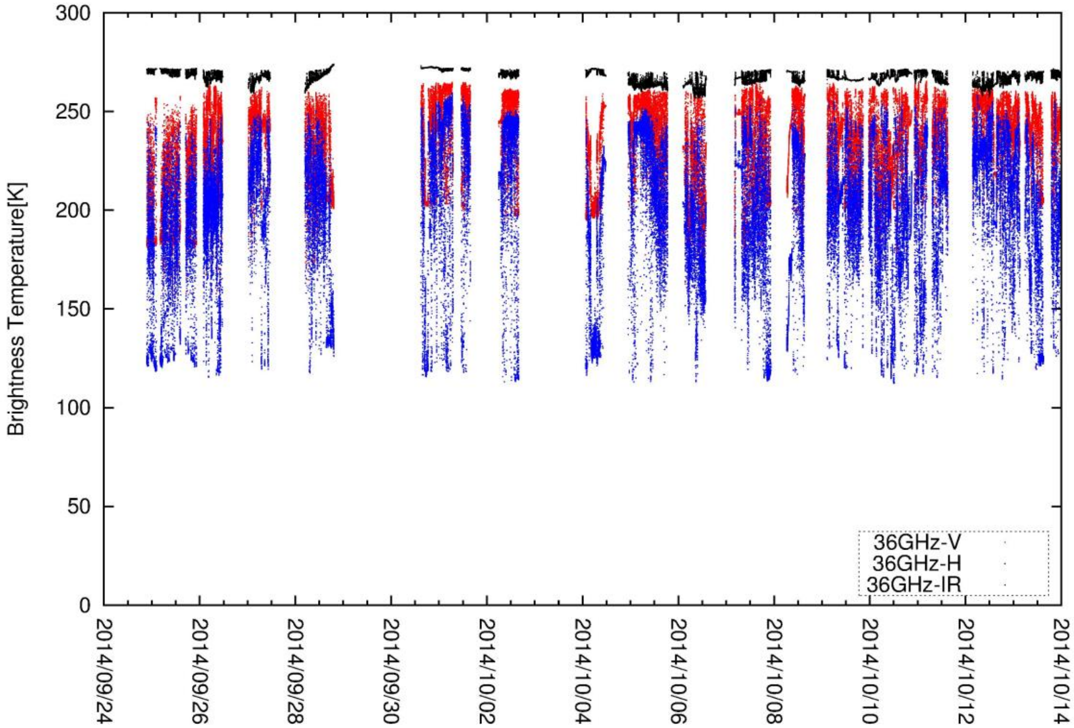
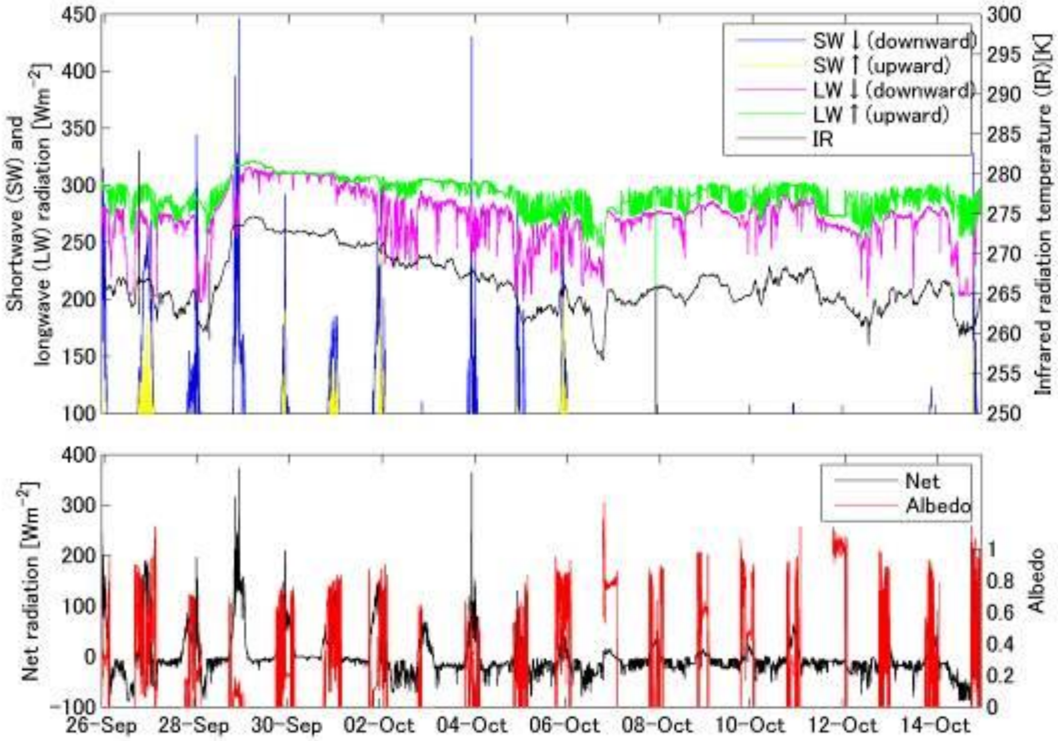


Figure 3. Profile of PMR observation while JOIS cruise 2014

Net radiometer observation

CNR-4 on the bow (Figure. 2) recorded the radiation balance of solar and far infrared every 10 seconds during 26 September-14 October. These data are shown in Figure 5. This data will be used for assuming ice albedo feedback and to help interpret satellite images of sea ice.



We found out the unusual albedo data (over 1) in 26-27 September and 7-14 October. It is necessary to calibrate because these are affected the shortwave radiation shutdown and the influence of longwave radiation by ship.

Figure 5. Shortwave (SW), longwave (LW) radiation and infrared radiation (IR) temperature radiation observations along JOIS2014 cruise track.

On-Ice Measurements

Ice Thickness Survey

Yasuhiro Tanaka (KIT)
Seita Hoshino (KIT)

Ice station measurements

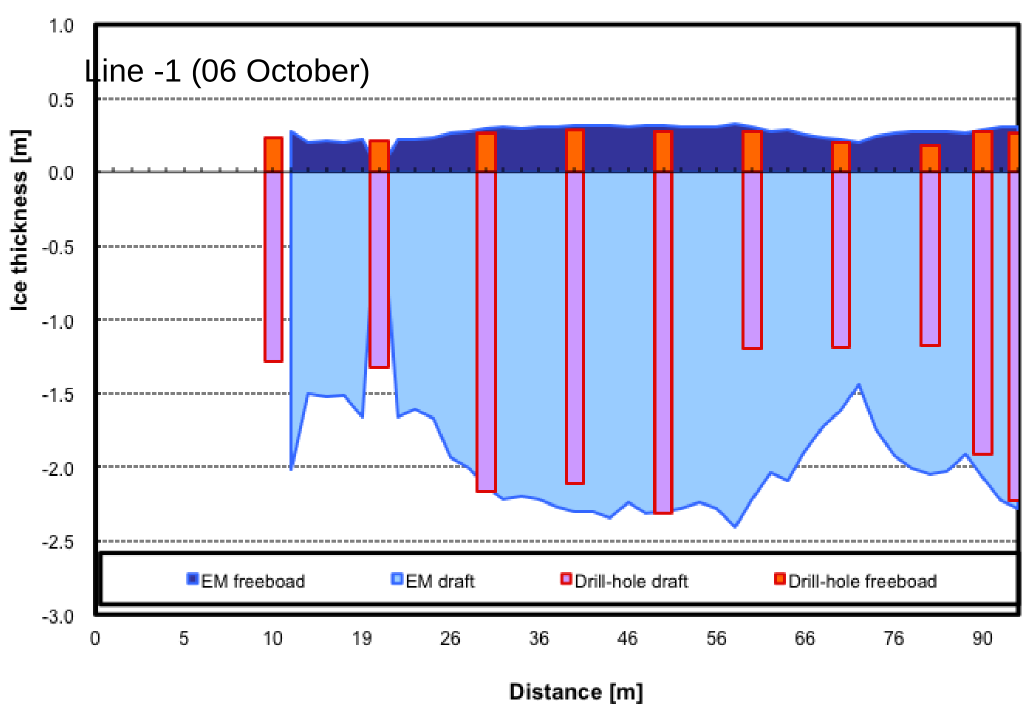
Drill-hole and EM Survey

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

Comparison of EM total snow and sea-ice thicknesses with drill-hole thicknesses are shown for Ice Stations 1 to 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.

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	79° 00'63"N 150° 02'01"W	Line-1	90	0.1	0.05	2.24	0.32
St.2	76°01'15.6"N 139° 48'20.3"	Line-1	50	0.16	0.03	0.81	0.14
		Line-2	50	0.16	0.03	0.78	0.07



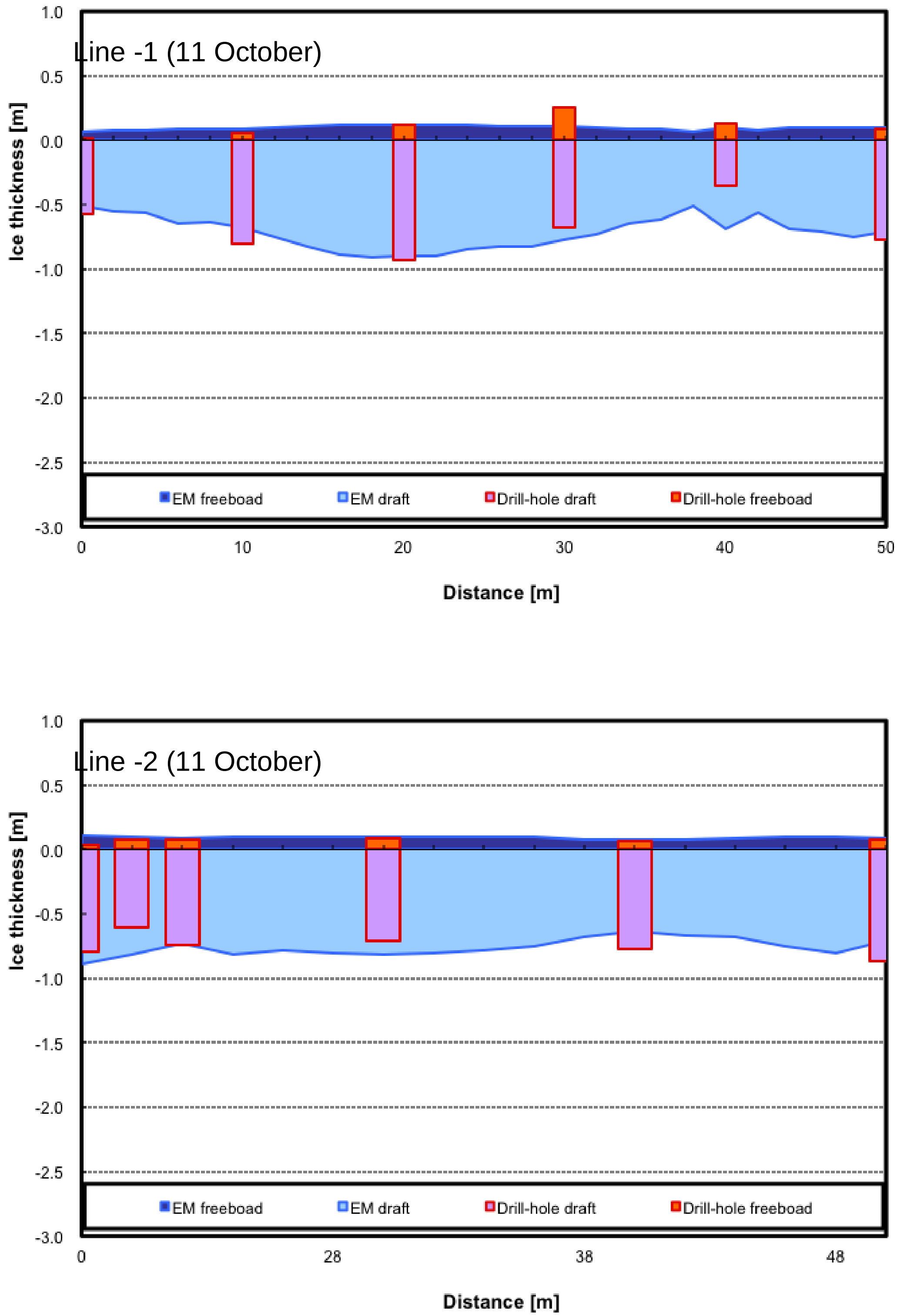


Figure 5. Comparison of EM31SH with drill-hole thickness measurements at Ice Station #1 on 6th of October 2014 and #2 on 11th of October 2014.

5.16 Radiometer and Ceilometer Data

Sigrid Salo (PMEL/NOAA)

PI Dr. Kevin Wood, Dr. James Overland

Summary

In September and October 2014, PMEL/NOAA measured weather parameters with two instruments. We continuously measured cloud layers and boundary level height with a Vaisala CL31 ceilometer, and deployed 37 radiosondes (weather balloons). In addition, researchers from PMEL who were conducting an atmospheric boundary layer study overflew the ship in the NOAA P-3 aircraft on October 7.

Ceilometer Data

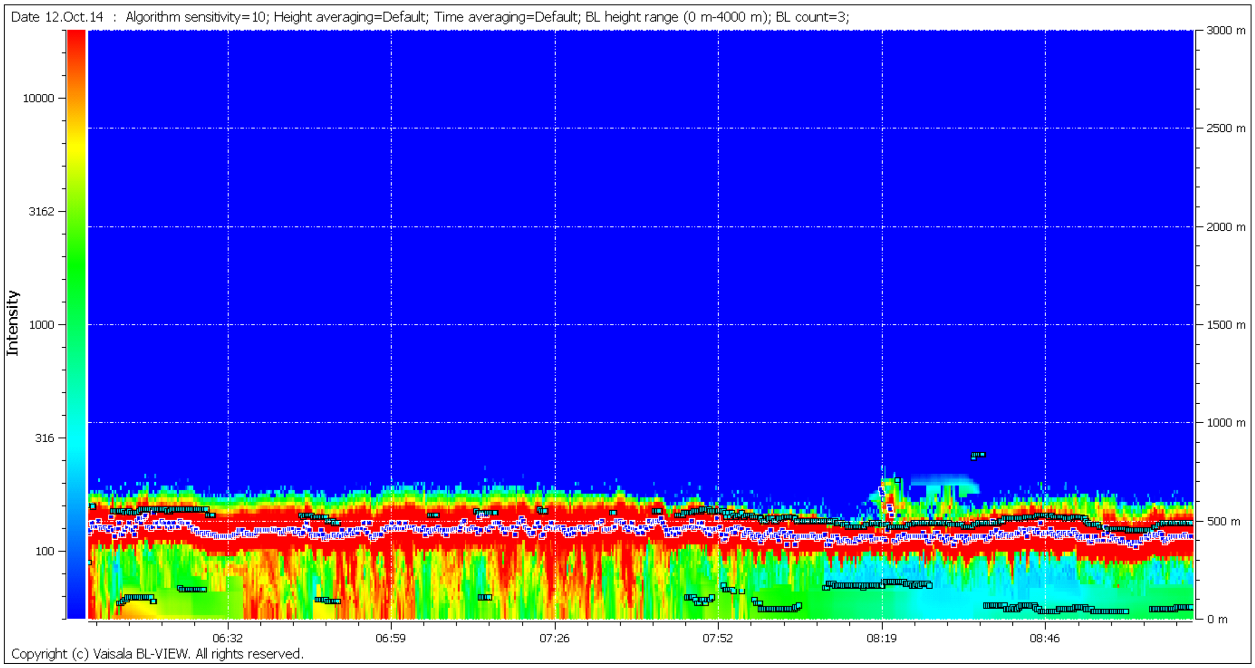
Ceilometers use LIDAR technology; they send out a laser pulse every 2 seconds and measure the backscatter to determine the presence of clouds and to calculate cloud base heights and boundary level height as well. The CL31 backscatter profile contains 770 10-m bins.

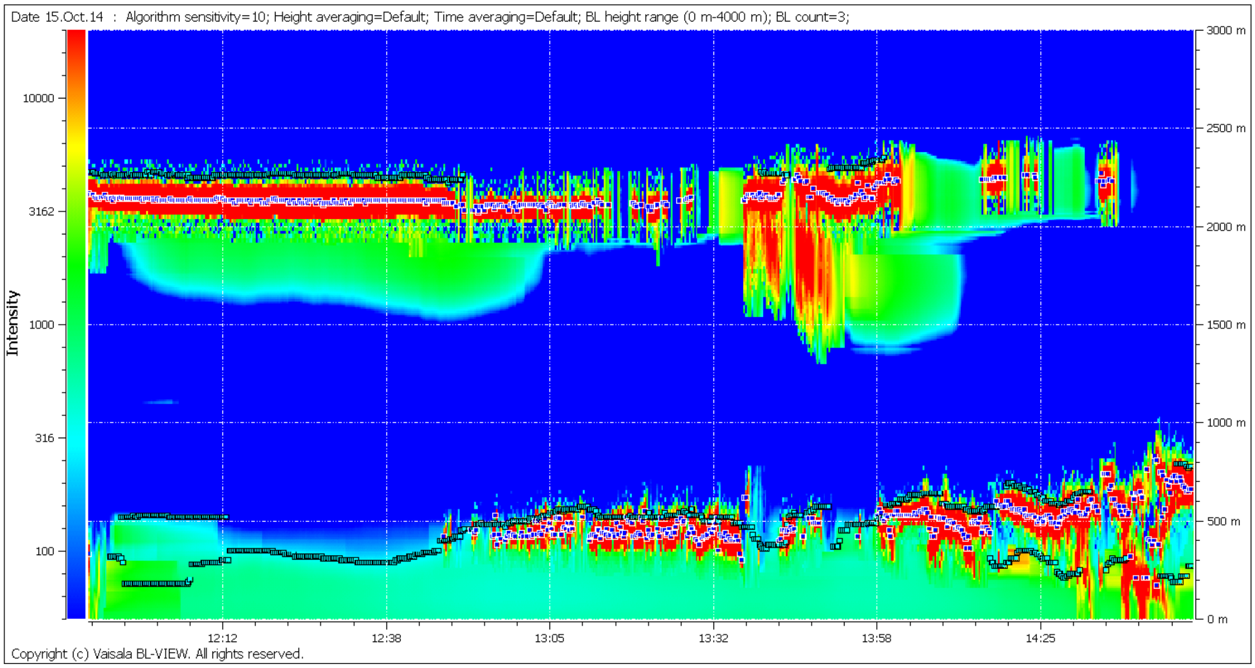
Unfortunately, dense fog interferes with some of the ceilometer calculations; primarily the ones giving boundary layer heights because so much of the energy is absorbed in the near-surface layer. Since fog is common in the Arctic when there is open water, that will present problems in our assessment of the data.

In addition, I noticed several occasions when the ceilometer was displaying high-intensity returns from just above the ship when I didn't see haze "by eye" near the surface. This year, the ceilometer was on the "Monkey Island" deck, above but just aft of the radio room, and the wind sometimes carried smoke from the stack over the ceilometer (of course smoke is going to blow over the instrument at times where-ever we place it on a ship). We will have to correlate the ceilometer record with the ships track and relative wind data and compare it to concurrent soundings data, to see if we do have to make corrections or if the instrument simply sees particles in the atmosphere more accurately than my eye.

Two examples of ceilometer data are 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. The first image shows a near-surface cloud layer, with snow-flurries descending to the surface at times. This stratus-cloud layer, often closer to the surface than this example, covered the Beaufort during most of the cruise.

The second image is from October 15, at the time of CB28b, the last CTD station. It was south of the ice edge, in open water except for ice "chunks" and slush on the surface. The stratus layer was intermittant, and there was a higher (too dark to see) layer of clouds. The last weather balloon was launched at 12:13 on that day and is shown in the next section.





Radiosondes

The weather balloons used RS92-SGP radiosondes, with Vaisala's MW41 program to track the balloons and process the data. We measured pressure, temperature, relative humidity, and winds calculated from the radiosondes' GPS positions. Most of the radiosondes reached an altitude of 20-25km before the balloon burst. During their ascent, the balloons were displaced by 15-80 km from their launch position by winds.

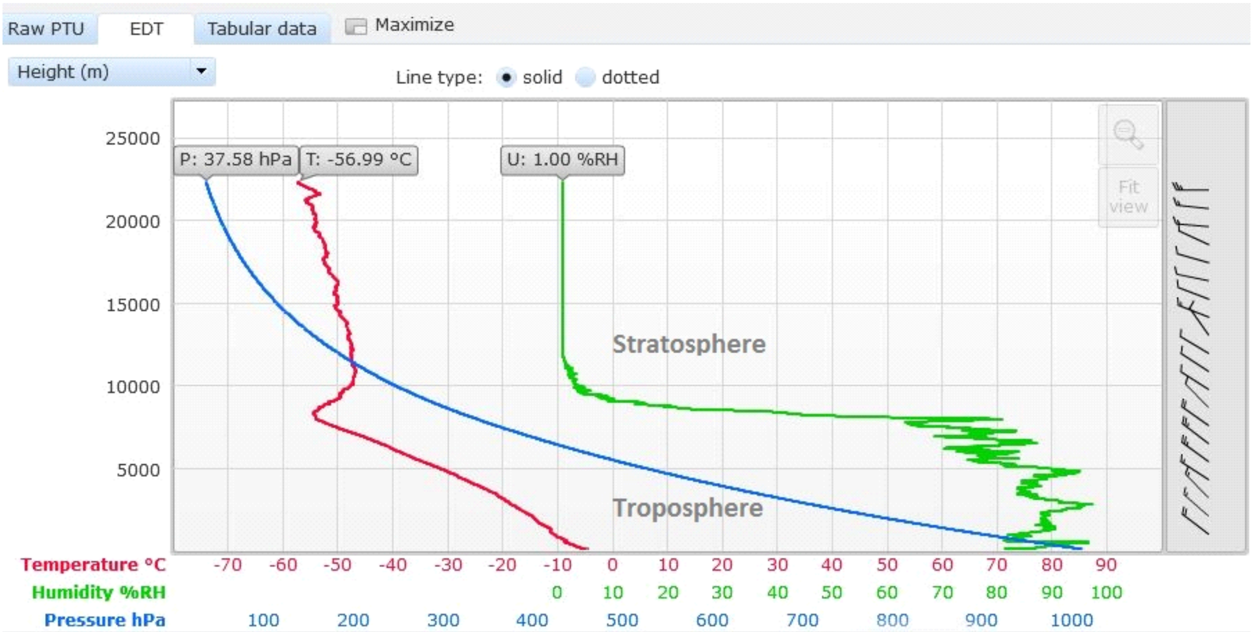
We launched the balloons from the helicopter deck and set up the probes and received their data from an antenna on "Monkey Island" and Vaisala monitoring instruments in the radio room aft of the bridge. This worked well except for the production of a text report that the Vaisala programs generate; the text report starts when the operator enters surface values after the balloon has been launched, and it took me several minutes to get back to the computer after a launch. The raw data file is complete; nothing is lost, but we should create a routine to create our own near-real-time file.

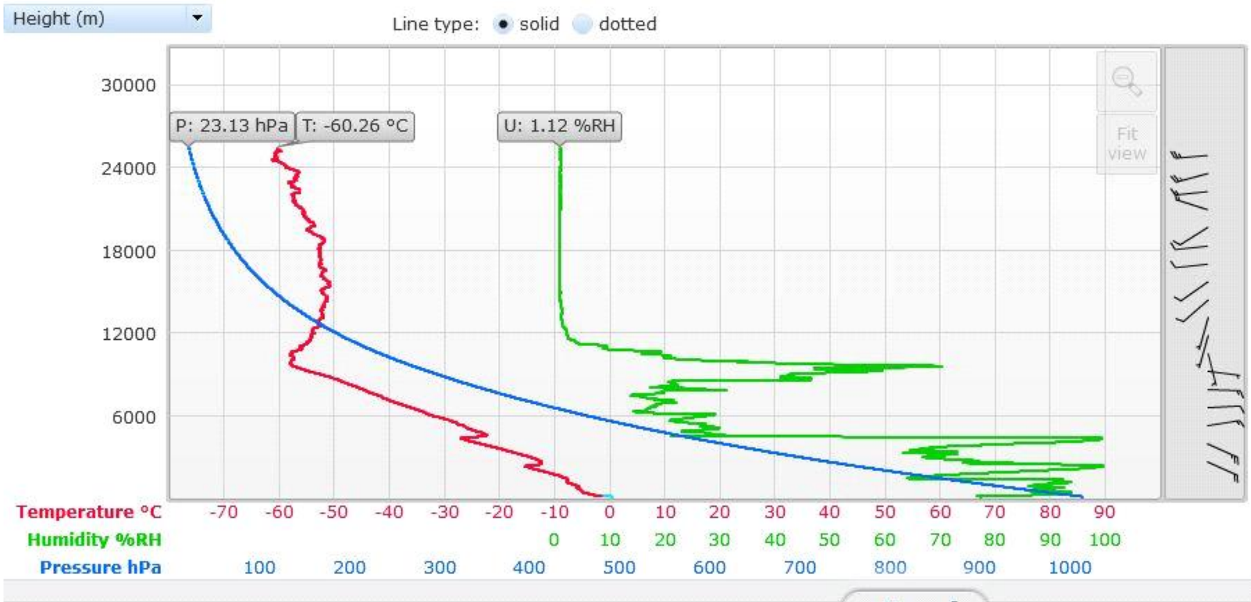
This year, we launched balloons at 00Z and 12Z; the same time as shore weather stations. This gives us a more synoptic dataset than last year, when we released balloons during each CTD cast.

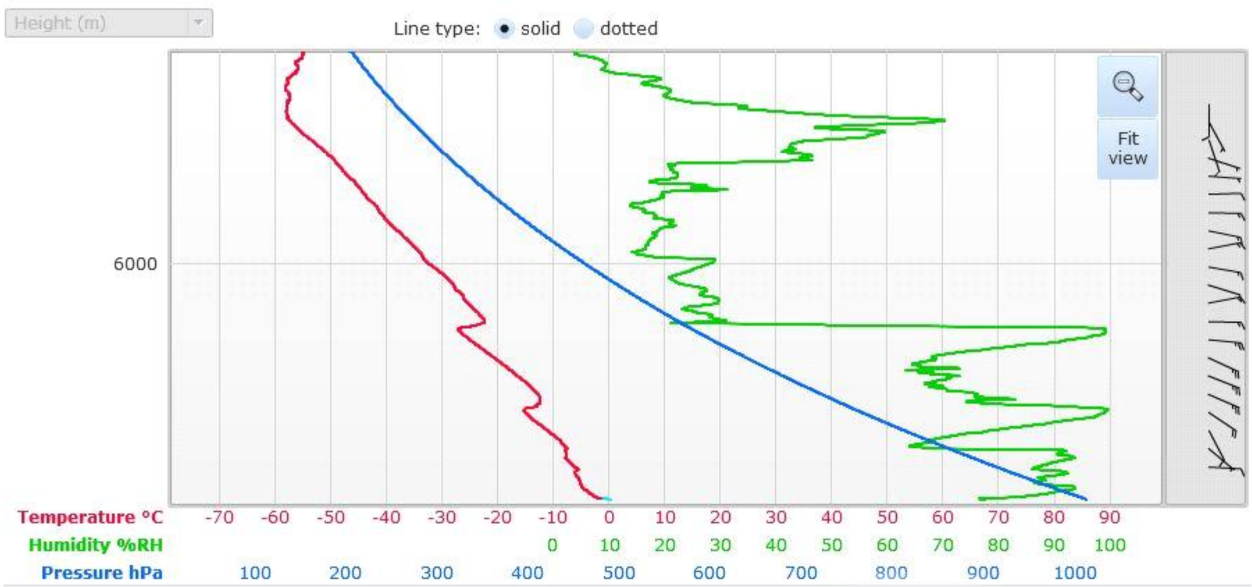
Two examples of radiosondes are shown below. The left part of the image shows the pressure, temperature, and humidity as a function of height, and the right part shows the wind vectors. The barbs indicate strength, one long barb is for 10 m/s, a short barb indicates 5 m/s and a triangle indicates 50 m/s. Wind direction (from) is shown by the angle of the vector.

The first image is from a radiosonde launched on October 2 near 75.5N 156W in 80% ice cover with westerly winds and blowing snow. There was high humidity in the entire troposphere, and westerly (from the west) winds with little variation in direction throughout the launch.

The second and third images is from October 15 near 71.0N 138.9W, at the end of the CTD at CB28b; the third image is a zoomed version of the mesosphere. The corresponding ceilometer image is shown above for comparison. Surface winds were from the northeast but, as with all the radiosondes, winds in the stratosphere became westerly.







The atmosphere varies over too short scales of time and length for us to create atmospheric "snapshots" to match the oceanic transects and surface plots from the CTD data. However, the ceilometer and radiosonde data provide localized 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. We will use data from both our instruments as well as weather charts and shore station radiosondes to interpret our data.

In the list of radiosondes included with this report, the times given are the actual time of launch, calculated by Vaisala programs from pressure records. However, the position is from the Vaisala file headers. These are the first position obtained after the radiosonde is QC'ed and initialized, rather than the first position collected by the radiosonde after launch. This position may be from 5-10 minutes before launch, but the difference is generally small.

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6. APPENDIX

1. SCIENCE PARTICIPANTS 2014-11

Table 6. Onboard Science Team for 2014-11.

Name	Affiliation	Role
Bill Williams	DFO-IOS	Chief Scientist and Program Lead
Sarah Zimmermann	DFO-IOS	CTD data QA/QC, sample cop, spreadsheet
Kenny Scozzafava	DFO-IOS	Oxygen Analyst / TOI / CTD watch help
Marty Davelaar	DFO-IOS	DIC / Alkalinity Analyst
Hugh Maclean	DFO-IOS	Day watchleader / bongos / salinity
Sarah-Ann Quesnel	DFO-IOS	Day watchstander / bongos / microplastics lead / lab supervisor
Melissa Schwab	ETH-Zürich	Day watchstander / deuterium / sediment traps
Yusuke Ogiwara	TUMSAT	Day watchstander / SF_6 / RAS deployments
Joey Wenig	UVIC/Yale	Day watchstander / daily dispatches
Mike Dempsey	DFO-IOS	Night watchleader / bongos / TOI / salinity
Caroline Wylie	TrentU	Night watchstander / CDOM
June Marion	OSU	Night watchstander / chi-pods
Daniel Sauvé	UOttawa	Night watchstander / radioisotopes
Sigrid Salo	NOAA	Night watchstander / bongos / radiosondes
Deo Florence Onda	ULaval	Microbial Diversity
Robyn Edgar	ULaval	Microbial Diversity
Yasuhiro Tanaka	KIT	Ice observations / XCTD watch
Seita Hoshino	KIT	Ice observations / XCTD watch
Sam Thomas	OSU	Ice observations / XCTD watch
Alek Petty	OSU	Ice observations / XCTD watch
John Wes Halfacre	PurdueU	O-Buoys / CTD watch help
Brice Griffith Loose	URI	Lead Ra/Rn Isotopes / submersible pump
Roger (Pat) Kelly	URI	Ra/Rn Isotopes / submersible pump
Cory Beatty	U Montana	CO_2 Underway and under ice / Moorings / Buoys
Rick Krishfield	WHOI	Lead Moorings / ITPs / Buoys
John Kemp	WHOI	Moorings / ITPs / Buoys
Jeff O'Brien	WHOI	Moorings / ITP / Buoys
Meghan Donohue	WHOI	Moorings / ITP / Buoys

Table 7. Principal Investigators Onshore for 2014-11.

Name	Affiliation	Program
John Nelson	DFO-IOS/UVIC	Zooplankton net tows

Svein Vagle	DFO-IOS	Ship-side ADCP / Underway measurements
John Smith	DFO-BIO	CTD/Rosette / ^{129}I
Jack Cornett	UOttawa	CTD/Rosette / ^{129}I / ^{137}Cs / ^{236}U
Peter Ross	VAquarium	CTD/Rosette / Microplastics
Celine Gueguen	Trent U.	CTD/Rosette / CDOM / Underway measurements
Christopher Guay	PMST	CTD/Rosette / Barium
Connie Lovejoy	ULaval	CTD/Rosette / Microbial diversity / Bacteria
Rachel Stanley	WHOI	CTD/Rosette / TOI and O_2/Ar
Johnathan Nash	OSU	CTD/Rosette / Chi-pods
Michiyo Yamamoto-Kawai	TUMSAT	CTD/Rosette / SF_6 / RAS deployment
Andrey Proshutinsky	WHOI	CTD/Rosette / Moorings / ITP Buoys / XCTD
John Toole	WHOI	ITP Buoys
Mary-Louise Timmermans	Yale U.	Moorings
Motoyo Itoh	JAMSTEC	CTD/Rosette / XCTD
Koji Shimada	TUMSAT	XCTD / Moorings
Jennifer Hutchings	OSU	On-ice / Underway ice Observations
Don Perovich	CRREL	Ice Mass-Balance Buoy
Tim Stanton	NPS	Arctic Ocean Flux Buoy
Patricia Matrai	BLOS	Ozone Buoys
Mike Degrandpré	UMontana	Mooring Sami pCO_2 / pCO_2 Underway measurements
Kazu Tateyama	KIT	On-Ice / Underway Ice Thickness Measurements
Shigeto Nishimo	JAMSTEC	CTD/Rosette
Tim Eglinton	ETH-Zürich	Deuterium and POC
Jim Overland	NOAA	Radiosondes / Ceilometer
Kevin Wood	NOAA	Radiosondes / Ceilometer

Table 8. Affiliation Abbreviations.

Abbreviation	Definition
BIO	Bedford Institute of Oceanography, DFO, Dartmouth, NS, Canada
BLOS	Bigelow Laboratory for Ocean Sciences, Maine, USA
CRREL	Cold Regions Research Laboratory, New Hampshire, USA
DFO	Department of Fisheries and Oceans, Canada
ETH-Zürich	Swiss Federal Institute of Technology Zürich, Zürich, Switzerland
IOS	Institute of Ocean Sciences, DFO, Sidney, BC, Canada

JAMSTEC	Japan Agency for Marine-Earth Science Technology, Yokosuka, Kanagawa, Japan
KIT	Kitami Institute of Technology, Kitami, Hokkaidō, Japan
NPS	Naval Postgraduate School, Monterey, California, USA
OSU	Oregon State University, Corvallis, Oregan, USA
PMEL/NOAA	Pacific Marine Environmental Laboratory / National Oceanic and Atmospheric Administration, Seattle, Washington, 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
ULaval	University of Laval, Quebec City, Quebec, Canada
UMontana	University of Montana, Missoula, Montana, USA
UOttawa	University of Ottawa, Ottawa, Ontario, Canada
URI	University of Rhode Island, Kingston, Rhode Island, USA
UVIC	University of Victoria, Victoria, British Columbia, Canada
VAquarium	Vancouver Aquarium, Vancouver, British-Columbia, Canada
WHOI	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
YaleU	Yale University, New Haven, Connecticut, USA

Table 9. Project websites

Project	Website Address
Beaufort Gyre Observing System	www.whoi.edu/beaufortgyre
Beaufort Gyre Observing System dispatches	www.whoi.edu/beaufortgyre/2014-dispatches
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	http://imb.crrel.usace.army.mil/
O-buoy Project	www.o-buoy.org

2. LOCATION OF SCIENCE STATIONS for JOIS 2014-11

The scientific crew boarded the *CCGS Louis S. St-Laurent* icebreaker in Cambridge Bay, NU, on 21 September, 2014 and returned to Kugluktuk, NU on 17 October, 2014. Locations of CTD/Rosette, XCTD, zooplankton vertical net and any other over-the-side casts, as well as the mooring and buoy recovery and deployments are listed in the tables below.

2.1 CTD/Rosette

Table 10. CTD/Rosette cast for 2014-11

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample Numbers	Comments
1	AG-5$_{short}$	23/09/2014 18:29	70.5530	122.9050	0	146.444	1-8	RNA/DNA cast. ISUS and Biospherical PAR on cast. CDOM sensor not working.
2	AG-5	23/09/2014 19:55	70.5540	122.9187	657	641.403	9-28	ISUS and Biospherical PAR used on cast.
3	CB-1	24/09/2014 7:57	71.7728	131.8798	1137	1110.49	29-52	Sample 40 - accidently fired early at 275m instead of target of 275. Sample 41 to 47 may all be off target depth? Biospherical PAR used on cast.
4	CB-31b	24/09/2014 15:09	72.2973	134.0705	2105	2066.133	53-76	Sample 67 - Niskin bottom end cap leaked. CDOM cable swapped around and now CDOM sensor is working.
5	CB-23a	25/09/2014 1:44	72.9040	135.9292	2768	2734.321	77-100	Two mooring releases on frame for testing. Cosine PAR added to CTD.
6	CB-22	25/09/2014 14:22	73.4327	138.1063	3159	3116.839	101-124	Sample 124: niskin 24 lanyard accidently hooked onto pylon position 1. All samples are out of expected depth order by one place. Sample 124, niskin 24 is the deepest bottle. Sample 101, niskin 1 is the second deepest bottle etc.
7	CB-27	25/09/2014 23:07	72.9937	139.9912	3237	3204.656	125-148	
8	CB-21$_{short}$	26/09/2014 11:32	73.9825	140.1008	1000	1001.072	149-172	33.1 psu layer was above the chl-amax and so the Niskins were fired out of order. The sample labels have been changed accordingly.
9	CB-18	27/09/2014 7:09	74.9585	140.0162	3640	3616.245	173-196	Sample 181 and 182: 500m T_{max} out of order. Switched the sample and niskin numbers. Sample 192: sampled for TOI and CDOM instead of originally planned on sample 191 due to the shifted chl-a_{max}. Sample 193: sampled at 60m as sample 192 was already sampled at chl-a_{max} and 31.8 psu.
10	CB-21	27/09/2014 16:00	73.9932	139.8630	3523	3492.819	197-220	Rosette paused at 2684m for ~10min, then went @ 30m/min from 2550-2700m to 570m to surf for high resolution profiles through intrusions.
11	STA-A$_{short}$	28/09/2014 19:57	72.6033	144.6865	3455	1001.141	221-244	Sample 239: double chl-a_{max}.
12	STA-A	28/09/2014 21:56	72.6168	144.6750	3458	3428.803	9244-267	Sample 9244 as 244 was used twice. WHOI Release test 15 min. Sample 247: TOI sample collected late (after bacteria)
13	CB-2	29/09/2014 6:27	72.9930	149.9710	3677	3738.174	269-292	
14	CB-3	29/09/2014	74.0008	149.9910	3845	3813.815	294-317	Sample 303: Niskin 10 has slow drip at spigot

		12:39						
15	CB-6	29/09/2014 21:52	74.7038	146.6895	3801	3770.914	318-341	Release test from WHOI. Sample 327: Niskin leaking from top o-ring.
16	CB-4	30/09/2014 10:43	75.0068	150.0628	3850	3817.52	342-365	Calibration cast to get good agreement between CTD and samples with "Up Stop Mix" bottles. USM - stop 30 sec, down 1 m, up 2 m, down 1m, wait 30 sec, fire! Sample 362: Niskin 21 has sticky spigot.
17	CB-7	01/10/2014 6:46	75.9958	149.9853	3581	3820.267	366-389	Sample 375: slow leak on niskin (dribble).
18	CB-4$_{short}$	01/10/2014 15:58	74.9983	149.9735	3848	1000.038	390-413	DNA/RNA and Microplastic cast
19	CB-5	02/10/2014 4:34	75.2987	153.2988	3862	3832.049	414-437	
20	TU-1$_{short}$	03/10/2014 2:38	75.9678	159.9530	1718	602.749	438-446	RNA/DNA and ^{137}Cs cast
21	TU-1	03/10/2014 4:24	75.9643	159.9335	1618	1566.459	447-470	Samples 441 to 444 repositioned with niskin number due to unexpected sequence of target properties. Samples were ordered by depth with niskin number and labels on sample bottles were changed. ISUS on cast.
22	TU-2$_{short}$	04/10/2014 10:40	77.0012	169.9975	2241	601.737	471-481	RNA/DNA and ^{137}Cs cast. Addition of extra RNA/DNA samples (chl-a_{max} and 100 m) threw off the niskin order. Sample numbers kept in original order but depths and niskin numbers changed. This applies to samples 474 to 481 (niskin 4 to 11).
23	TU-2	04/10/2014 12:19	76.9955	169.9988	2241	2204.755	482-505	Samples 501 and 502 have Niskin numbers (21,20) switched due to unexpectedly shallow chl-$a_{\max}$. Niskin numbers are out of sequence with sample numbers now. Up at 30m/min started at 195m instead of the usual 300m.
24	CB-10	06/10/2014 1:36	78.2992	153.2708	2200	2170.374	506-529	Sample 515: niskin 10 has slow leak. ^{236}U sample collected from nearest bottles to desired depths of 200, 300 and 400m.
25	CB-11	07/10/2014 4:55	79.0048	149.9482	3848	3808.157	530-553	Sample 538: not trip. Sample 539: slow leak. Styrafoam cups added to wire 50m after rosette sent down.
26	CB-8	08/10/2014 6:11	77.0253	150.0268	3845	3819.132	554-577	Mooring releases tested on cast. Sample 554: DRW collected for salt. Niskin 11 tripped at wrong depth, not sampled and sample number given to next niskin.
27	CB-9	08/10/2014 15:22	77.9817	150.0307	3842	3821.904	578-601	Sped up to 60m/min at 200m instead of typical 300m. Due to winch error, the rosette was gently lowered to seafloor (winch pays out when moving through neutral between brake and raising, confusing the new winch operator).
28	CB-9$_{short}$	09/10/2014 1:18	77.9875	150.0350	3844	1000.897	602-624	RNA/DNA and microplastic cast. ISUS used on cast.
29	CB-12	09/10/2014 8:36	77.6888	146.7252	3832	3802.51	625-648	CTD data on winch display stopped reading correctly at 500m.
30	CB-13	09/10/2014 20:40	77.3095	143.4967	3807	3775.351	649-672	

31	CB-16	10/10/2014 9:22	77.9617	140.2035	3775	3743.176	673-696	Stopped at 170m and went back to 175 for niskin 14 and 15; Slowed to 30 m/min at 175m instead of 300m. Oxygen thermometer broke at niskin 13.
32	CB-15	10/10/2014 19:09	76.9883	139.7695	3743	3711.235	697-720	Sample 712: Niskin 16 lost upper valve (didn't sample). Sample 713: Niskin 17 lost upper valve (didn't sample). Sample 714: Niskin 18 upper valve was very loose (didn't sample). Sample 718: Niskin 22 top cap got stuck and didn't close (didn't sample). Deuterium will be sampled at the next station since 4 niskins on this cast were lost.
33	PP-7	11/10/2014 4:42	76.4122	135.6383	3585	3552.772	721-744	RNA/DNA chl-a_{max} sample was taken from PSW eddy (38 m); Sample 740, 741, 742: shallow chl-a_{max} so re-ordered sample log sheet, keeping Niskin and sample number together (old #20 = New #22; old #21= new #20 and old #22=new #21.
34	CB-17	12/10/2014 0:49	76.0198	139.9147	3715	3684.157	745-768	Chl-*a* fluorometer not working. Transmissometer not working. ISUS channel had noise. Sample 745: was tripped late (3379m). Sample 448: niskin 4 had a slow leak from bottom cap. Sample 754: niskin 10 was leaking from bottom spigot. pCO2 Cast (only one during thiscruise) with full DIC's for both BIO and IOS groups.
35	CB-40	13/10/2014 3:19	74.5012	135.4553	3279	3243.401	769-792	Sample 776: niskin 8 had slow drip and TOI sample bottle broke Sample 778: niskin 10 had slow leak. Nutrient DWR collected from bottom bottle (Sample 769) at 3052m.
36	CB-51	13/10/2014 15:46	73.4643	131.1378	2562	2523.138	793-816	Calibration cast to get good agreement between CTD and samples with "Up Stop Mix" bottles. USM - stop 30 sec, down 1 m, up 2 m, down 1m, wait 30 sec, fire! Started cast without the chl-*a* reading, so at 106 m, went back up to 20 m to find it. Sample 794: niskin 2- USM not done properly, stopped at 2396 instead.
37	CB-50	14/10/2014 1:33	73.5048	134.2563	2916	2877.789	817-840	Nutrient preservation test.
38	CB-23a$_{calibration}$	14/10/2014 8:45	72.8990	136.0745	2890	2750.929	841-864	Calibration cast. Sample 859: niskin 19 did not trigger.
39	CB-29	14/10/2014 22:28	72.0418	139.9967	2738	2700.252	865-888	Sample 876: niskin 12 had slow drip from bottom end cap. Changed to single chl-*a* samples (no duplicates) on several niskins to conserve water for other samples. Nutrient preservations tests.
40	CB-28b	15/10/2014 8:44	71.0160	140.0422	2122	2084.899	889-912	Sample 893: niskin 5 TOI sampled after DIC. Sample 897: niskin 9 was leaking from spigot. Rosette stopped at 94m, then raised, closing bottle at 90m for sample 905 (niskin 17).

2.2 XCTD

Table 11. XCTD cast deployment locations for 2014-11.

Filename	Cast #	Cast Start Date and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Comments
C5_00143.EDF	XCTD-01	24/09/2014 11:06	72.0656	132.9594	1705	1000.1794	
C5_00144.EDF	XCTD-02	24/09/2014 21:04	72.5937	135.0866	2525	1000.1794	
C3_00146.EDF	XCTD-03	25/09/2014 9:11	73.3567	136.8017	3103	132.1987	
C5_00147.EDF		25/09/2014 12:43	73.4332	137.9722		604.6324	Failure
C5_00148.EDF	XCTD-04	25/09/2014 12:51	73.4318	137.9726	3156	1000.1794	
C3_00150.EDF		25/09/2014 19:32	73.2147	138.9985		44.5877	Failure
C5_00151.EDF	XCTD-05	25/09/2014 19:52	73.1906	139.1119	3213	1000.1794	
C5_00152.EDF	XCTD-06	26/09/2014 7:15	73.5018	139.7294	3361	1000.1794	
C5_00153.EDF		27/09/2014 3:47	74.4929	140.0766		839.9827	Failure
C5_00154.EDF		27/09/2014 3:54	74.4926	140.0758		484.6083	Failure
C5_00155.EDF	XCTD-07	27/09/2014 3:59	74.4924	140.0753	3361	1000.1794	
C5_00156.EDF	XCTD-08	28/09/2014 8:47	73.5959	140.9632	3546	306.1575	
C5_00157.EDF	XCTD-09	28/09/2014 12:40	73.3145	142.3507	3571	1000.1794	
C5_00158.EDF	XCTD-10	28/09/2014 16:22	72.9446	143.4241	3479	1000.1794	
C5_00159.EDF	XCTD-11	29/09/2014 2:21	72.7487	146.4345	3419	1000.1794	
C5_00160.EDF	XCTD-12	29/09/2014 4:40	72.8850	148.4284	3719	1000.1794	
C5_00161.EDF	XCTD-13	29/09/2014 10:39	73.4766	150.0091	3835	1000.1794	
C5_00162.EDF		29/09/2014 17:59	74.3507	148.3790		726.1348	Failure
C5_00163.EDF	XCTD-14	29/09/2014 18:05	74.3524	148.3752	3838	1000.1794	
C5_00164.EDF	XCTD-15	30/09/2014 4:00	74.8407	148.3003	3830	1000.1794	
C5_00165.EDF	XCTD-16	01/10/2014 3:35	75.5353	149.2456	3846	1000.1794	
C5_00166.EDF	XCTD-17	01/10/2014 11:41	75.5211	149.9770	3851	1000.1794	
C5_00167.EDF		02/10/2014 1:30	75.1621	151.6824		853.8924	Failure
C5_00168.EDF	XCTD-18	02/10/2014 1:36	75.1642	151.7024	3863	1000.1794	
C5_00169.EDF	XCTD-19	02/10/2014 10:19	75.4624	154.8373	3861	137.3325	
C5_00170.EDF	XCTD-19	02/10/2014 10:24	75.4640	154.8532	3861	762.4894	
C5_00171.EDF	XCTD-	02/10/2014	75.6372	156.5150	1209	1000.1794	

	20	13:10					
C5_00172.EDF	XCTD-21	02/10/2014 15:57	75.8189	158.2342	601	609.7291	
C5_00173.EDF	XCTD-22	03/10/2014 11:27	75.6044	160.1891	2013	1000.1794	
C5_00174.EDF	XCTD-23	03/10/2014 12:28	75.4354	160.1249	1074	1000.1794	
C5_00175.EDF	XCTD-24	04/10/2014 0:47	76.1718	161.6553	2129	1000.1794	
C5_00176.EDF	XCTD-25	04/10/2014 2:48	76.3116	163.1994	1038	1000.1794	
C5_00177.EDF	XCTD-26	04/10/2014 4:53	76.5032	164.9323	510	581.0888	
C5_00178.EDF	XCTD-27	04/10/2014 6:35	76.6583	166.5147	604	612.8647	
C5_00179.EDF	XCTD-28	04/10/2014 8:24	76.8260	168.2175	1769	1000.1794	
C5_00180.EDF	XCTD-29	05/10/2014 1:18	77.1774	167.8764	557	544.1372	
C5_00181.EDF	XCTD-30	05/10/2014 4:13	77.3431	165.8048	828	668.4249	
C5_00182.EDF	XCTD-31	05/10/2014 7:17	77.5104	163.6389	316	324.3057	
C5_00183.EDF	XCTD-32	05/10/2014 10:30	77.6672	161.4026	2569	1000.1794	
C5_00184.EDF	XCTD-33	05/10/2014 21:21	78.1434	155.3075	2248	616.1958	
C5_00185.EDF		06/10/2014 8:41	78.5555	151.9151	0	1000.1794	Failure
C5_00186.EDF	XCTD-34	07/10/2014 11:00	78.6071	150.2119	3853	1000.1794	
C5_00187.EDF	XCTD-35	08/10/2014 3:02	77.5217	150.1056	3851	1000.1794	
C5_00188.EDF		09/10/2014 5:31	77.8508	148.2433	0	264.0044	Failure
C5_00189.EDF		09/10/2014 5:36	77.8502	148.1993	0	163.7059	Failure
C5_00190.EDF	XCTD-36	09/10/2014 5:44	77.8506	148.1404	3839	1000.1794	
C5_00191.EDF	XCTD-37	09/10/2014 14:37	77.4956	145.0303	3819	1000.1794	
C5_00192.EDF	XCTD-38	10/10/2014 3:09	77.7213	142.2712	3485	1000.1794	
C5_00193.EDF	XCTD-39	10/10/2014 15:30	77.4882	139.5035	3747	1000.1794	
C5_00194.EDF	XCTD-40	11/10/2014 1:13	76.6684	137.8674		1000.1794	
C5_00195.EDF	XCTD-41	11/10/2014 10:21	76.4644	137.8026	3640	1000.1794	
C5_00196.EDF	XCTD-42	12/10/2014 6:35	75.7623	141.2252	3744	736.2522	
C5_00197.EDF	XCTD-43	12/10/2014 8:50	75.4941	142.1371	3758	1000.1794	
C3_00198.EDF	XCTD-44	12/10/2014 10:45	75.3694	141.0286	3720	335.3081	Broken in ice
C3_00199.EDF	XCTD-45	13/10/2014 8:26	74.0710	134.4618	3092	1000.1794	
C3_00200.EDF	XCTD-46	13/10/2014 22:41	73.5006	132.4575	2751	1000.1794	
C3_00201.EDF	XCTD-47	14/10/2014 5:43	73.2097	135.1442	2861	1000.1794	
C5_00202.EDF		14/10/2014	72.4410	136.6936		871.4556	Failure

		15:05					
C5_00203.EDF		14/10/2014 15:11	72.4422	136.7171		575.7869	Failure
C5_00204.EDF	XCTD-48	14/10/2014 15:17	72.4436	136.7376	2547	1000.1794	
C5_00205.EDF	XCTD-49	14/10/2014 19:36	72.2551	138.8041	2661	391.9431	
C5_00206.EDF	XCTD-50	15/10/2014 4:23	71.5196	140.3636	2489	1000.1794	
C5_00207.EDF	XCTD-51	15/10/2014 13:14	71.1073	137.8239	1619	1000.1794	
C5_00209.EDF	XCTD-52	15/10/2014 15:54	71.2661	135.6705	1179	1000.1794	
C5_00210.EDF	XCTD-53	15/10/2014 18:50	71.3999	133.2576	794	759.382	

2.3 ADCP

Table 12. ADCP cast locations for 2014-11.

Filename is of format ADCPXXX_000000.LOG, where XXX is the file name in the table.

File Name	Cast Start Time and Date (UTC)	CTD Cast #	STATION	Comments
218	24/09/2014 15:25		test	bench test
219	24/09/2014 20:27		test	bench test
220	25/09/2014 3:48	5	CB-23a	
221	25/09/2014 16:05	6	CB-22	
222	26/09/2014 1:14	7	CB-27	
223	26/09/2014 12:20	8	$CB\text{-}21_{short}$	
224	27/09/2014 7:24	9	CB-18	
225	27/09/2014 16:17	10	CB-21	
226	28/09/2014 20:05	11	STA-A	
227	29/09/2014 6:43	13	CB-2	Re-started
228	29/09/2014 7:29	13	CB-2	Connector may have been stressed during this deployment/recovery.
229	29/09/2014 12:53	14	CB-3	connector cleaned and pins re-bent before deployment. Cables re-dressed to put slack in cable
230	29/09/2014 21:54	15	CB-6	
231	30/09/2014 11:40	16	CB-4	
232	01/10/2014 6:48	17	CB-7	
233	02/10/2014 5:13	19	CB-5	
234	03/10/2014 2:21	20	TU-1	
235	04/10/2014 10:52	22	TU-2	
236	06/10/2014 1:37	24	CB-10	
237	06/10/2014 4:59	25	CB-11	
238	08/10/2014 6:13	26	CB-8	

239	08/10/2014 15:34	27	CB-9	
240	09/10/2014 8:45	29	CB-12	
241	09/10/2014 20:41	30	CB-13	
242	10/10/2014 9:40	31	CB-16	
243	10/10/2014 19:16	32	CB-15	
244	11/10/2014 4:44	33	PP-7	
245	12/10/2014 0:50	34	CB-17	
246	13/10/2014 3:08	35	CB-40	
247	13/10/2014 15:57	36	CB-51	
248	13/10/2014 1:33	37	CB-50	
249	14/10/2014 8:58	38	CB-23a	
250	14/10/2014 20:46	39	CB-29	
251	15/10/2014 8:57	40	CB-28b	

2.4 Underway System

Table 13. Underway system sensors

Discrete samples were collected from the underway system for CDOM, ^{2}H, salinity, DIC/alkalinity and microplastics. CDOM, DIC/alkalinity and salinity were sampled to calibrate the corresponding sensors, while ^{2}H and microplastics were sampled for surface spatial distribution. CDOM, ^{2}H and DIC/alkalinity were sampled 1-4 times per day, salinity once every 2-3 days and microplastics at selected station.

Parameter	Sensor	S/N	Location
Thermosalinograph	SBE-21	3297	TSG lab
In-line thermometer	SBE-38	0319	Engine room, inline at 4 m from pump at intake
Hull-mounted temperature	SBE-48	?	Inside the hull, below waterline
Total gas tension	Total Gas Device	?	TSG lab, blue cooler
Oxygen saturation	Optode oxygen sensor	?	TSG lab, blue cooler
Chl-*a*	WetLabs WETStar fluorometer	WS3S-521P	TSG lab
CDOM	WetLabs CDOM	WSCD-1281	TSG lab
PAR	Biospherical Scalar PAR Refence QSR2100	10350	Helicopter hanger roof
Depth	Knudsen 12 KHz sounder	?	?

2.5 Zooplankton – Vertical Bongo Net Hauls

Table 14. 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). * Two 53 µm cod end samples per NET were combined together, into 1 sample. The 236 µm samples were preserved in 95% ethanol, while the 150 and 53 µm samples were preserved in buffered formalin.

Station	NET Number	RBR Depth Recorded (m)	236	150	*53	Total	Comment
AG-5	NET1	n/c	1	1	1	3	
AG-5	NET2	n/c	1	1	1	3	
CB-21	NET3	n/c	1	1	1	3	
CB-21	NET4	n/c	1	1	1	3	
Sta-A	NET5	475.8	1	1	1	3	
Sta-A	NET6	99.5	1	1	1	3	
CB-4	NET7	101.6	1	1	1	3	
CB-4	NET8	498.8	1	1	1	3	
TU-1	NET9	489.6	1	1	1	3	
TU-1	NET10	90.7	1	1	1	3	
TU-2	NET11	488.4	1	1	1	3	
TU-2	NET12	95.4	1	1	1	3	
CB-9	NET13	496.2	1	1	1	3	
CB-9	NET14	99.1	1	1	1	3	
CB-15	NET15	536.1	1	1	1	3	Counter coupling slipped
CB-15	NET16	99.7	1	1	1	3	Counter coupling slipped
CB-51	NET17	557.7	1	1	1	3	Counter coupling slipped
CB-51	NET18	117.5	1	1	1	3	Counter coupling slipped
CB-28b	NET19	495.7	1	1	1	3	
CB-28b	NET20	98.3	0	1	1	2	236 cod end lost
All Stations			***19***	***20***	***20***	***59***	

2.6 Microbial Diversity Casts

Table 15. Locations of microbial diversity stations.

At each station, 3-8 depths were sampled and were defined as either: surface (usually ~ 5 m), mixed layer (~25 m), subsurface chlorophyll maximum, below SCM (SCM - 10 m), 100m-depth and the core of the Pacific Winter Water (33.1 psu). *** Stations were sampled in 2014, 2013 and 2012, ** Stations were sampled in 2014 and 2013, * Stations were sampled in 2014 and 2012.

Station	Cast #	Cast Start Date and Time (UTC	Latitude (N) Longitude (W)	Bottom depth (m)	Cast depth (m)	Sample #	Comments
***AG-5	1	9/23/2014 6:31	70° 33.172’ N 122° 54.402’ W	640	120	1-8	Sunny, no waves

**CB-31b	4	9/24/2014 15:13	72° 17.820’ N 134° 4.158’ W	2110	1500	9-13	Slightly sunny, calm
**CB-22	6	07/08/2013 14:27	73° 25.934’ N 138° 6.210’ W	3159	3115	14-18	Ice, calm
CB-27	7	9/26/2014 23:12	74° 1.35’ N 139° 59.501’ W	3237	3004	19-23	Cloudy but calm
***CB-21	8	9/26/2014 11:34	73° 58.938’ N 140° 6.055’ W	3538	1000	24-28	Calm
***Stn-A	11	9/26/2014 20:01	72° 36.246’ N 144° 41.214’ W	3463	1000	29-33	1m swell
***CB-2	13	9/29/2014 6:30	72° 59.615’ N 149° 58.469’ W	3769	3547	34-38	Foggy ,1m swell
***CB-3	14	9/29/2014 12:42	74° 0.042’ N 149° 59.376’ W	3845	3620	39-42	Snowy, ice
CB-7	17	10/01/2014 6:49	75° 59.755’ N 149° 59.105’ W	3851	3629	43-47	Calm
*CB-4	18	10/01/2014 16:00	74° 59.896’ N 149° 58.406’ W	3489	1000	48-53	Cloudy
***CB-5	19	10/02/2014 4:38	75° 17.912’ N 153° 17.910’ W	3861	3641	54-58	Cloudy, snowing
***TU-1	20	10/02/2014 2:38	75° 58.070’ N 159° 57.188’ W	1705	600	59-63	Calm
***TU-2	22	10/04.14 10”40	77° 0.071’ N 169° 59.357’ W	2241	500	64-69	Calm
**CB-10	24	10/06/2014 1:40	169° 59.357’ N 153° 16.262’ W	2200	2170	79-73	Snowy, raining
***CB-11	25	10/07/2014 22:31	78° 1.33’ N 149° 56.888’ W	3848	3697	74-79	Low winds
***CB-9	10	10/08/2007 22:50	77° 31.05’ N 147° 50.45’ W	3809	1000	80-85	Cloudy, smooth sea
**CB-12		10/09/2024 8:36	77° 41.321’ N 146° 43.518’ W	3832	3611	86-90	Windy, snowy
IBO1 (near CB-11)		24/08/2013 1:50	79° 2.100’ N 149° 58.500’ W			91-96	Chilly
***CB-16	31	10/10/2014 9:25	77° 57.702’ N 140° 12.216’ W	3775	1000	97-101	Calm
*CB-15	32	10/10/2014 4:45	76° 59.293’ N 139° 46.151’	3743	3520	102-104	calm

			W					
PP-7	33	10/11/2014 4:45	76° 24.734’ N 135° 38.20’ W	3586	3360	105-109	Calm, snowing
CB-17	34	10/12/2014 0:51	76° 1.189’ N 139° 54.901’ W	3716	3491	110-112	Calm
***CB-40	35	10/13/14 3:32	74° 30.065’ N 135° 27.348’ W	3279	3052	114-118	Calm
CB-23a	38	10/14/14 8:46	72° 53.934’ N 136° 4.488’ W	2765	2740	119-122	Strong winds, chilly
CB-29	39	10/14/14 22:51	72° 2.471’ N 140° 0.484’ W	2739	2700	123-127	Calm seas, light wind
IBO2 (near PP-7)		10/31/14	76° 0.702’ N 139° 49.098’ W			128-136	A bit windy
CB-28b	40	10/15/14 8:45	71° 0.960’ N 140° 2.549’ W	2122	2073	137-141	Waves

2.7 Radon and Radium isotopes

Table 16. Radon/Radium sampling locations

Large-volume (~200 L) water samples for radium (Ra) 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-222 to radium-226 ratio ($^{222}Rn/^{226}Ra$) profiles sampling station and both type of samples were collected using a submersible pump.

Station	Latitude (°N)	Longitude (°W)	Cast start date	Sample depth (m)	Sample #	Comments
CB-31b	72.2973	134.0705	24/09/2014	1	4003 - 4008	Large volume Ra
				1, 10, 15, 20, 35, 50		Rn/Ra profiles
CB-27	72.9937	139.9912	25/09/2014	2.5	4009 - 4015	Large volume Ra
				2.5, 5, 10, 20, 35, 50, 65, 85		Rn/Ra profiles
Sta-A	72.6033	144.6865	28/09/2014	2.5, 85	4016 - 4021	Large volume Ra
				2.5, 5, 10, 20, 35, 50, 65, 85		Rn/Ra profiles
CB-6	74.7038	146.6895	29/09/2014	2.5	4022 - 4029	Large volume Ra
				25., 5, 10, 20, 30, 40, 60, 94		Rn/Ra profiles
CB-7	75.9958	149.9853	01/10/2014	2.5	4030 - 4037	Large volume Ra
				2.5, 5, 10, 20, 35, 50, 60, 85		Rn/Ra profiles
CB-5	75.2987	153.2988	02/10/2014	2.5	4038 - 4045	Large volume Ra
				2.5, 5, 10, 20, 30, 40, 50, 85		Rn/Ra profiles
TU-1	75.9643	159.9335	03/10/2014	2.5	4046 - 4053	Large volume Ra
				2.5, 5, 10, 20, 30, 40, 50, 85		Rn/Ra profiles

TU-2	76.9955	169.9988	04/10/2014	2.5	4054 - 4061	Large volume Ra
				2.5, 5, 10, 20, 40, 60, 80		Rn/Ra profiles
CB-8	77.0253	150.0268	08/10/2014	5	4062 - 4065	Large volume Ra
				5, 15, 35, 55		Rn/Ra profiles
CB-13	77.3095	143.4967	09/10/2014	2.5	4066 - 4071	Large volume Ra
				2.5, 10, 25, 45, 60, 75		Rn/Ra profiles
PP-7	76.4122	135.6383	11/10/2014	2.5	4074 - 4079	Large volume Ra
				2.5, 5, 15, 35, 50, 65, 80		Rn/Ra profiles
CB-17	76.0198	139.9147	12/10/2014	2.5	4082 - 4085	Large volume Ra
				2.5, 10, 20, 40, 60, 80		Rn/Ra profiles
CB-40	74.5012	135.4553	13/10/2014	2.5	4086 - 4091	Large volume Ra
				2.5, 10, 20, 40, 60, 80		Rn/Ra profiles
CB-50	73.5048	134.2563	14/10/2014	2.5	4092 - 4097	Large volume Ra
				2.5, 10, 20, 40, 60, 80		Rn/Ra profiles
CB-29	72.0418	139.9967	14/10/2014	2.5	4103 - 4098	Large volume Ra
				2.5, 8, 15, 30, 50, 80		Rn/Ra profiles
CB-28b	71.0160	140.0422	15/10/2014	2.5	4104 - 4109	Large volume Ra
				2.5, 8, 15, 30, 40, 70		Rn/Ra profiles

2.8 Radiometer and Ceilometer (PMEL, NOAA)

Table 17. Location of radiosonde RS92-SGP deployments.
Deployment dates and times are the actual release date and time, calculated by Vaisala programs from pressure records. The positions (Latitude and Longitude are from the sounding logs which were initiated at the time the radiosondes were ground checked and initialized. The actual deployment location generally occurred 5-10 min later.

Radiosonde Event #	Deployment Date and Time (UTC)	Latitude (°N)	Longitude (°W)	Comments
1	26/09/2014 20:27	73.996	139.954	C-130 overflight
2	27/09/2014 12:05	74.554	140.168	
3	28/09/2014 0:32	74.012	139.952	
4	29/09/2014 0:02	72.625	144.680	
5	29/09/2014 12:00	73.778	150.008	
6	30/09/2014 0:02	74.714	146.692	
7	30/09/2014 12:28	75.008	150.064	
8	01/10/2014 0:07	75.070	148.557	
9	01/10/2014 12:26	75.452	150.001	

10	02/10/2014 0:08	75.073	150.786	
11	02/10/2014 12:09	75.548	155.724	
12	02/10/2014 23:56	76.000	160.003	
13	03/10/2014 12:02	75.563	160.172	
14	03/10/2014 23:59	76.049	160.543	
15	04/10/2014 12:30	76.998	170.000	
16	05/10/2014 0:04	77.093	168.934	
17	05/10/2014 11:58	77.746	160.587	
18	06/10/2014 0:00	78.254	153.876	
19	06/10/2014 11:57	78.889	150.731	
20	07/10/2014 4:25	79.040	149.926	Late, helicopter operations
21	07/10/2014 12:24	78.431	150.291	
22	07/10/2014 23:54	77.982	150.035	
23	08/10/2014 12:13	77.580	150.153	
24	09/10/2014 0:01	78.012	149.997	
25	09/10/2014 12:21	77.639	146.161	
26	10/10/2014 0:00	77.325	143.381	
27	10/10/2014 11:41	77.963	140.221	
28	11/10/2014 0:00	76.905	138.779	
29	11/10/2014 12:03	76.395	138.973	
30	12/10/2014 0:25	76.018	139.834	
31	12/10/2014 11:59	75.291	140.466	
32	13/10/2014 0:06	74.763	137.112	
33	13/10/2014 11:57	73.571	132.615	
34	13/10/2014 23:59	73.515	133.163	
35	14/10/2014 12:20	72.785	136.131	
36	14/10/2014 23:57	72.040	140.031	
37	15/10/2014 12:13	71.048	138.894	

2.9 Mooring Operations

Table 18. Location of mooring recovery and deployments.

Mooring Name	Bottom Depth (m)	2013 Deployment	2013 Location	2014 Recovery	2014 Deployment	2014 Location
BGOS-A	3830	14-Aug 18:30 UTC	74° 59.5738' N 149° 58.8354' W	30-Sep 16:39 UTC	01-Oct 22:21 UTC	75° 0.137' N 149° 57.322' W
BGOS-B	3830	21-Aug 20:38 UTC	77° 59.5161' N 150° 3.2380' W	07-Oct 20:18 UTC	09-Oct 00:28 UTC	78° 0.6177' N 149° 59.8203' W
BGOS-D	3530	09-Aug 21:09 UTC	73° 59.7817' N 139° 57.3017' W	26-Sep 20:01 UTC	27-Sep 21:20 UTC	74° 1.853' N 140° 3.741' W
GAM-1	2103				03-Oct 22:39 UTC	76° 0.145' N 160° 8.749' W

GAM-2	2222				04-Oct 21:45 UTC	77° 0.031' N 170° 3.051' W

Table 19. Ice-Based Observatory buoy deployment summary.

IBO: Ice-Based Observatory; ITP: Ice-tethered Profiler; IMBB: Ice Mass Balance Buoy; O-Buoy: atmospheric chemistry Ozone Buoy; S-IMBB: Seasonal Ice Mass Balance Buoy.

IBO	ITP / Buoy System	Date (UTC)	Location
1	ITP85 / IMBB/ O-Buoy11	07-Oct 23:29	79° 2.1' N 149° 58.5' W
2	ITP84 / S-IMBB / O-Buoy12	11-Oct 1:15	76° 1.9' N 139° 48.7' W

Table 20. Ice-Tethered Profiler recovery summary

Recovery	ITP	Date (UTC)	Location
1	ITP79	30-Sep 23:30	75° 2.6' N 148° 28.2' W
2	ITP77	02-Oct 18:33	75° 53.1' N 158° 28.7' W
3	ITP71	12-Oct 18:07	75° 10.9’ N 139° 47.3’ W

Table 21. Instruments utilized or deployed by the University of Montana.

Measurement system	Instrument IDs	Location	Duration
underway infrared-equilibrator *p*CO_2	SUPER (Sunburst Sensors)	Entire cruise track (see IOS report in this document)	9/24/14-10/16/14
ITP SAMI-CO_2 & ITP SAMI-pH including PAR, Seabird Microcat with dissolved oxygen sensor	WHOI ITP #85, SAMI-CO_2 C87, SAMI-pH P130	First ice station, pH ~6 m depth CO_2 ~ 9 m depth, Microcat ~ 8 m depth (see WHOI cruise report in this document)	10/6/14- present
ITP SAMI-CO_2 including PAR & Seabird Microcat with dissolved oxygen sensor	WHOI ITP #84, SAMI-CO_2 C88	Second ice station CO_2 ~6.5 m depth, Microcat ~ 8m depth (see WHOI cruise report in this document)	10/11/14 – present
SAMI-pH	S47	BGOS-A mooring	9/30/14 – present
SAMI-CO2	C38	BGOS-B mooring	10/8/14 - present

2.10 Ice Observations during 2014-11 (KIT, OSU)

Table 22. EM31/ICE observation log.

Profile number	Start Time (UTC)	Start Position	End Time (UTC)	End Position	Length of profile [km]
1	25/09/2014 2:39	72.9059 °N 135.9346 °W	25/09/2014 14:19	73.4327 °N 138.1077 °W	126.85
2	25/09/2014 17:03	73.3814 °N 138.1427 °W	25/09/2014 23:30	72.9921 °N 139.9952 °W	79.07
3	26/09/2014 17:03	73.0060 °N 140.0403 °W	26/09/2014 11:35:59	73.9822 °N 140.1010 °W	144.65
4	26/09/2014 13:18:06	73.9840 °N 140.0462 °W	26/09/2014 15:30:12	73.9984 °N 139.9476 °W	26.58
5	27/09/2014 1:00:10	74.0377 °N 140.1213 °W	27/09/2014 11:14:09	74.6862 °N 140.2174 °W	152.76
6	27/09/2014 11:15:54	74.6777 °N 140.2177 °W	27/09/2014 16:16:40	73.9933 °N 139.8676 °W	90.84
7	30/09/2014 1:00:10	74.7441 °N 146.9443 °W	30/09/2014 10:49:20	75.0069 °N 150.0623 °W	104.73
8	01/10/2014 1:38:54	75.2510 °N 148.8367 °W	01/10/2014 6:52:29	75.9959 °N 149.9850 °W	89.31
9	01/10/2014 9:19:03	75.9966 °N 149.9675 °W	01/10/2014 16:35:03	74.9976 °N 149.9721 °W	117.25
10	01/10/2014 23:35:00	75.0566 °N 150.5976 °W	02/10/2014 4:45:00	75.2982 °N 153.2973 °W	82.12
11	02/10/2014 5:55:56	75.2953 °N 153.2899 °W	02/10/2014 16:39.6	75.8834 °N 158.4792 °W	160.3
12	04/10/2014 1:39:33	76.2278 °N 162.2415 °W	04/10/2014 11:31:24	76.9984 °N 170.000134W	218.45
13	04/10/2014 21:58:18	77.0044 °N 170.0537 °W	05/10/2014 0:59:59	77.1650 °N 168.0335 °W	53.28
14	05/10/2014 1:00:10	77.1653 °N 168.0294 °W	2014/14/06 0:59:59	78.2947 °N 153.2644 °W	60
15	06/10/2014 1:00:10	78.2949 °N 153.2644 °W	06/10/2014 2:05:45	78.2999 °N 153.2755 °W	1.67
16	06/10/2014 2:19:02	78.2992 °N 153.2775 °W	06/10/2014 13:56:14	79.0006 °N 150.0623 °W	123.37
17	07/10/2014 4:17:51	79.0232 °N 149.9489 °W	07/10/2014 19:05:37	77.9917 °N 150.0524 °W	163.87
18	201410/09 2:32:58	77.9807 °N 149.9932 °W	09/10/2014 11:43:24	77.6489 °N 146.4176 °W	102.71

19	09/10/2014 11:45	77.6474 °N 146.3930 °W	09/10/2014 20:44	77.3091 °N 143.4980 °W	95.82
20	09/10/2014 23:22:09	77.3004 °N 145.5010 °W	10/10/2014 11:32:10	77.9631 °N 140.2330 °W	143.54
21	10/10/2014 11:34:16	77.9632 °N 140.2230 °W	10/10/2014 20:56	76.9823 °N 139.7630 °W	133.67
22	10/10/2014 22:18:11	76.9572 °N 139.5910 °W	11/10/2014 4:53	76.4120 °N 135.6360 °W	138.77
23	11/10/2014 4:53	76.4050 °N 135.6120 °W	11/10/2014 15:28	76.0352 °N 139.8210 °W	155.46
24	12/10/2014 3:31	76.0191 °N 139.9320 °W	12/10/2014 15:29	75.1836 °N 139.7330 °W	214.9
25	12/10/2014 17:30:41	75.1713 °N 139.7552 °W	13/10/2014 3:14:38	74.5015 °N 135.4545 °W	240.66
26	13/10/2014 0:01:10	74.6544 °N 136.9888 °W	13/10/2014 15:18:07	73.4426 °N 131.2040 °W	292.7
27	13/10/2014 18:55:32	73.4334 °N 131.2811 °W	14/10/2014 1:16:34	73.5060 °N 134.2521 °W	116.06
28	14/10/2014 3:50:49	73.4993 °N 134.3107 °W	14/10/2014 22:03:34	72.0554 °N 139.9156 °W	316.21

Table 23. Summary of on-ice EM31SH and drill-hole measurements.

See Figure 1 below to see schematic of the IBO's transects.

IBO	Latitude (°N) Longitude (°W)	Transect Line	Length of profile [m]	Snow depth [m]		Ice thickness [m]	
				Mean	s.d.	Mean	s.d.
1	79.0350 °N 149.9750 °W	Line-1	90	0.1	0.05	2.24	0.32
2	76.0317 °N 139.8117 °W	Line-1	50	0.16	0.03	0.81	0.14
		Line-2	50	0.16	0.03	0.78	0.07

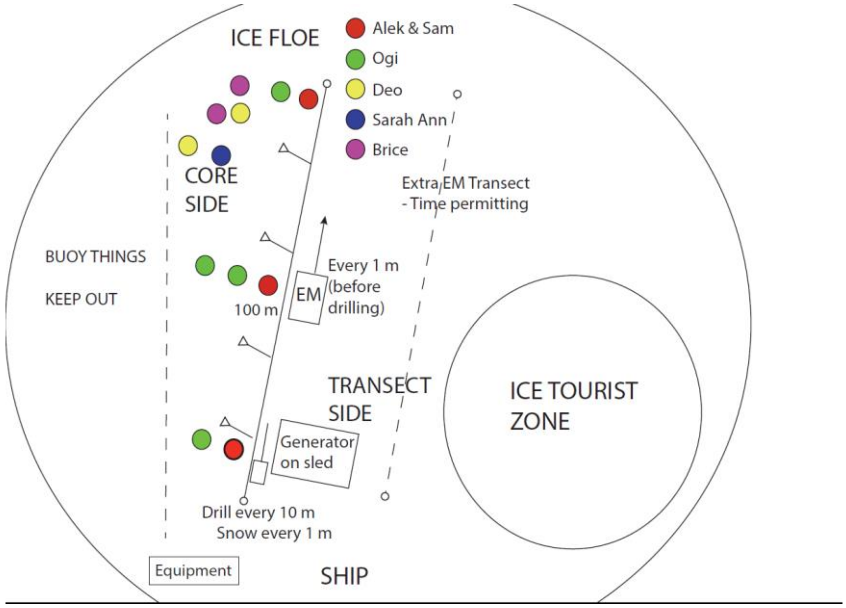
Table 24. IBO ice core sample summary

T/S profiles = temperature/salinity profiles for Jenny Hutchings (OSU), Microbial Diversity for Connie Lovejoy (ULaval), Fe/PFAS/BC = Iron/polyfluorinated alkyl substances/black carbon for Jun Nishioka (UHokkaido)/Michiyo Yamamoto-Kawai (TUMSAT), Rn/Ra activity = radon to radium ratio activity for Brice Loose (URI) and Microplastics for Peter Ross (VAquarium). See Figure 1 below to see location of ice cores relative to drill-hole transects.

Date	Parameters	Core #	Site	Thickness (exact) (cm)	Thickness (approx) (cm)	Snow depth (cm)	Freeboard (cm)
07/10/2014	T/S profiles	1	1	224.3	240	17.5	6

	T/S profiles	2	2	177.7	190	12	24
	T/S profiles	3	3	187.9	190	20	17
	Microbial Diversity	1	1	243	240	17.5	6
	Microbial Diversity	2	3	N/A	190	20	17
	Fe/PFAS/BC	1	1	N/A	240	17.5	6
	Fe/PFAS/BC	2	3	N/A	190	20	17
	Fe/PFAS/BC	3	3	N/A	190	20	17
	Rn/Ra acitvity	1	1	N/A	240	17.5	6
	Rn/Ra acitvity	2	2	N/A	190	12	24
	Microplastics	1	3	171.2	190	20	17
11/10/2014	T/S profiles	1	1	68.3	70	14	4
	T/S profiles	2	2	109.2	105	10	13
	T/S profiles	3	3	69.8	90	12	8
	Microbial Diversity	1	1	N/A	70	14	4
	Microbial Diversity	2	3	N/A	90	12	8
	Fe/PFAS/BC	1	1	N/A	70	14	4
	Fe/PFAS/BC	2	3	N/A	90	12	8
	Fe/PFAS/BC	3	2	N/A	105	10	13
	Microplastics	1	1	81.8	70	14	4
	Spare	1	2	N/A	105	10	13

(A)



(B)

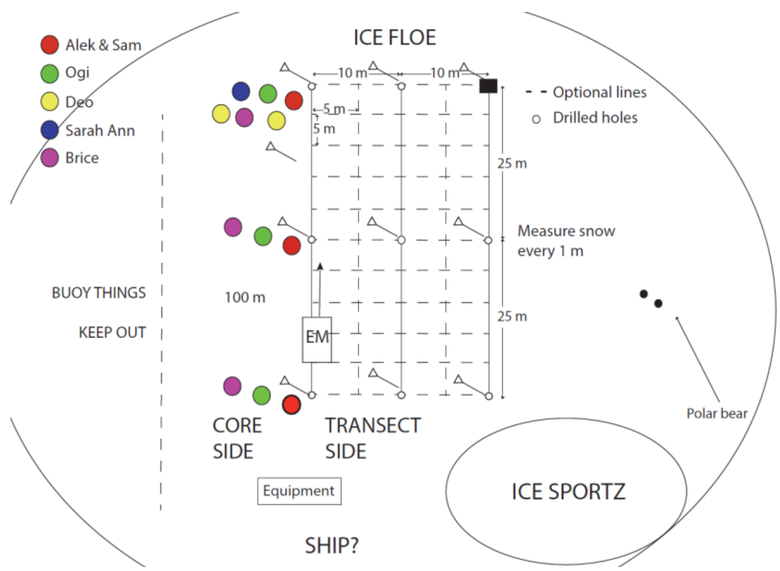


Figure 11. Ice-Based Observatories schematic. Map of the location of ice cores collected during Ice-Based Observatory (IBO) 1 ((A), on 7/10/2014) and 2 ((B), on 11/10/2014). Cores collected for "Alex & Sam" were for temperature/salinity ice core profiles, "Ogi" for iron and polyfluorinated alkyl substances/black carbon, "Deo" for microbial diversity, "Sarah-Ann" for microplastics and "Brice" for radon/radium activity. EM = electro-magnetic sensor.

2.11 Microplastics

Table 25. Microplastic depth profile sample summary.

BSB = Barents Sea Branch, FSB = Fram Strait Branch, wPW = winter Pacific Water, T_{max} = temperature maximum, S = salinity, chl-*a* = chlorophyll-*a*, DO = dissolved oxygen concentration.

Station	Date, Time (UTC)	Latitude (°N)	Longitude (°W)	Niskin	Depth (m)	Sample ID	Volume (L)	Note

CB-21	26/9/2014	73.9786	140.1062	1-4	1000	149-152	40	Atlantic water from BSB
	12:39:00			5-7	449	153-155	30	T_{max}, Atlantic water from FSB
				8-10	212	156-158	30	S = 33.1 psu, wPW
				12-13	75	166-167	20	chl-*a* max
				21-23	5	170-172	30	surface water
CB-4	1/10/2014	74.9983	149.9734	1-3	1000	390-392	30	Atlantic water from BSB
	16:58:00			7-9	268	396-398	30	Atlantic water from BSB with incresed DO, below FSB
				10-12	211	399-401	30	S = 33.1 psu, wPW
				16-18	75	405-407	30	chl-*a* max
				21-23	5	410-412	30	surface water
CB-9	9/10/2014	77.9875	150.0349	1-2	1000	602-603	20	Atlantic water from BSB
	01:19:00			3-5	445	604-606	30	T_{max}, Atlantic water from FSB
				6-8	244	607-609	30	Atlantic water from BSB with incresed DO, below FSB
				9-11	193	610-612	30	S = 33.1 psu, wPW
				15-17	57	616-618	30	chl-*a* max
				20-22	5	621-623	30	surface water

Table 26. Microplastic seawater loop sample summary.

Microplastic seawater loop samples were collected as we were approaching or leaving the CTD/Rosette station (Station). Flow rate was calculated from measuring the time it took to fill a 20L graduated bucket from the seawater loop outlet utilized to collect the samples.

Station	Date	Sample ID	Start / End	Latitude (°N)	Longitude (°W)	Sieving time (min)	Flow rate (L/min)	Volume sieved (L)
AG-5	23/09/2014	loop 217	start	70.499	122.636	19.58	3.45	67.53
			end	70.540	122.851			
CB-1	24/9/2014	loop 222	start	71.718	131.433	21.12	3.59	75.87
			end	71.759	131.729			
CB-6	29/09/2014	loop 256	start	74.766	147.225	20.88	3.62	75.53
			end	74.784	147.446			
CB-4	1/10/2014	loop 268	start	74.999	150.029	20.05	3.83	76.85
			end	75.020	150.223			

TU-1	2/10/2014	loop 275	start end	75.957 75.981	159.599 159.815	20.07	3.83	76.84
TU-2	4/10/2014	loop 283	start end	77.006 77.023	170.031 169.813	20.50	3.83	78.51

Table 27. Microplastic ice core sample summary.

See Table 22 and Figure 1 (above) for ice core location within the ice-based observatory.

IBO	Date	Latitude (°N) / Longitude (°W)	Snow depth (cm)	Freeboard (cm)	Core piece	core section length (cm)	Date melted	Volume sieved (mL)	T°$_{melted\ sample}$ (°C)
1	6/10/2014	79.035 149.975	20	17	1	46.4	7/10/2014	2490	7.3
					2	22.3		1300	13.4
					3a	47.8		2815	7.5
					3b	41.1		2365	9.1
					4	13.6		830	13.5
					TOTAL	***171.2***			
2	11/10/2014	76.032 139.812	14	13	1	9	12/10/2014	430	17.9
					2	15.2		920	17.8
					3	19.7		920	17.7
					4	15.9		850	20.7
					5	22		1000	20.6
					TOTAL	***81.8***			

2.12 Chi-pod Temperature Microstructure sensors

Table 28. Chi-pod data collection summary.

Station	Date	Cast Depth (m)	Start Time (UTC)	End Time (UTC)	Up RBR Sensor #	Up Sensor #	Down Sensor #
AG-5$_{short}$	23/09/2014	146	18:31	18:53	1009	1008	1014
AG-5	23/09/2014	641	20:03	20:37	1009	1008	2014
CB-1	24/09/2014	1109	8:02		1009	1008	1014
CB-31b	24/09/2014	1000	15:13	16:54	1009	1008	1011
CB-23a	25/09/2014	2730	1:50	3:55	1009	1008	1011
CB-22	25/09/2014	1000	14:27	16:33	1009	1008	1011
CB-27	9/25-26/14	3200	23:12	1:37$_{next\ day}$	1009	1008	1006
CB-21$_{short}$	26/09/2014	1000	11:34	12:09	1009	1008	1006
CB-18	27/09/2014	3605	7:12	9:32	1009	1008	1006
CB-21	27/09/2014	3500	16:05	19:03	1009	1008	1006
Sta-A$_{short}$	28/09/2014	1000	20:01	20:56	1009	1008	1006

Sta-A	9/28-29/14	3427	22:00	12:21 next day	1009	1008	1006
CB-2	29/09/2014	3737	6:30	8:50	1009	1008	1006