Joint Ocean Ice Study (JOIS) 2015
Cruise Report

Photo credit: Rick Krishfield's camera

Report on the Oceanographic Research Conducted aboard the *CCGS Louis S. St-Laurent,*
September 20 to October 16, 2015
IOS Cruise ID 2015-06

Bill Williams, Sarah Zimmermann and Sarah Ann Quesnel
Fisheries and Oceans Canada
Institute of Ocean Sciences Sidney, B.C.

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2015 is an important contribution from Fisheries and Oceans Canada to international Arctic climate research programs. It is a collaboration between 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/**) which maintains the Beaufort Gyre Observing System (BGOS) as part of the Arctic Observing Network (AON).

In 2015, JOIS also includes collaborations with researchers from:

Japan:
- National Institute of Polar Research, GRENE Project.
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC), as part of the Pan-Arctic Climate Investigation (PACI).
- Tokyo University of Marine Science and Technology, Tokyo.
- Kitami Institute of Technology, Hokkaido.

USA:
- Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.
- Yale University, New Haven, Connecticut.
- Oregon State University, Corvallis, Oregon.
- Cold Regions Research Laboratory (CRREL), Hanover, New Hampshire.
- Bigelow Laboratory for Ocean Sciences, Maine.
- Applied Physics Laboratory, University of Washington, Seattle, Washington.
- University of Washington, Seattle, Washington.
- University of Montana, Missoula, Montana.
- Naval Postgraduate School, Monterey, California.
- NOAA Pacific Marine Environmental Laboratory, Seattle, Washington.

Canada:
- Trent University, Peterborough, Ontario.
- Université Laval, Quebec City, Quebec.
- University of British Columbia, Vancouver, British Columbia.
- Dalhousie University, Halifax, Nova Scotia
- University of Ottawa, Ottawa, Ontario
- Concordia University, Montreal, Quebec
- University of Victoria, Victoria, British Columbia

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

CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S. St-Laurent* began September 20th and finished October 16th, 2015. The research was conducted in the Canada Basin from the Beaufort Slope in the south to 80°N by a research team of 26 people. Full depth CTD/Rosette casts with water samples were conducted. These casts measured biological, geochemical and physical properties of the seawater. Underway expendable temperature and salinity probes (XCTDs) were deployed between the CTD/Rosette casts to increase the spatial resolution of CTD measurements. Moorings and ice-buoys were serviced and deployed in the deep basin and Northwind Ridge to collect year-round time-series data. Underway ice observations and on-ice surveys were 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. The location of science stations, the primary sampling at each station, and the total number of each type of station, is shown in Figure 1 below.

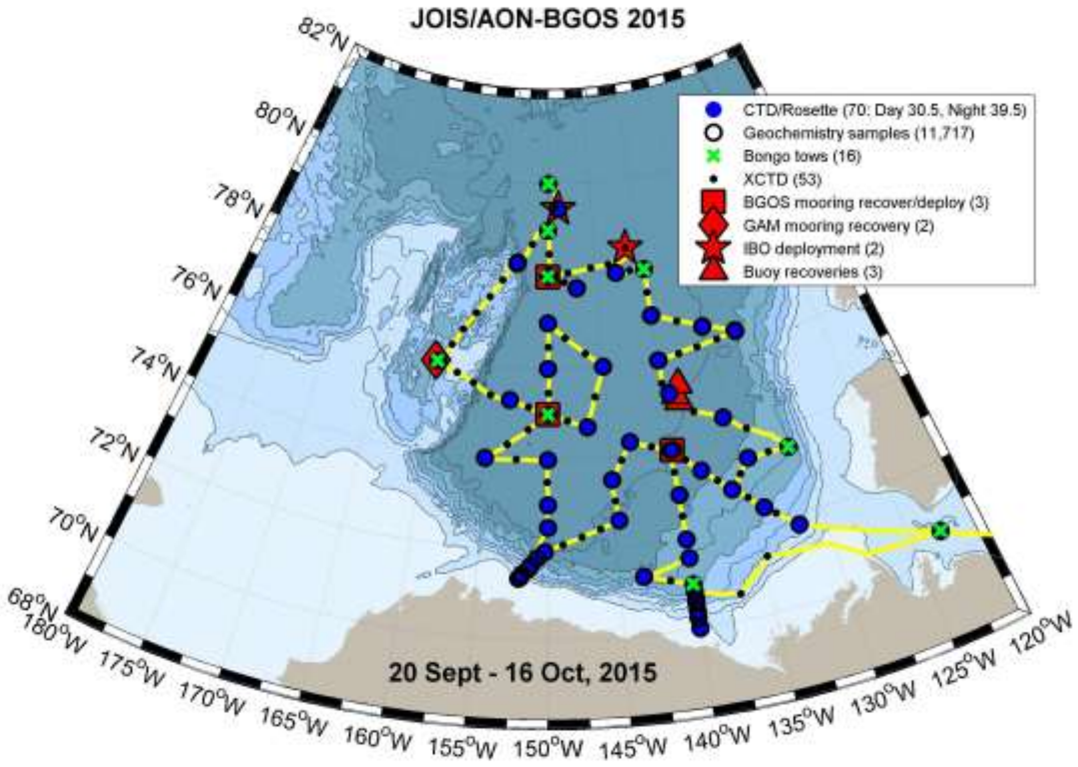

Figure 1.The JOIS-2015 cruise track showing the location of science stations.

1.1 Program Components

Measurements:

- At CTD/Rosette Stations:
  - 70 CTD/Rosette Casts at 54 Stations (DFO) with 1502 Niskin bottle water samples collected for hydrography, geochemistry and pelagic biology (bacteria and phytoplankton) analysis (DFO, Trent U, TUMSAT, WHOI, U Laval, UBC, Dalhousie, U Ottawa, Vancouver Aquarium). Water samples taken:
    - At all full depth stations: Salinity, dissolved O_2 gas, Nutrients (NO_3^-, PO_4^{3-}, SiO_4^{4-}), Barium, ^{18}O isotope in H_2O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a, dissolved ^{16}O, ^{17}O and ^{18}O in dissolved O_2 (triple oxygen isotopes), ^{15}N nitrate
    - At selected stations: microbial diversity, ^{129}I, ^{137}Cs, ^{236}U, dissolved N_2/Ar ratio, microplastics, N_2O/CH_4, $^{13}CH_4$.
  - 15 Vertical Net Casts at 9 select CTD/Rosette stations with one cast each to 100m and 500m per station, where possible. Mesh size is 150 µm and 236 µm. (DFO)

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

- Mooring and buoy operations
  - 3 Mooring Recoveries/Deployments in the deep basin (BGOS-A,B,D; WHOI)
  - 1 Mooring Recovery on the Northwind Ridge (GAM-1, 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 (OBuoy13, BLOS)
    - the second:
      - 1 Ice-Tethered Profiler (ITP84, WHOI, UMontana)
      - 1 S-Ice Mass Balance Buoy (S-IMBB, CRREL)
      - 1 O-buoy (OBuoy14, BLOS)
  - 4 Buoy Recoveries (AOFB30, O-Buoy10, ITP70, ITM3 WHOI)

- Ice Observations (OSU/KIT)

  Hourly visual ice observations from bridge with periodic photographs taken from 2 cameras mounted on Monkey's Island (one forward-looking and one port-side camera).

  Underway ice thickness measurements electromagnetic inductive sensor (EM31-ICE).

  Snow/Ice Microwave emission using a Passive Microwave Radiometer (PMR).

  Sea-ice radiation balance for solar and far-infrared using a CNR-4 net-radiometer mounted on the bow while the ship was in sea ice and underway.

  On-ice measurements at 2 IBO sites including:

-EM31 ice thickness transects
-Drill-hole ice thickness transects
-Ice-cores for temperature, salinity and structure profiles
-Ice-cores for iron, microdiversity and microplastics.
-Snow pits

- Cloud and weather observations:
  35 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).

- Daily dispatches to the web (WHOI)

- 4 Spot Messenger Trace surface drift trackers deployed: 2 over the slope at 140W and 2 at Cape Bathurst (DFO)

2. COMMENTS ON OPERATION

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We steamed anti-clockwise around the Beaufort Gyre this year, first steaming north along our eastern stations and then heading west across the northern stations and south along the western stations. Our last mooring operations were at BGOS-D and the final CTD/Rosette stations on the southern end of 140W over the slope of the Canadian Beaufort Shelf. This was the first year we tried steaming anticlockwise, and it had several benefits:
1. Ice-buoy deployments: All buoys and other on-ice work, were completed early in the expedition, before mooring operations began, which was logistically easier, and before very short days and very cold temperatures set in after the equinox.
2. Freeze-up: There were large areas of open water this year at the sea-ice minimum in mid-September. By steaming to the north first, we worked our way south as freeze-up occurred, so we spent a lot of time in new ice, which damped ocean waves and swell while still allowing us fast transit speeds.
3. Additional stations: We made very good progress this year due to high ship speeds in light ice and no delays due mechanical problems, medevac or search and rescue. Thus our contingency time was available towards the end of the expedition and, because we steamed anticlockwise and were in the south last, we were able to occupy our slope stations on the southern end of 150W and 140W.

We plan to go anticlockwise next year, should ice conditions allow. The ‘tail’ of multi-year ice that stretches south along the eastern edge of the Beaufort Gyre is typically too thick to break easily and stations in this area have been omitted in previous years due to the slow ship speed and high fuel use while in this region. Thus, in a heavy-ice year, it is best to sail clockwise so that most of the science stations can be completed before dealing with the thickest ice. This year the multi-year ice was relatively thin, so the ship proceeded through the ‘tail’ with only moderate effort and we occupied all the planned science stations there.

This year we received 3 additional days of ship-time from the National Science Foundation to support deployment of buoys in the ice for other projects. This was most welcome, since, for the first time, we had an appropriate amout of shiptime to get the job done. The multi-year ice we found in the north this year was thinner than usual, and we spent time (at least 1-2 days) looking for large, stable ice floes and needed to steam north of our intended route to find the floes for buoy deployments.

See the figures below for details of the ice, weather and freeze-up during the expedition.

All of the various science programs aboard the ship, that together build this inter-disciplinary expedition, were conducted successfully. Individual reports on each program are provided below.

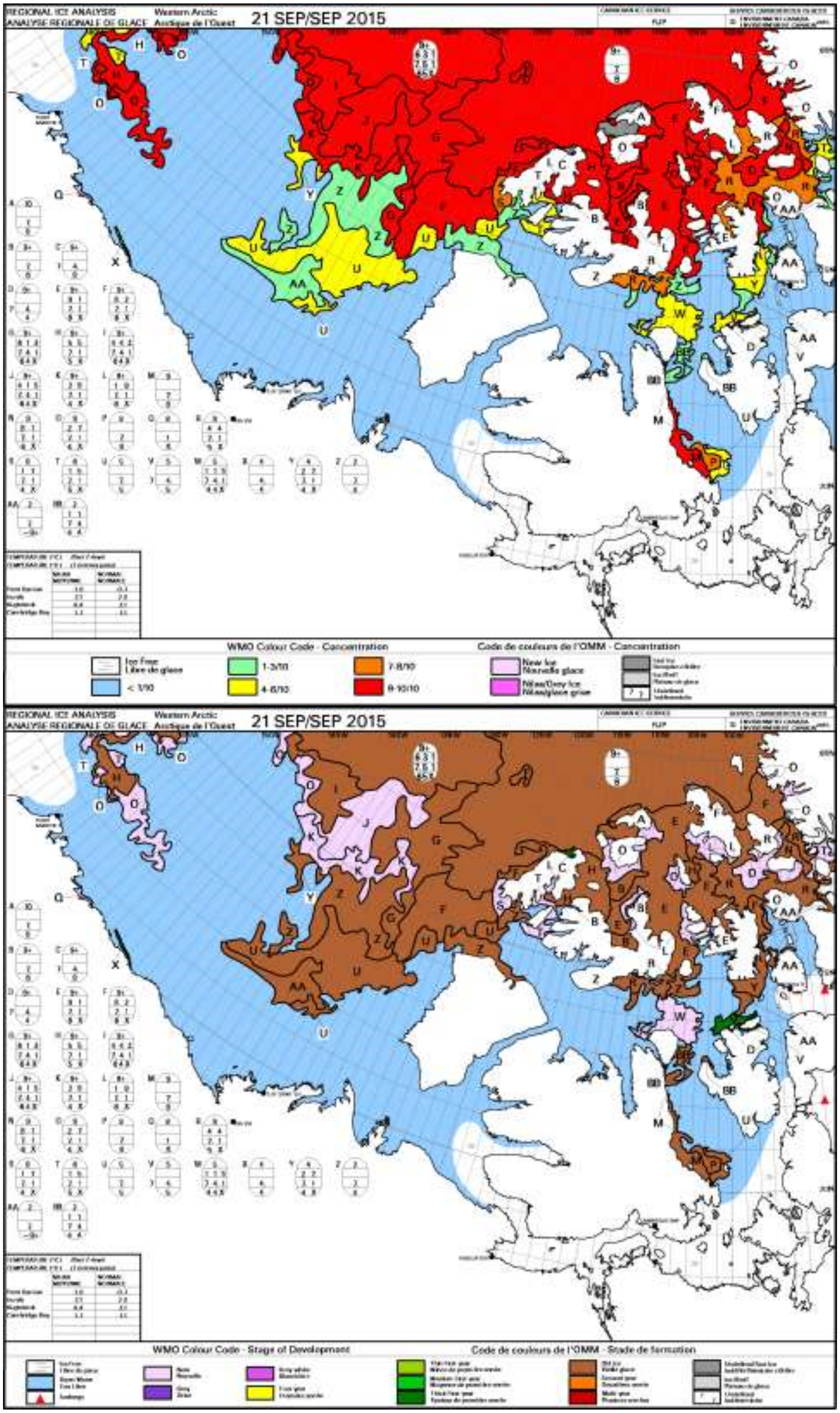

Figure 2a: Canadian Ice Service ice concentration and stage charts from the beginning of the cruise.

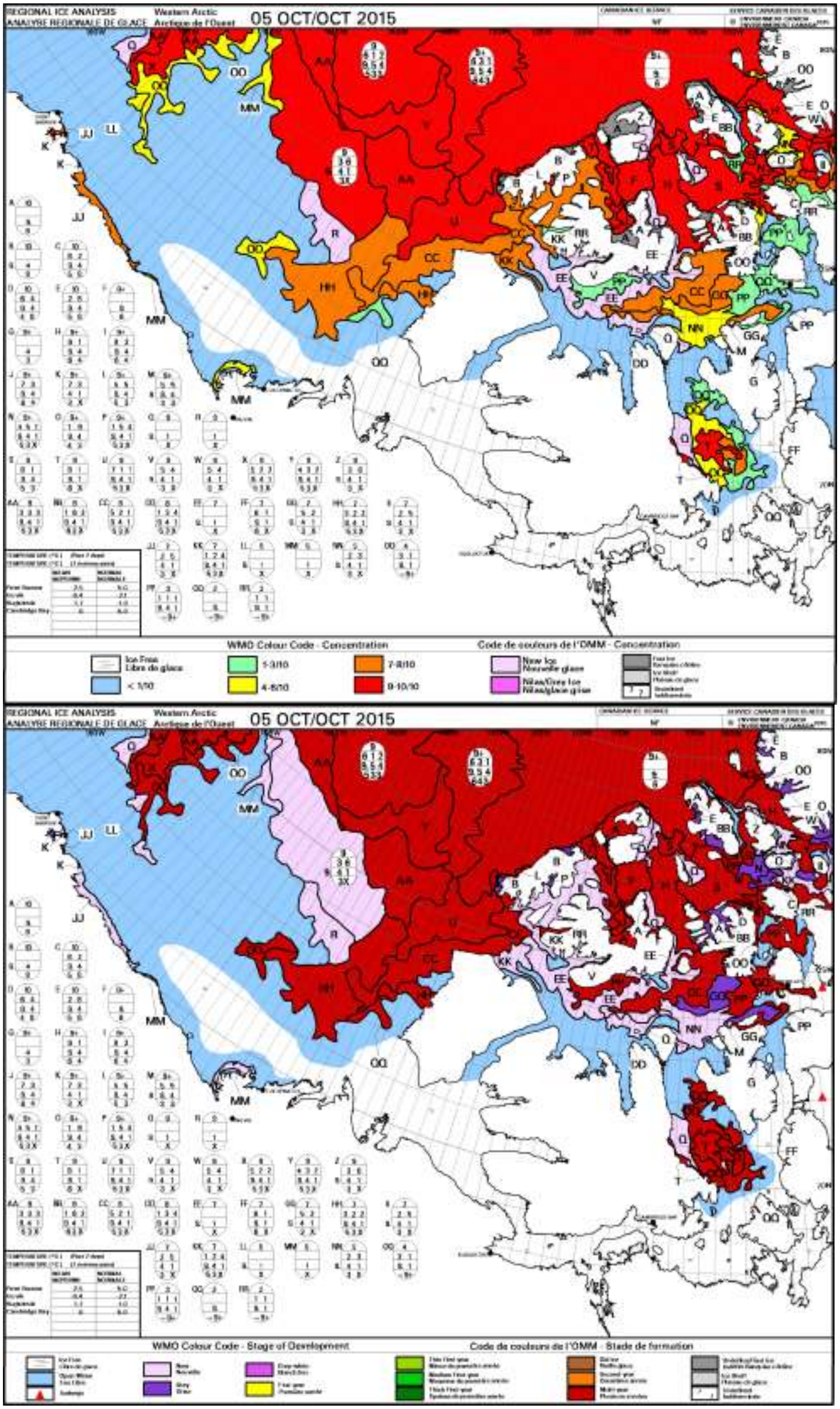

Figure 2b: Canadian Ice Service ice concentration and stage charts from the middle of the cruise. Note the new ice. On Oct 1st the ice 'ages' increase by a year.

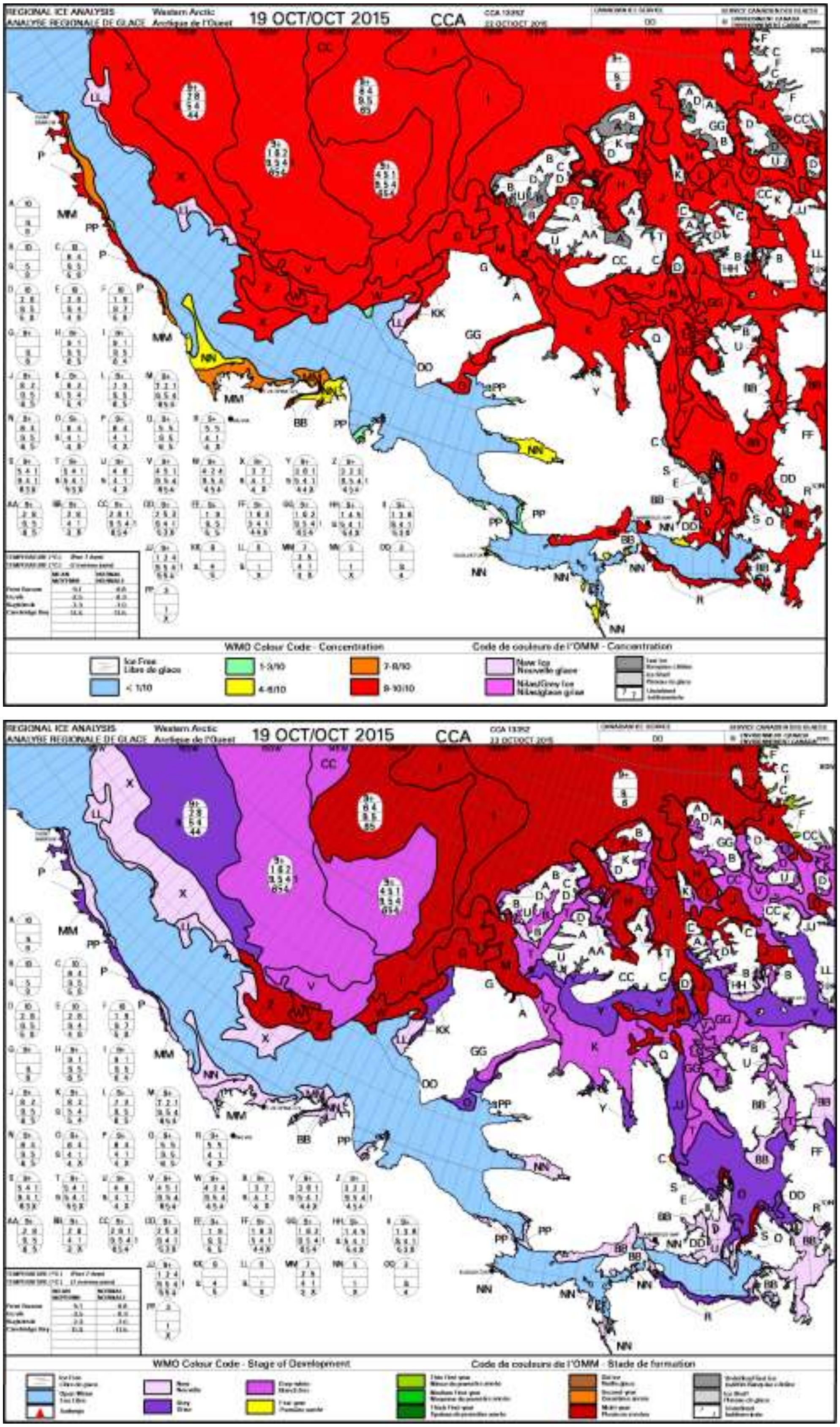

Figure 2c. Canadian Ice Service ice concentration and stage charts for the end of cruise. Note the large areas of new ice. On Oct 1st the ice 'ages' increase by a year.

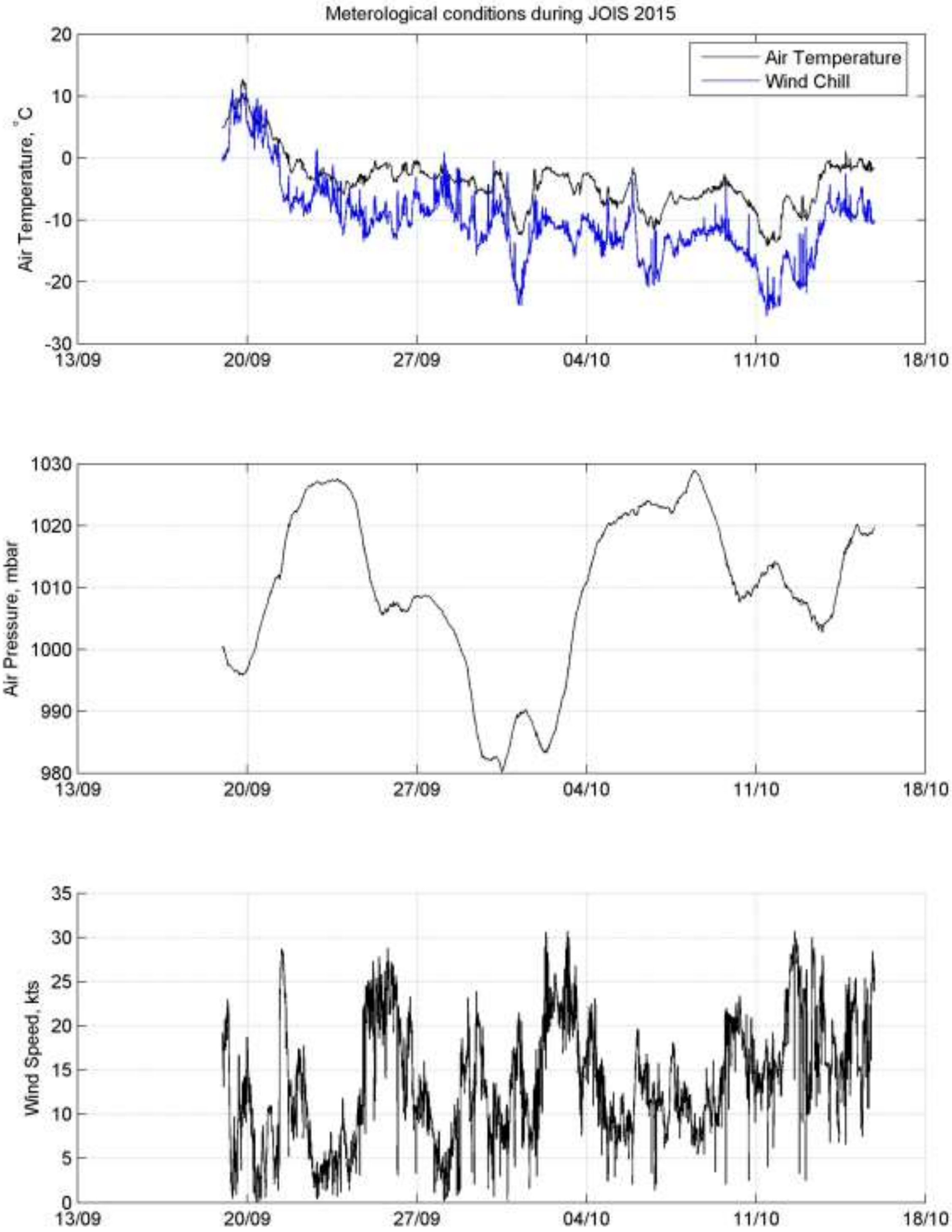

Figure 2d. AVOS weather station data during JOIS 2015, showing the drop in temperature during the cruise and windy autumn weather that caused wind-chill of about 10 °C.

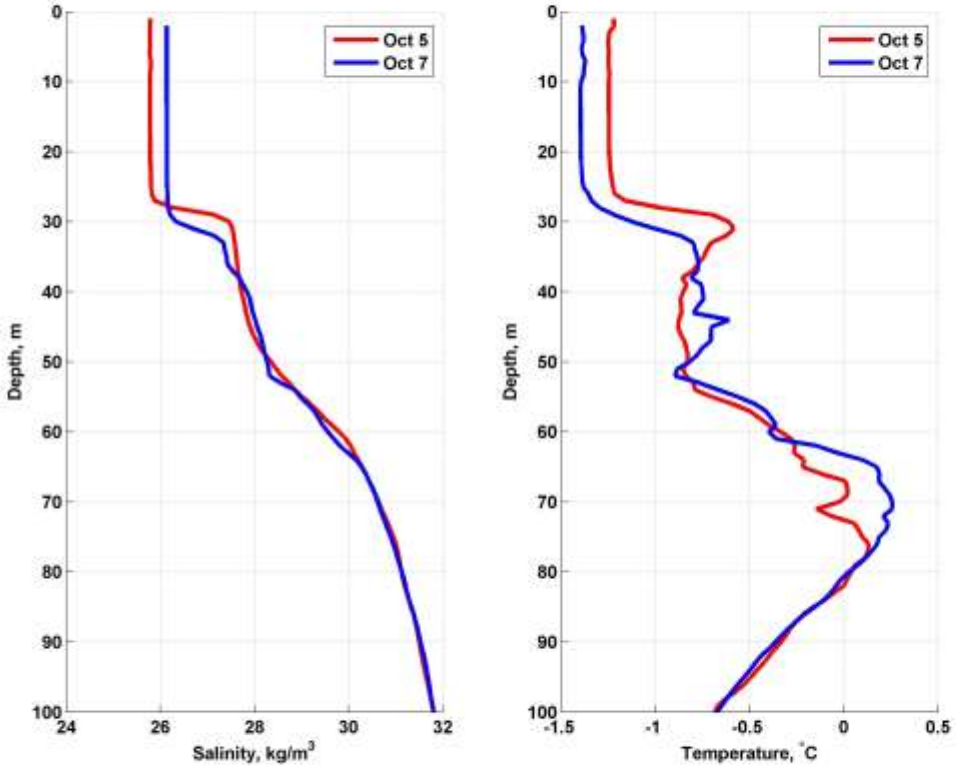

Figure 2e. Temperature and salinity profiles at BGOS-A, just before and just after ice formation. After the ice forms the surface mixed layer is slightly saltier and thicker and cooled to the freezing point.

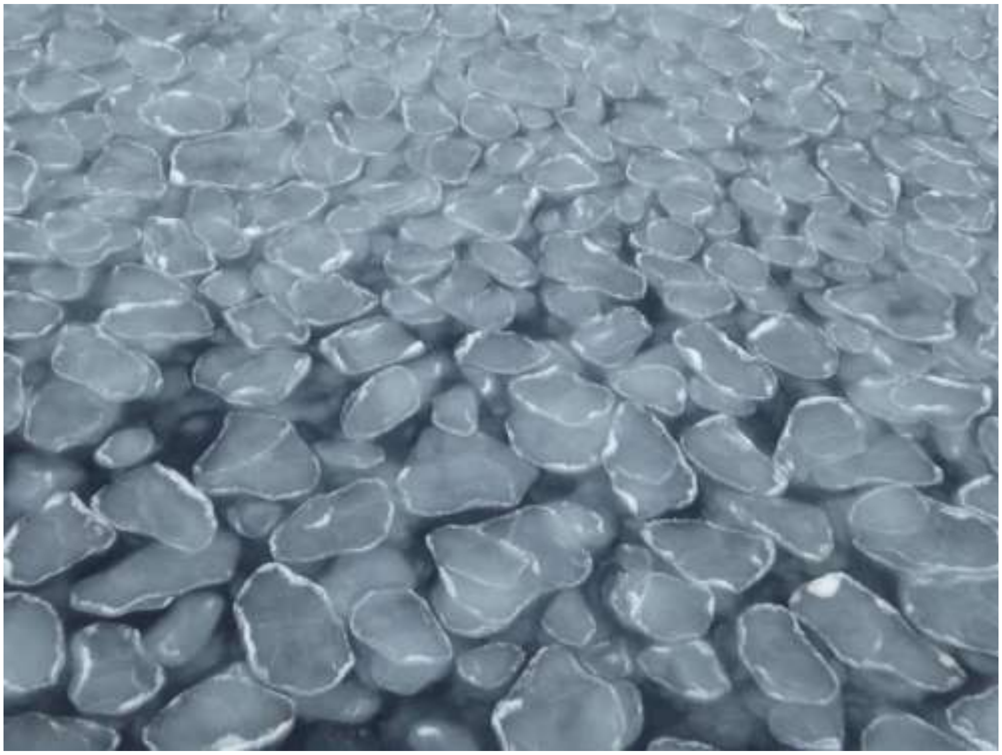

Figure 2f. One of the many type of young ice observed this year.

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. We were also fortunate to have minimal mechanical delays and no medevac or search and rescue this year. While our arrival on the ship was delayed by poor weather, we had planned to arrive early, refueling commenced as soon as we were all on board, and the ship departed Kugluktuk on October 20, as planned. No planned stations were dropped this year, rather standard stations from previous years were added back in, as time became available towards the end of the expedition.

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.
b) Minimization of the science program prior to the cruise by:
    i) Selecting the minimal geographic extent needed for the core science stations, and removing the Beaufort shelf and slope stations.
    ii) Planning for overnight turnarounds of all moorings being re-deployed.
    iii) Refusing additional projects if they require wire time.
c) Autumn in the Beaufort Gyre has short days, cold temperatures and high winds. Work in these conditions is difficult in comparison to summertime and we appreciate the hard work of the crew to accommodate us.

ACKNOWLEDGMENTS

The science team would like to thank Captains Tony Potts and Marc Rothwell and the crews of the *CCGS Louis S. St-Laurent* and the Canadian Coast Guard for their support. Extensive pre-cruise work, to address our wish list from last year, was completed, particularly installation of the winch deck plates on the foredeck, improvements to the container lab doors, plumbing and below freezing drainage for the container labs, repairs on the seawater loop, and replacement of the NOAA server. At sea, we were very grateful for everyone's top-notch performance and assistance with the program. As usual, there were a lot of new faces on-board and we appreciate the effort everyone took to accommodate us and our science. 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 and container labs drainage and plumbing. We would also like to thank the deck crew for their assistance, 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 Colin Lavalle and mechanic Jacques Lefort and we would like to thank them for their support on the ice, and transportation. Importantly, we'd like to acknowledge Fisheries and Oceans Canada, the National Science Foundation (USA), National Institute for Polar Research (Japan) and the Japan Agency for Marine Earth Science and Technology for their continued support of this program.

This was the program's 13th annual expedition and the exciting and valuable results are a direct result of working with such experienced, well trained and professional crews.

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.

2.1 Rosette/CTD Casts

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

On JOIS 2015, the CTD system used was a Seabird 9/11. Initially Seabird SBE9 s/n 756 was used for the first cast and then Seabird s/n 724 thereafter. The CTD is mounted on an ice-strengthened rosette frame configured with a 24- position SBE-32 pylon with 10L Niskin bottles fitted with internal stainless steel springs. 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, chlorophyll fluorometer, transmissometer, CDOM fluorometer, cosine PAR and altimeter. In addition, an ISUS nitrate sensor was used on select casts shallower than 1000 m. A surface PAR sensor connected to the CTD deck unit was integrated into the CTD data for all casts. In addition a serial communicating surface PAR sensor providing continuous 1hz data was mounted beside the other SPAR unit. Continuous PAR data was collected for the whole cruise. These 1-minute averaged data are reported with the underway suite of sensors.

Figure 1. Typical rosette deployment in ice covered waters
Figure 2. Brooke Ocean Technology IMS winch display
Figure 3 Hawbolt oceanographic winch and operator

During a typical station:
During JOIS 2015, CTD stations were much simplified from previous years. This year the underway ADCP was not installed and bongo stations reduced to a few standard positions and periphery sampling stations. Typically, a station would consist of one CTD cast to 5 m of the bottom. In 2015, due to damage to the winch wire, casts were restricted to 3000m starting with cast 9. On select stations, there was a second cast for DNA/RNA or calibration as well as bongo nets at select stations. There were a total of 70 CTD/Rosette casts.

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 however due to sea cable problems encountered during cast 8, depth of the cast was limited to a maximum of 3000 m. Niskin bottles were on the upcast, normally 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 much of the 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.

2.1.1 Chemisty Sampling

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

Table 1. Water Sample Summary for Main CTD/Rosette.

Parameter	Canada Basin Casts	Depths (m)	Analyzed	Investigator
Dissolved Oxygen	All	Full depth	Onboard	Bill Williams (IOS)
ONAr	23, 25	Full depth	Shore lab	Roberta Hamme (UVic)
	2, 5, 7, 9,13,17-19,22,29,31-32,37,42,44,45,46,48,50,52, 55,64,66,67,68,70	< 200		
	20	5-500		
Ar/O_2 and TOI	2, 20, 31, 33, 38, 55, 56, 59, 64	5-650	Shore lab	Rachel Stanley (WHOI / Wellesley)
	3-9, 11, 13, 17-19, 22, 25-26, 29, 32, 34-36, 40-42, 50, 54, 57, 60-61	5 and 80		
	52	Full depth		
N_2O / CH_4	3-5, 38, 44, 46, 48, 65-70	Full depth	Shore lab	Philippe Tortell (UBC)
^{13}CH4	2, 66-68	Full depth	Shore lab	Philippe Tortell (UBC)
DIC/alkalinity	All	5-500	Onboard	Bill Williams (IOS)
	9, 11, 17-18, 23, 38, 52, 55, 61, 64	Full depth		
CDOM	All	5-1500	Shore lab	Celine Gueguen (UTrent)
$\delta^{15}NO_3$ and $\delta^{18}O$ from NO_3	All, except 62, 63	Full depth	Shore lab	Marcus Kienast (Dalhousie)
Chl-*a*	All	5-325	Shore lab	Bill Williams (IOS)

Bacteria	All	Full depth	Shore lab	Connie Lovejoy (Ulaval)
Nutrients	All	Full depth	Onboard and Shore lab	Bill Williams (IOS)
Salinity	All	Full depth	Onboard and Shore lab	Bill Williams (IOS)
$\delta^{18}O$	All	5-450	Shore lab	Bill Williams (IOS)
	9, 11, 17, 18, 23, 38, 45, 46, 52, 55, 61, 64, 66-70	Full depth		
Barium	All	5-450	Shore lab	Christopher Guay (PMST)
	9, 11, 17, 18, 23, 38, 45, 46, 52, 55, 61, 64, 66-70	Full depth		
DNA/RNA	1, 12, 14, 16, 21, 24	Full depth (special cast)	Shore lab	Connie Lovejoy (Ulaval)
	2, 4, 7, 8, 11, 18, 25-26, 28, 30, 32, 35, 39, 41, 42, 50, 51, 58, 60, 64	< 260 (opportunistic sampling)		
Iodine-129	12, 14, 16, 21, 24, 28, 51, 52, 61, 64, 65, 68	Full depth (special cast)	Shore lab	John Smith (DFO-BIO) and Jack Cornett (UOttawa)
^{236}U / ^{137} Cs	12, 14, 16, 21, 24, 28, 51	Full depth (special cast)	Shore lab	John Smith (DFO-BIO) and Jack Cornett (UOttawa)
Microplastics	30, 39, 58	Full depth (special cast)	Shore lab	Peter Ross (Vancouver Aquarium)

Following are short backgrounds of a few of the chemistries sampled. Please see the full reports for more details.

2.1.1.1 N_2/Ar and Noble Gas Samples

Jennifer Reeve (UVic)
PI: Roberta Hamme (UVic)

N_2/Ar is a gas tracer used to determine the state of the marine nitrogen cycle in a water mass. The tracer allows us to utilize the signal of biological nitrogen fixation and removal processes found in N_2 gas by subtracting out the effects of physical processes using Ar as a proxy. The Arctic Ocean connects the Atlantic and Pacific Oceans, which are known to have very different nitrogen cycle processes dominating. We hope to use these measurements to gain a new perspective on the transition of the nitrogen cycle from the Pacific to the Atlantic.

N_2 saturation is only altered physically by air-sea gas exchange processes and mixing. Biologically N_2 gas is removed by nitrogen fixation, and added by several biological removal processes which all convert biological nitrogen into N_2 gas when taken to completion. Many other measurements can only observe one of these biological processes, making it difficult to determine if there is a net loss or gain of nitrogen to the system. The benefit of the N_2/Ar tracer is that it observes the net state rather than the rate of individual processes. This both eliminates differentiation of processes, but also spatial differentiation both water column and sedimentary processes are important to the net state of the nitrogen cycle in the water column.

Noble gases are used as tracers of physical processes as they are only affected by a limited set of processes. Different noble gases react differently to physical processes which allows us to observe water mass properties and aids in our understanding of water mass formation.

2.1.1.2 Methane and Nitrous Oxide in the Arctic

Sampled by CTD Watch
PI: Lindsey Fenwick and Philippe Tortell (UBC)

Quantifying the distribution of greenhouse gases in the Arctic Ocean water column is necessary to understand potential biogeochemical climate feedbacks. As the Arctic Ocean warms, methane (CH4) may be released from destabilizing gas hydrates on the continental shelf, while the thaw of subsea permafrost may supply organic matter that fuels microbial methanogensis and denitrification, which produces nitrous oxide (N2O). While previous measurements of CH4 and N2O have been reported in Arctic waters, no study to date has measured water column distributions of these gases over a widespread area in the Arctic within a single sampling season. This synoptic coverage is important to provide a snap shot of spatial CH4 and N2O variability. This sampling is part of a ~10,000 km transect from the Bering Sea to the Labrador Sea which was sampled in summer and fall 2015 on 3 separate cruises. Our sampling transect provided a large-scale, three-dimensional view of CH4 and N2O concentrations across contrasting hydrographic environments, from the deep oligotrophic waters of the deep Canada Basin, to the high productivity continental shelf regions. Our work contributes new insight into the cycling of two important climate-active gases in the Arctic Ocean, and provides a benchmark against which to compare future measurements in a rapidly evolving system.

2.1.1.3 Nitrogen Isotopes

Sampled by CTD Watch
PI: Markus Kienas (Dalhousie)

The Arctic Ocean plays an important role in the global oceanic nitrogen cycle. Water with a low N:P ratio enters this ocean basin from the Pacific, transits through the Bering Strait and the Beaufort Sea and eventually flows into the North Atlantic Ocean. By introducing a distinct nitrogen:phosphorus ratio, Arctic waters might significantly influence nitrogen cycling and productivity in the Atlantic Ocean (*Yamamoto-Kawai et al.,* 2006).
However, there are still great uncertainties in how water masses are geochemically modified as they flow from the Pacific through the Canadian Arctic into the Atlantic Ocean and what processes are leading to those transformations. Biological processes such as N_2 fixation, denitrification and NO_3^- assimilation are imprinted into the N and O isotopic composition of nitrate, leaving the water mass with a distinct isotopic signature depending on it’s origin, history and the biological processes that occurred along it’s pathway.
The goal of our group is to analyze and interpret depth profiles of nitrate $\delta^{15}N$ and $\delta^{18}O$ from the Beaufort Sea and along a transect spanning the Canadian Arctic. Those $^{15}N/^{14}N$ and $^{18}O/^{16}O$ measurements will help identifying the main water masses and will be used to characterize the geochemical modifications and the cycling of nitrogen within those waters as they move through the Canadian Arctic into the Atlantic Ocean.

Yamamoto-Kawai, M., Carmack, E., & McLaughlin, F. (2006). Nitrogen balance and Arctic throughflow. Nature, 443(7107), 43-43.

2.1.1.4 O_2/Ar & Triple Oxygen Isotopes

Zoe Sandwith (WHOI)
P.I.: Rachel Stanley (WHOI)

O_2/Ar and Triple Oxygen Isotopes (TOI – a collective term for ^{16}O, ^{17}O, and ^{18}O), are gas tracers that can be used to directly quantify rates of Net Community Production (NCP) and Gross Primary Production (GPP). They are ultimately used to help create a better understanding of present-day carbon cycling in a system. Both tracers are measured directly from dissolved gas extracted from seawater. NCP is derived from the measurement of O_2/Ar ratios, and GPP is derived from TOI. These measurements will help us understand how rates of biological production respond to changes in environmental pressures, and can help constrain ecosystem models for the Beaufort Gyre region.

Traditionally, most estimates of biological production have been of Net Primary Production (NPP) by methods such as ^{14}C bottle incubation and satellite algorithms. In contrast, TOI and O_2/Ar generate a different picture of the story: NPP is photosynthesis minus autotrophic respiration, whereas NCP is photosynthesis minus autotrophic and heterotrophic respiration. The relationships between these and GPP, the total photosynthetic flux, are outlined in figure 1. NCP is a more important climatic variable than NPP since NCP is the net amount of carbon taken up by the biological pump. By measuring both NCP and GPP concurrently, we can separately look at the effects of photosynthesis and respiration in a system.

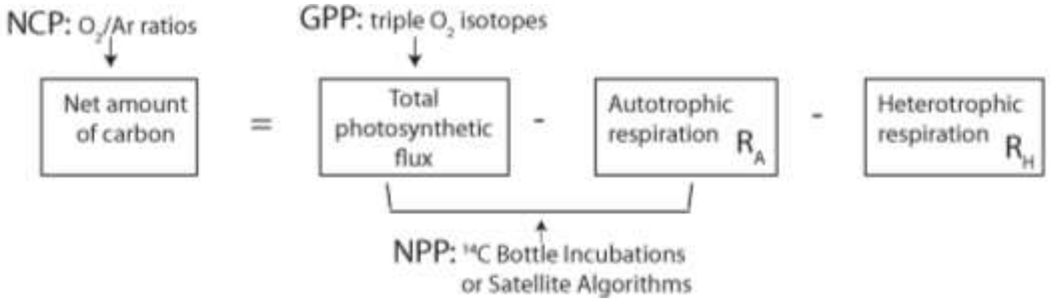

Figure 2. Schematic illustrating the different types of biological production.

Net Community Production (NCP), Gross Primary Production (GPP), and Net Primary Production (NPP).

2.1.1.5 Iodine-129, cesium-237 and uranium-236

Christopher R.J. Charles (UOttawa)
P.I.: John Smith (DFO-BIO) and Jack Cornett (UOttawa)

There are two basic tracer applications of radionuclides ^{129}I and ^{137}Cs in the Arctic Ocean:

First, measurements of ^{129}I and ^{137}Cs, separately provide evidence for Atlantic-origin water labeled by discharges from European reprocessing plants; and second, measurements of ^{129}I and ^{137}Cs, together can be used to identify a given year of transport through the Norwegian Coastal Current (NCC) thereby permitting the determination of a transit time from the NCC to the sampling location (Smith *et al.*, 1998).

Recently the use of ^{236}U released from nuclear reprocessing plants in France and the UK has been proposed as a potential label for Atlantic Sea Water entering the Arctic. (Christl *et al*., 2012). A new ^{129}I/^{236}U tracer may also be possible to determine transit times of water in the North Atlantic and Arctic region (Christl et al, 2015).

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2.1.1.6 Oxygen Isotope Ratio (δ^{18}O)

P.I.: Bill Williams (DFO-IOS)

Oxygen isotopes,^{16}O and ^{18}O, are two common, naturally occurring oxygen isotopes. Through the meteoric water cycle of evaporation and precipitation, the lighter weight ^{16}O is selected preferentially during evaporation, resulting in a larger fraction of ^{16}O in meteoric water than in the source water (i.e. seawater). Sea-ice formation and melt on the other hand, only changes the source water's ^{18}O/^{16}O ratio (noted as δ^{18}O) slightly. River water is fed from meteoric sources and thus the δ^{18}O is a valuable tool used in the Arctic Ocean to distinguish between fresh water from river (meteoric) sources and from sea-ice melt.

2.1.2 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.

Water Sampler

Problems were encountered with the water sampler not closing bottles.

Cast 1. The water sampler (pylon sn 452) would not respond at depth (600 m). Eventually bottles were closed from 209 m to surface. Since the pylon was changed on the previous leg's first cast (UNCLOS 2015-05) after similar problems, it was decided to change CTD s/n 756 out for CTD s/n 724.

Cast 2. The bottom contact alarm went off although no sensor attached to the CTD. After bringing back on board and reseating the dummy plug there was no further problem.

Cast 5. The next two casts, 3 and 4 were fine but on cast 5 the water sampler would not respond at depth and began working at 1433 db when fired by user specified method. After this cast the sea cable was chopped back 1.5 m and re-terminated with new pigtail. There was 0.20V of noise was seen on ch7 (open) during this cast. The connectors on the CTD bulkhead (JT6) and the PAR/ISUS Y cable and sensors were cleaned and re greased.

Cast 9. The water sampler worked for casts 6 to 8 but on cast 9 would not respond at depth. It began working mid-way on upcast at 858m. The SBE11 deck unit was swapped out at depth with no improvement.

Cast 10 and 11. For a water sampler test, two casts were performed at the same station. On the first cast (10), the rosette was sent to 600m and all bottles tripped but no samples collected. Then on cast 11 the CTD was sent to 3000 m with all external sensors dummied off at the CTD (cross talk communication test on Seabird's advice), but successful tripping of bottles did not start until 2156 m. Removed 40m of seacable and re-terminated after cast 11.

Cast 12. The water sampler was changed out (replaced pylon sn452 with sn498) to test for compatibility issues with CTD prior to cast 12.

Cast 15. There had been no water sampler problems on casts 12 to 14 but a complete failure was encountered on cast 15. The water sampler did not respond at shallower depths as previously seen on other casts. The water sampler continued to fail on deck. Pylon 452 was plugged in and worked on deck. The bulkhead connector on 498 had some discolouration on pin 6, so it was decided to change it out. Inside pylon 498, the screws securing the circuit board set were found to be loose and the interboard header was seen to make intermittent contact when flexed. After the connector was changed and the screws tightened, pylon 498 was re-assembled and put back onto the rosette. No trouble with water sampler on subsequent casts. Pylon 452 was also inspected, but the circuit boards are completely different and the screws all tight.

Cast 16 to 70 worked well using the repaired water sampler, pylon sn 498.

CTD Wire

Cast 8. No noise on cast 8 but a sea cable wire problem was encountered. A broken outer strand was detected at 3111 m. The cast reached a maximum depth of 3241 m and the broken strand

snagged the ice chummy on the way up. The strand showed signs of corrosion or production flaw. No other strands were seen to be damaged nearby.
Talking with Phil Lobb at IOS, it was passed on that a single wire was not a major concern for structural integrity, but that 3 breaks in 5 m would delegate immediate retirement of the wire. At this level, the wire was extremely rusty and it was decided to limit future casts to 3000 m.

Cast 25. Fuse blew in the deck unit. After replacement of the 0.5A bus fuse there was no further issue.

Fluorometer and Transmissometer
Cast 20.
Noise was seen on the fluorometer during casts 16-18. The connectors were inspected and pin 4 on the bulkhead of Seapoint fluorometer SCF2841 was seen to be eroded slightly (sea water short). Fluorometer 2841 was replaced by SCF3652 for cast 20.
Noise was also seen on the transmissomter that shares the Y cable with the fluorometer. All connections were opened and some green, but no corrosion found on the female VMG4 interface cable. Due to a lack of immediate spares, the cables were cleaned up and re-assembled. The connectors were inspected , greased and re-assembled again during the cruise and no green observed.
Due to the observation of noise on ch0 during the open connector test on cast 11, it was decided to change channel assignments from cast 20. The Y cables for fluor/xmiss were moved to ch6&7 and the PAR/ISUS Y cable moved to ch0&1. Con file changed to "…2015-09-29.xmlcon".

Oxygen
Cast 56. During cast 56, the Seabird SBE43 sensor s/n 615 failed. It was swapped out with s/n 1489 for cast 57 and worked well the duration of the cruise. The weather had been cold previous to cast 56 and it is suspected the sensor failed due to a ruptured membrane caused by freezing.

Niskins
Due to irreparable leaks, 2 Niskins were replaced. Niskin 4 was replaced after cast 27 due to a chipped lower seal. Niskin 24 was replaced after cast 29 due to an unidentified lower seal leak (likely glue joint). On 3 other occasions, Niskins leaked severely from the top seal during pre-sampling checks. In all cases the seal was eventually re-seated before sampling. It is suspected that ice accumulated in the seal and forced the top seal open. All failures of this type occurred while air temperatures were below -10C.

IMS block display
The IMS display hung a few times during casts. The likely cause was opening a text window and leaving it waiting too long before sending message to winch. It is recommended CTD operators limit the time they leave these windows open due to buffer overflow issues.

See appendix for CTD sensor configuration

2.2 XCTD Profiles

Operators: Kazu Tateyama (KIT), Jenny Hutchings (OSU), Shin Toda (UTokyo), Ed Blanchard (UW)
P.I.s: Motoyo Itoh (JAMSTEC), Andrey Proshutinsky (WHOI), Bill Williams (IOS)

Profiles of temperature and salinity were measured using expendable probes capable of being deployed while the ship was underway. Profiles were collected at 53 stations along the ship's track.

Procedure

XCTD (eXpendable Conductivity – Temperature – Depth profiler, Tsurumi-Seiki Co., Ltd.) probes were launched by a hand launcher LM-3A (Lockheed-Martin_Sippican, Inc.) from the stern of the ship into the ocean to measure the vertical profiles of water temperature and salinity. Three types of probes were used, with differing maximum depth and ship speed ratings.

Probe Type	Max Depth (m)	Max Ship Speed (Kts)
XCTD-1	1100	12
XCTD-2	1850	3.5
XCTD-3	1000	20

The data is communicated back to a digital data converter MK-21 (Lockheed-Martin-Sippican, Inc) and a computer onboard the ship by a fine wire which breaks when the probe reaches its maximum depth.

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 [%] (whichever is larger)

The casts took approximately 5 minutes for the released probe to reach 1100m. In open water, depending on the probe type, the ship may have slowed to 12 knots for deployment, but when the ship was surrounded by sea ice, the ship slowed or stopped. XCTD deployments were spaced along the ship track typically between CTD casts or deployments/recovery of buoys to increase the spatial resolution. In and around the Northwind Ridge area, XCTD deployments had a higher horizontal resolution, especially across the slope region.

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.

2.3 Zooplankton Vertical Net Haul.

Mike Dempsey (DFO-IOS)

PI: John Nelson, Bill Williams (DFO-IOS)

Zooplankton sampling and preservation were conducted on board by Mike Dempsey and Chris Charles (day watch, DFO-IOS and University of Ottawa), and Sigrid Salo, Hugh Maclean and Jen Reeves (night watch, NOAA, DFO-IOS and UVic, respectively) using a standard Bongo net system (previously a 4 net enclosure was used - consisting of four nets). On one side a 150 um net was fitted and on the other a 236 um net. Both sides had a calibrated TSK flowmeter installed to measure the amount of water flowing through the nets. In addition, an RBR Virtuoso pressure recorder was mounted on the gimble rod to record the actual depth of each net cast

Figure 3. Hugh Maclean and Sigrid Salo deploy bongo nets during JOIS 2015

Samples collected from the 236 µm mesh nets were preserved in 95% ethanol, while those collected from the 150 µm were preserved in formalin for both 500 m and 100 m net tows. The formalin samples will be examined for species identification and the ethanol samples for DNA sequence analysis. Rinsing of the nets was accomplished by using the salt water tap on the port side near the outer door near the lounge. It froze up intermittently and ship addressed this by wrapping in heat tape and insulation. An electrically heated hose was installed but never plugged in.

A total of 15 bongo vertical net hauls were completed at 9 stations. The sampling strategy was changed again for 2015 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 was reduced to single 500m and 100m vertical net tows 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.

Several planned stations were omitted during the cruise due to weather. Cold temperatures and high winds precluded samples being taken when temperatures approached -15C and when the wind exceded 25 kts. Low temperatures result in unacceptable amounts of ice build up when rinsing down the nets. High winds make the nets impractical to handle. Both conditions can result in a safety hazard for the samplers.

The bongo frame went back to IOS in the fall of 2014. The twin 53um nets were removed and the weight line and cod ends re-rigged. A second TSK was fitted into the second 56 cm net hoop. In addition, the bongo box was shortened and had a removable side installed to ease launching and recovery of the 25kg pig weight.

The redesigned bongo and box worked fairly well. The more robust TSK flowmeters on both sides generally worked well and were not susceptible to freezing like the plastic flowmeters used previously. The drop down side on the box made deployment and recovery of the pig easier. The line to the pig should be shortened further if possible to allow the A frame to pick the weight off the deck. The box should also be re-inforced when the side is removed. It was damaged a couple of times when moving. Larger handles would also be appreciated.

See Appendix for table of samples and stations.

2.4 Biogeography, taxonomic diversity and metabolic functions of microbial communities in the Western Arctic

David Walsh (Collaborator, Concordia University), Deo Florence Onda (PhD Student, ULaval)
P.I.: Connie Lovejoy (ULaval)

Introduction and objectives

The Canada Basin in the Western Arctic Ocean is a complex hydrographic system and its physical oceanography is strongly coupled to meteorological drivers. This coupling influences chemical and biological dynamics at different regional scales (McLaughlin and Carmack, 2010; Nishino et al., 2011). The changing conditions in some regions of the Arctic thought to be associated with the changing global climate are expected to affect phytoplankton communities by limiting nutrient supply, changing salinities and even increasing ocean acidification (e.g. Coupel et al., 2012; Riebesell et al., 2013; Thoisen et al., 2015). Loss of ice for example has been implicated in the shift in size of the dominant autotrophs in the Arctic (Li et al., 2009), which would have implications on the feeding ecology of larger heterotrophic organisms by limiting the range and size of prey items available, and on the overall carbon transfer and cycling in the region. Likewise, taxonomic comparison of microbial communities before and after the 2007 sea ice minimum also detected significant differences from all three domains of life (Comeau et al., 2011). As a consequence, a significant shift on the importance of microbial loop and microzooplankton in bridging the pico-bacterioplankton to classical food web is predicted (Sherr et al., 2012). However, despite the ecological importance, apparent abundance and wide distribution of these microorganisms, several aspects of their ecology, diversity and oceanography are still poorly understood. As change continues, knowledge on the taxonomic and functional diversity of microbial life will become critical for predicting consequences of a warmer, more stratified Arctic Ocean.

In recent years, Lovejoy and colleagues have extensively characterized the taxonomic composition of arctic microbial communities (Bacteria, Archaea, picoeukaryotes) using molecular approaches, and recently venturing into targeted high throughput sequencing (HTS) approaches (Galand et al., 2009; Kirchman et al., 2009; Monier et al., 2015). Past JOIS expeditions have provided Lovejoy with the platform to test spatial and temporal variability of these microorganisms, and infer their potential functions and ecological roles. However, in order to further broaden our understanding of these ecological functions, knowledge of their metabolic activities and characteristics are needed. For example, Walsh has been combining metagenomics and metaproteomics to study the metabolic diversity and activity of marine Bacteria and Archaea (Georges et al., 2014). Thus, for JOIS 2015, a collaborative effort between the two laboratories (Lovejoy and Walsh) will be employed utilizing targeted sequencing, metagenomics and metaproteomic approaches to gain insights on Arctic microbial communities. In collaboration, we aim to generate and analyze a set of metagenomes from stratified waters of the Canada Basin (CB), which is among the last undisturbed oceanic regions on earth. Owing to hydrography, the photic zone of the CB is oligotrophic and most summer productivity occurs at a deeper subsurface chlorophyll maximum. This physical stratification impacts the vertical structure of microbial communities. Therefore, at several locations in the CB we will analyze samples from different layers to maximize the microbial diversity represented in our dataset and to facilitate comparative metagenomic studies.

Overall, our aim is to provide an Arctic Ocean metagenomic resource that can be used in studies on the genomic and functional diversity of marine microbes. In such studies, it is common practice to use publically available metagenomic data to test hypotheses on the biogeographical distribution of particular taxa (Brown et al., 2012) and metabolic pathways (Doxey et al., 2015), or to combine these two by exploring population and pangenome structure across environments (Alonzo-Saez et al., 2012; Santoro et al., 2015). Compared to lower latitudes, there is much less metagenomic representation from high latitude seas, particularly the open Arctic Ocean. Hence the availability of a metagenomic dataset representative of the Arctic Ocean would fill an important void in metagenomic coverage of the global oceans.

Methodology

Samples were collected at 26 (Figure 1) stations that were mostly visited in 2012-2014 but extending to deeper waters including Arctic Deep Water, Atlantic Water, and the core of the Pacific Winter Water. Samples were collected at 6-8 depths per station to include the understudied deep waters. Additional samples from 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 (~5 m), mixed layer (~20 m), subsurface chlorophyll maximum (SCM), 100 m depth, PWW characterized by 33.1 psu, AW at 800 m and ADW from 2500-3000 m. Nucleic acid (DNA/RNA, single-cells in Gly-TE), microscopy samples (DAPI, FISH, FNU), and pigment samples (chlorophyll a, HPLC) were collected for each station.

DNA and RNA

DNA/RNA samples from large (>3 µm) and small (0.22 -3 µm) fractions were collected by filtering 6 L 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.

In the lab, DNA and RNA material will be simultaneously extracted from the filter as described by Dasilva et al. (2014). RNA will be first converted to cDNA before being used for targeted sequencing (Comeau et al., 2011). Metagenomic data will first be compared to each other using a functional gene-centric approach. We will focus on comparing the vertical distribution of functional genes and metabolic pathways involved in energy and carbon metabolism, as well as nitrogen, phosphorous, sulfur, and vitamin acquisition and utilization. These results will lead to genomic insight into ecological specialization and metabolic strategies at the community level. We will then use multivariate analyses to quantify the influence of temperature, hydrology, pH, nutrient supply, and the quantity and source of organic carbon on the metabolic diversity and capabilities of microbial communities. These environmental factors are all set to change with a warming Arctic (Monier et al., 2015). Hence, we expect that an understanding of the relationship between these factors and the metabolic capabilities of associated microbes will provide insights into the response of microbes to change.

The metagenome will also represent an essential resource for development of forthcoming projects. For example, The Walsh lab will leverage the metagenomics resource produced to perform functional metaproteomics studies of arctic microbial communities. Compared to other marine systems, there are far fewer metagenomic datasets available for the Arctic Ocean, which limits the power of metaproteomics approaches that rely on protein sequence databases for peptide identification. Over the last few years, Walsh has used metaproteomics to investigate seasonal and spatial patterns in microbial metabolism in the coastal ocean. As part of the Arctic project, samples suitable for metaproteomics are also being collected. Hence, a nonredundant protein sequence database will be generated from the gene catalogue for proteomic purposes. This resource will also be invaluable for protein-stable isotope probing (protein-SIP) experiments that the Walsh lab is developing in order to track carbon and nitrogen metabolic flux through marine microbial communities.

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 in 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.

Single-cell genetics

For single cells genetic, 100 µL of TE-Glycerol was added to 1 mL of water samples in a 2 mL cryovial tube. 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 194 samples from different depths at 26 stations including the ice cores from 2 IBO stations were collected during this expedition. With more depths and samples, a higher resolution investigation of microbial community partitioning and diversification can be carried out.

Issues

Like in JOIS 2014, the RNA/DNA group was provided with 2-3 dedicated bottles primarily for collecting in the first 100 m during full casts and 6 bottles in special casts. For the other depths, we just collected the excess from other bottles particularly in deeper waters.

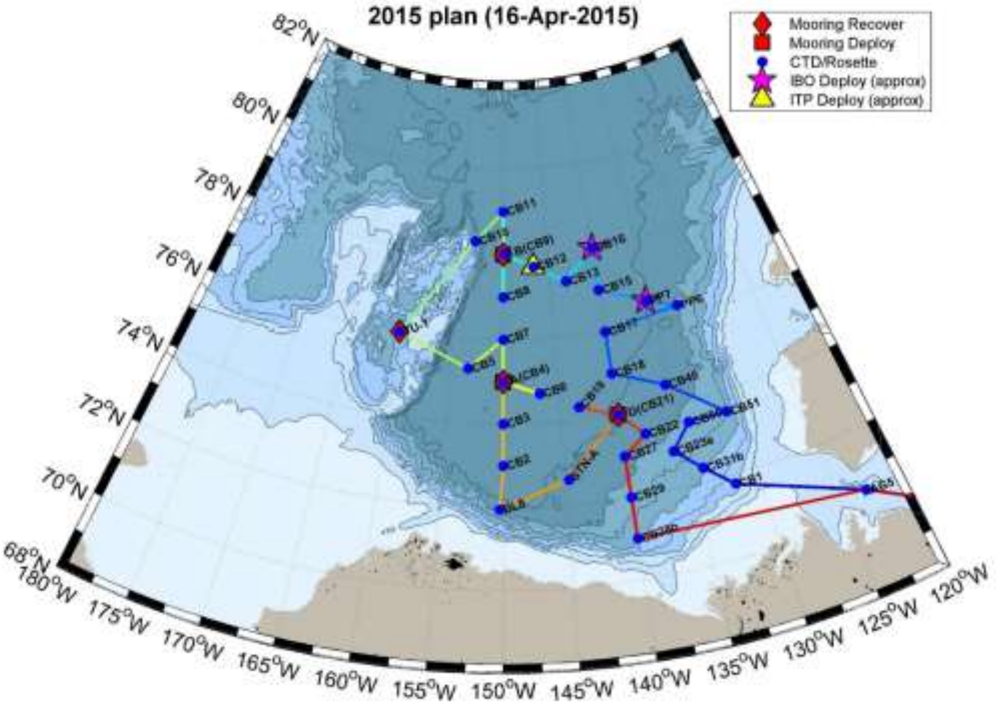

Figure 1. Map of the stations were samples for microbial taxonomic and functional diversity studies were collected (green dots).

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2.5 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 2015 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 permits.

In total, 13 samples were collected from 3 stations (CB-21, CB-4 and TU-1) for depth profiles, 7 samples were collected from the seawater loop system close to 7 stations (AG-5, CB-1, TU-1, CB-4, BL-1, CB-21, CB-28aa) for surface distribution and 3 samples were collected from 2 ice cores at 2 Ice-Based Observatory.

Sampling method

For depth profile samples, 3 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 30.54 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 leaving station, giving a total sieved volume of ~148-153 L per sample. 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 12 L bucket and a stopwatch.

Two ice cores (1 per IBO) were collected for microplastic samples. Each core was cut in two smaller pieces for easier transport and melting. The samples can be analyzed to determine if microplastics concentrate in sea ice. Each core piece was melted in either stainless steel pot (+ rinsed plastic bag or aluminum foil for cover) or simply in the rinsed plastic bags 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 plastic 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. Two blanks were prepared to account for plastic particles that could originate from sampling and from the plastic bags.

All samples were collected by Sarah-Ann Quesnel (DFO-IOS), acidified with HCl (~5%) and stored in the dark, in the 4°C walk-in cooler until the ship arrived in Halifa (NS), where the samples were shipped back to IOS (Sidney, BC).

See Appendix for sample location.

2.6 Underway Measurements

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

Underway measurements summary

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

- The seawater loop system:
    a. Electronic measurements of salinity, temperature (inlet and lab), fluorescence for Chlorophyll-a, and fluorescence for CDOM.
    b. Water samples were drawn for salinity, CDOM, microplastics and a few for chlorophyll.
- The Shipboard Computer System (SCS) was used to log
    a. From the Marine Star 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 and direction, and barometric pressure
    c. 12kH sounder reported depth and applied sound speed
- 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 seawater to instruments and sampling locations. This system allows measurements to be made of the sea surface water without having to stop the ship for sampling. The water is as unaltered as possible coming directly from outside of the hull through stainless steel piping without recirculation in a sea-chest. On one of the manifold arms is a Kates mechanical flow rate controller followed by a vortex debubbler, installed inline to remove bubbles in the supply to the SBE-21 thermosalinograph (TSG). 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 4. Seawater loop system
The seawater loop provides uncontaminated seawater from 9m depth to the science lab for underway measurements. No "Black Box" or "Gas Cooler" 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 in the engine room. This is the closest measurement to actual sea temperature.

These readings are normally integrated into the SBE-21 data stream. However, due to an unknown problem with the SBE-21, the SBE38 temperature could not be integrated into its data stream (showing as 0 in the Seabird TSG data) and was logged separately by the NOAA SCS system.

- ***SBE21 Seacat Thermosalinograph s/n 3297:***

Instruments used in the TSG were:
Temperature and Conductivity s/n 3297
Seapoint Chlorophyll Fluorometer s/n SCF 2979
WETLabs CDOM Fluorometer s/n WSCD-1281

The fluorometer and CDOM sensors were plumbed off a separate manifold output from the TSG 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.

The flow rate was set to maintain a pressure of 18 PSI with safety shut off at 35% to protect the pump (i.e.00000000 pressure at pump should not be more than 35% higher than 18 PSI). Readings of the manifold were typically 18 PSI and 20 to 25% output on open water and light ice. The system ran well and never tripped the safety shut off (common during other cruises) even though we did travel through snow covered ice that tends to clog the strainer.

Flow rate to the fluorometers was measured at 7.5L/min (Sep 19 to Oct 10) and 3.9 to 4.4 L/min (Oct 10 to end of cruise) by using the time to fill 10L.

The TSG flow was measured at 12 to 13.6 L/min.

A flow meter was repositioned again his year, installed on the line running to the fluorometers. With flow rate measurements, counts per second can be converted to L/min and inferred from this to the TSG and fluorometer.

Discrete water samples were collected for salinity, CDOM, microplastics and occasional chlorophyll samples via the fluorometer outflow. Samples can be used to calibrate the corresponding sensors.

Two tests were performed this trip:

Chl-a fluorometer comparison 1, Oct 10th 2015
WET Labs WETStar fluorometer s/n WS3S-367P
Seapoint Chlorophyll Fluorometer s/n SCF 2979
Two chlorophyll sensors were put on together (removing the CDOM sensor) while on station and values from the two sensor were compared while also changing the flow rate to see the effect on the output voltage.

Chl-a fluorimeter comparison 2, Oct 14th 2015
Seapoint Chlorophyll Fluorometer s/n SCF 2979
Seapoint Chlorophyll Fluorometer s/n SCF 3651
This time a second Seapoint chlorophyll sensor, used on the previous leg, replaced the CDOM sensor. This was done at the end of the cruise, steaming from Cape Bathurst to Kugluktuk. At first glance there appears to be a slope difference.

Chlorophyll samples were taken to help calibrate the sensors.

Please note the settings used for the TSG are not the same as were used during the UNCLOS trip and the UNCLOS report should be referred to. In particular, the elapsed time variable is not correct in the UNCLOS data from the start of the cruise to August 23rd due to a mismatch in sampling rate specified in the configuration file (3 seconds) and the minimum allowed in the TSG (5 seconds). The variable “NMEA seconds” can be used for the accurate time. This variable is the number of seconds after 1 Jan 2000 at 00:00:00.

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 Chl-a fluorescence from the ship’s SBE 21 thermosalinograph.
- Sea surface temperature from the SBE38 hull mounted temperature sensor.

The RAW files were set to contain a day’s worth of data, restarting around midnight.

Sounder:
At the start of the cruise the 3.5kHz on the Knudsen 3260Chirp was turned on but was not working properly. The 12kHz was also tried but also had trouble getting this to work. The system was changed to use the 12kHz on the Knudsen 320B/RPlus which worked for a day or so but then stopped working. A power supply issue is suspected. The 12kHz was then reattached to the Knudsen 3260Chirp and data logging to the SCS system resumed. Unclear why it started working this time. The settings for the 3260Chirp were not clear and it was difficult to get a good bottom return in the southern end of the 150W line (~72 to 75N) even while stopped on station. On 8 Oct 2015 the “data out” option was cleared somehow and took a few hours to work out how to get the data feed back into the SCS system. Starting on 8 Oct 2015, an used variable was replaced with correction for ship’s draft so its more clear what correction is being applied to the data.

During JOIS, the depth correction of adding 9m for the ship’s draft was being applied. The sound speed was also adjusted during the cruise as is shown in the SCS data file. To obtain the best depth, a new sound speed should be calculated from the nearest CTD cast and applied.

Please see full report for sample strings definition for the SCS’s *.RAW files

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 02 deck, above where the rosette operations are performed (03 deck). The sensor was located directly next to the surface reference PAR that connects to the CTD deck unit. The view is unobstructed for approximately 300 degrees. 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 were sampled at 1/5 second intervals but averaged and recorded at 1 minute intervals.

Issues with the underway system and data

- Prior to the cruise from Halifax a Singer pressure relief valve was replaced with the specs listed below.

  Singer Pressure Relief Valve
  Model: 1-106-RPS-SST SiN 515-61-l
  Size: 1", Female NPT 300#, Body: Stainless Steel, Trim: Stainless Steel, Pilot System: Stainless Steel, (3) Isolation Valves,
  Strainer, Relief Pilot Model 8lRP (10-80, Set @ 40 psi, Std Orientation)

- During the first few days of the JOIS program a replacement for the removed Delta Temperature Flow Transducer was installed. The removed unit had lost its calibration and was not working properly. The sensor gives the temperature and flow readings to the Honeywell controller using 420mA analog output. This information is used by the controller to adjust the pump speed.

- Please note the settings used for the TSG are not the same as were used during the UNCLOS trip and the UNCLOS report should be referred to. In particular, the elapsed time variable is not correct in the UNCLOS data from the start of the cruise to August 23rd due to a mismatch in sampling rate specified in the configuration file (3 seconds) and the minimum allowed in the TSG (5 seconds). The variable “NMEA seconds” can be used for the accurate time. This variable is the number of seconds after 1 Jan 2000 at 00:00:00.

- It was observed that flow rate does affect the TSG fluorometer values. Results of comparison will be looked at to determine the influence due to flow.

2.7 Moorings and Buoys

Rick Krishfield (P.I.), John Kemp, Jeff O'Brien, and Andy Davies (WHOI).
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 2014 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in September and October of 2015 from the *CCGS Louis S. St. Laurent* during the JOIS 2015-06 Expedition. Furthermore, one of two similar moorings (labeled GAM-1) which was deployed to the west of our array in 2015 as part of a collaboration with the National Institute of Polar Research (NIPR) and Tokyo

University Marine Science and Technology Center (TUMSAT) in Japan was recovered this cruise. Two Ice-Tethered Profiler (ITP; www.whoi.edu/itp) buoys were deployed on ice floes with Seasonal Ice Mass Balance (SIMB), atmospheric chemistry O-Buoys, and one also included an Arctic Ocean Flux Buoy (AOFB). An ITP surface package, Ice-Tethered Mooring (ITM), O-Buoy, and AOFB which were deployed during JOIS 2013 were also recovered. A summary of moorings and buoys recovered, deployed, and serviced are listed in Tables 1 to 3.

Table 1. Mooring recovery and deployment summary.

Mooring Name	Bottom Depth (m)	2014 Location	2015 Recovery	2015 Deployment	2015 Location
BGOS-A	3830	75° 0.1244' N 149° 57.3725' W	5-Oct 18:23 UTC	7-Oct 20:18 UTC	75° 0.670' N 149° 54.178' W
BGOS-B	3833	78° 0.6658' N 149° 59.8457' W	29-Sep 19:39 UTC	1-Oct 01:38 UTC	78° 0.063' N 149° 59.838' W
BGOS-D	3530	74° 1.6996' N 140° 3.1684' W	11-Oct 18:10 UTC	12-Oct 20:45 UTC	73° 59.988' N 140° 6.461' W
GAM-1	2102	76° 0.2440' N 160° 8.7865' W	4-Oct 18:02 UTC		

Table 2. Ice-Based Observatory buoy deployment summary.

IBO	ITP / Buoy System	Date	Location
1	ITP88 / SIMB2/ O-Buoy13	28-Sep 23:30	78° 34.0' N 141° 22.1' W
2	ITP89 / SIMB / O-Buoy14 / AOFB37	2-Oct 23.46	79° 27.4' N 148° 49.3' W

Table 3. Buoy recovery summary.

Recovery	Buoy	Date	Location
1	AOFB30	24-Sep 19:55	75° 1.8' N 138° 45.3' W
2	O-Buoy10	24-Sep 18:33	75° 10.59' N 138° 57.24' W
3	ITP70 & ITM3	25-Sep 00:35	75° 24.75’ N 138° 37.57’ 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 twice every two days, assorted Microcat CTDs, 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, SAMI-CO_2, SAMI-pH, and McLane Remote Access Samplers (RAS) were installed on moorings A and B, and mooring D incorporated an acoustic wave and current profiler (AWAC) provided by the University of Washington. On redeployments, an AWACS was added to mooring A (in addition to the one on mooring D), only mooring B included a RAS, and the SAMIs were not included.

Twelve 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. One of the most striking observations in the past decade has been a reduction in both sea-ice extent and thickness, particularly in the BG region. Ocean changes have been as prominent as the reduction of ice volume: between 2003-2013 the BG accumulated more than 5000 km^3 of liquid freshwater, an increase of approximately 25% relative to the climatology of the 1970s. The magnitude of the liquid freshwater increased remarkably from 2003 to 2008 (from 17,000 to 22,000 km^3), after which it appears to have largely stabilized through 2012. In fact, combining both solid (ice) and liquid (seawater) fresh water components, indicated that a modest net export of 320 km^3 of fresh water from the region occurred between 2010 and 2012, suggesting that the ocean anticyclonic circulation regime may have weakened. In 2013, the liquid fresh water component was at it lowest value since 2007, however, in 2014, freshwater in the BG rebounded back to its 2008-2012 mean.

Last year, in collaboration with NIPR and TUMSAT in Japan, two additional mooring systems (which are delineated GAM-1 and GAM-2) were redeployed 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. One of these moorings (GAM-1) was recovered this year on this cruise, while the other was recovered from the Korean icebreaker Araon.

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 (***see appendix***).

Initiated in fall 2004, the international ITP program over the last 11 years has seen the deployment of 89 systems distributed throughout the deep Arctic Ocean (a small subset of which were instruments recovered, refurbished, renumbered and redeployed). All of these ITPs sampled ocean temperature and salinity (conductivity) and some of the systems were configured to additionally sample dissolved oxygen, bio-optical parameters (chlorophyll fluorescence, optical backscatter, CDOM, PAR), upper ocean chemistry (CO2, pH) and/or ocean velocity. ITP data are made publicly available in near real time from the project website, as well as distributed over the Global Telecommunications System (GTS) for operational forecast activities, with calibrated, edited and gridded data products generated and entered into national archives as completed. The ITP program has provided a unique, extensive and cost-effective dataset spanning all seasons with which to study the upper Arctic Ocean during a time of rapidly changing conditions. Indeed, ITP data have contributed to a variety of research studies by researchers and students worldwide.

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

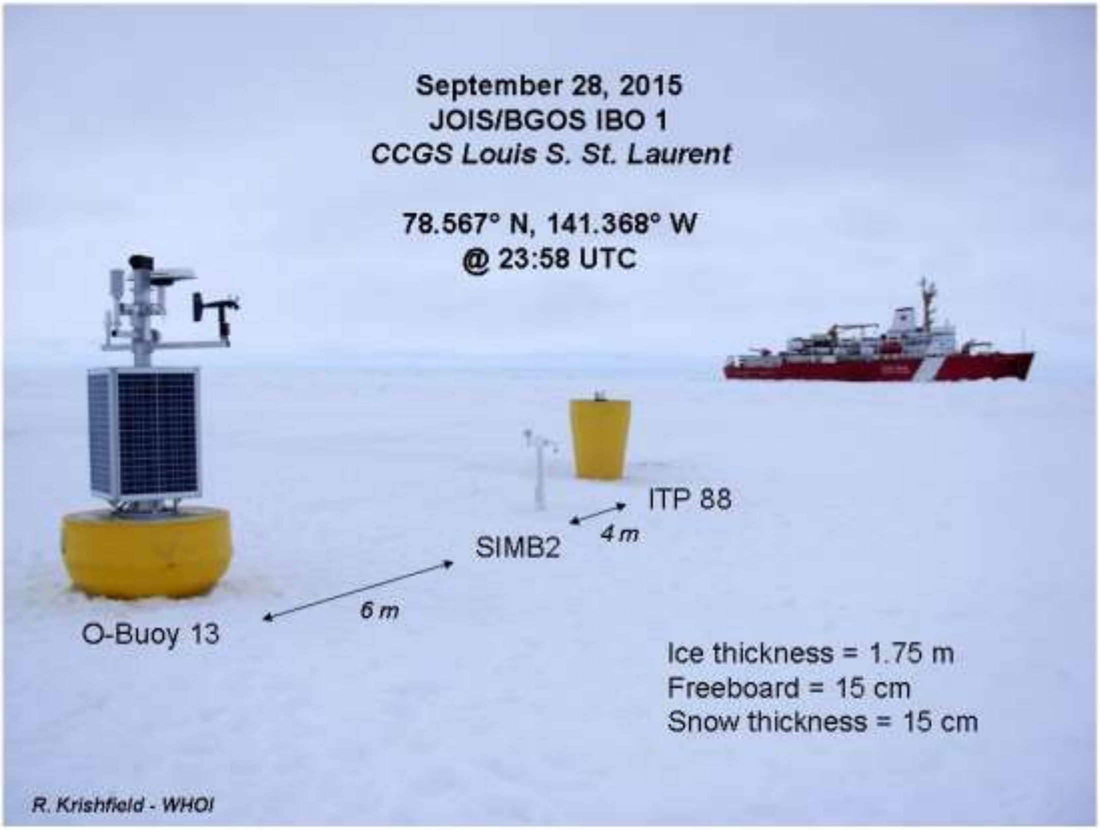
The mooring deployment and recovery operations were conducted from the foredeck using a dual capstan winch as described in WHOI Technical Report 2005-05 (Kemp et al., 2005). Before each recovery, an hour long precision acoustic survey was performed using an Edgetech 8011A release deck unit connected 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, except at mooring B whos transponder did not communicate. In addition, at every station attempts were made to locate the sphere by the ship's 400 khz fish finder.

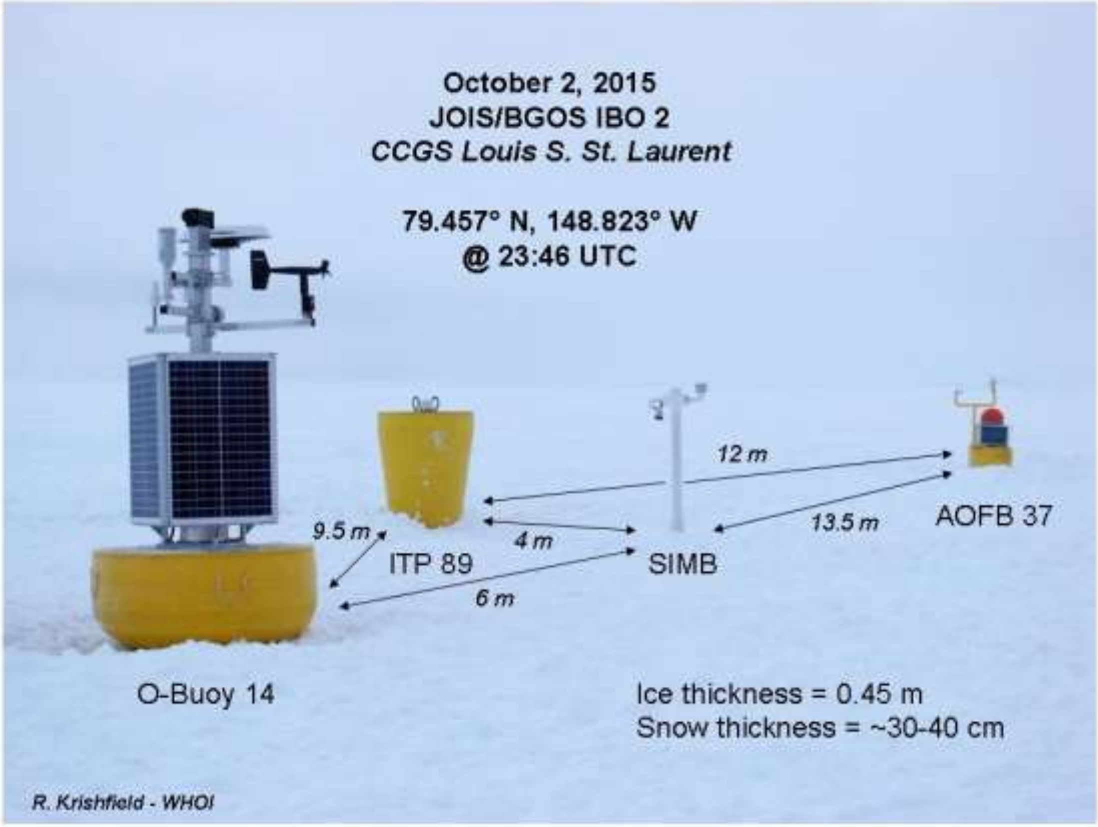
In coordination with the Captain acoustic release commands were sent to the release instruments just above anchor, which let go of the anchor, so that the floatation on the mooring could bring the systems to the surface. Then the floatation, wire rope, and instruments were hauled back on board. Data was dumped from the scientific instruments, batteries, sensors, and other hardware are replaced as necessary, and then the systems were subsequently redeployed for another year. The moorings were redeployed anchor first, which required the use of a dual capstan winch system to safely handle the heavy loads. During mooring D deployment, a polar bear approached the ship and settled on the ice a short distance away, unperturbed by our deck operations. 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, the AWACS (acoustic wave and current profiler), every BPR (bottom pressure recorder), and all three sediment traps collected samples for the duration of the deployment. Two out of three MMPs were recovered with full year-long profiler CTD data records (although one of these systems did not obtain velocity measurements), the other MMP failed due to a blown battery fuse.

The GAM mooring recovery operation was conducted in the same manner as the BGOS mooring deployments, but consumed only 2-3 hours as the mooring system was half a long as the BGOS systems. Complete year-long time series were recovered from all instruments on this mooring, except for the MMP which also has a blown battery fuse.

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). Due to the thin ice conditions, reconnaissance operations took 2 days for each IBO, as suitable ice could not be located on the first day, and weather limited daylight conditions constrained the operations. 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. One ITP surface package, one ITM, one O-Buoy, and one AOFB, all deployed as part of a single IBO during JOIS 2013 were also recovered this cruise. The recoveries were conducted using the ship's A-frame to haul out the instrumentation after the icefloes containing the buoys were strategically smashed and the systems released into the open water.





Other

Dispatches documenting all aspects of the expedition were written by Mengnan Zhao of Yale University and posted in near real time on the WHOI website at: www.whoi.edu/page.do?pid=147117.

2.8 O-buoy Deployment and Recovery

John W. Halfacre

PI: Paul Shepson (Purdue University)

Recovery of O-Buoy10

O-Buoy10 (deployed in 2013) was drifting along our cruise track, so the decision was made to recover it on 24 September. The Louis S St Laurent pulled up alongside the buoy, which was free floating. John Kemp (WHOI) was lowered down to the buoy in a man-basket from the forward deck, where he attached the O-Buoy sling to the O-Buoy mast (Figure 1). The buoy was then lifted by the ship's crane (Ricardo Amamio, bosun; Bernard Noseworthy, crane operator) into the forward hold. It appears a polar bear had tried to either bite or scratch its way into the flotation collar. Photographs of buoy's condition were obtained as buoy was disassembled and prepared for shipment home using the packing materials for OB14.

Figure 1. OB10 recovery
John Kemp (WHOI) retrieving O-Buoy10.

Pre-deployment Assembly and Testing of OB13 and OB14 (20 September-25 September 2015)

Mast was assembled on top of the hangar. Lifting of the instrument tube out of the crate was scheduled with the bosun (Ricardo Amamio). The lifting of the tube out of the crate was immediately followed by attaching the flotation collar, also using the crane. The 175 pound ballasts were attached at this time. 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 (Figure 2). As the buoy shipped with the rechargeable lead-acid batteries fully charged, the buoys were allowed to stay powered ~48 hours each. The O-Buoy team remotely verified function of all instruments. On 24 September, both masts were disconnected, and openings were covered with garbage bags to mitigate snow entry into mast.

On 25 September, OB13 was lowered onto the helicopter deck in preparation for deployment. On 2 October, OB14 was lowered onto the helicopter deck.

Figure 2. OB13 and OB14 Testing
O-Buoys 13 and 14 testing on top of the helicopter hangar.

OB13 Deployment on 28 September 2015

Figure 3. OB13 Installation
Left: Andrew Davies (WHOI) and John Kemp (WHOI) drilling O-Buoy hole with the Little Beaver Auger. Right: Rick Krishfield (WHOI) and John Kemp (WHOI) guiding OB13 into the drilled auger hole, with Gary Morgan (CCG) directing the helicopter pilot.

Location: 78.3 N 141 W

Weather: Overcast. occasional wind gusts, and temps around -3°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 1.2 m. The buoy was then slung out to the floe via helicopter and guided into position with help from Rick Krishfield (WHOI), John Kemp (WHOI), and Gary Morgan (CCG).

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). Next, the solar panels were installed and attached to the charge controller. There were issues with proper orientation of the top lid. Joining brackets on the O-Buoy lid were not able to be installed. Power connections were made and the buoy turned on at 0030 UTC. Pictures of the mast were taken.

0300 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 4. OB13 Installed
Left: Mike Dempsey (IOS) and John Halfacre (Purdue) installing O-Buoy solar panels. Right: Fully deployed OB13

OB14 Deployment on 1 October 2015

Location: 79.5 N 148.9 W

Weather: Overcast. Brisk winds. Snowy. Temps around -3°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 was then slung out to the floe via helicopter and guided into position with help from Rick Krishfield (WHOI), John Kemp (WHOI), and Gary Morgan (CCG).

2030 UTC: 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 Christopher Charles (University of Ottawa) and Geoffrey Oliver (CCG). 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.

Figure 5. OB14 deployment
Left: John Halfacre (Purdue University) and Christopher Charles (University of Ottawa) making O-Buoy mast-to-bulkhead connections. Right: Christopher Charles (University of Ottawa) working on solar panel installation, and John Halfacre (Purdue University) retrieving tools.

<u>0000 UTC:</u> Returned to the ship via gangway. 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.

2.9 RAS (Remote Access sampler) recovery and deployment

P.I.: Michiyo Yamamoto-Kawai (TUMSAT, michiyo@kaiyodai.ac.jp)
Mika Hasegawa (TUMSAT)

Recovery

Two Remote Access Sampler (RAS) were recovered at mooring stations BGOS-A and BGOS-B. WQM and SUNA sensors were also recovered at BGOS-B. Please see cruise report 2014 for equipment details and settings.

Each RAS was installed with 48 sample bags and was set to collect 450 mL of seawater. However, for RAS-B (at BGOS B), two sample bags were empty (#41 and 42) and volume of samples in other bags were only 200~300mL. Last three (one) bags were also empty for RAS-B (RAS-A) because they were scheduled to collect samples later than the recovery date. Total 43 and 47 samples were collected by RAS-B and RAS-A, respectively. Samples were analyzed for DIC and alkalinity onboard. Samples were also collected for analysis of $\delta^{18}O$, nutrients, and salinity.

Table 1. List of RAS samples

RAS B	DIC	TA	Sal	18O	nuts
1	○	○	△	×	×
2	○	○	○	×	×

RAS A	DIC	TA	Sal	18O	nuts
1	○	○	○	○	○
2	○	○	○	○	○

3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	×	×
11	○	○	○	○	○
12	○	○	○	○	○
13	○	○	○	○	○
14	○	○	○	○	○
15	○	○	○	○	○
16	○	○	○	○	○
17	○	○	○	○	○
18	○	○	○	○	○
19	○	○	△	×	×
20	○	○	○	○	○
21	○	○	○	○	○
22	○	○	○	○	○
23	○	○	○	○	○
24	○	○	○	○	○
25	○	○	○	○	○
26	○	○	○	○	○
27	○	○	○	○	○
28	○	○	○	○	○
29	○	○	×	×	×
30	○	○	○	○	○
31	○	○	×	○	×
32	○	○	○	○	○
33	○	○	○	○	○
34	○	○	○	×	×
35	○	○	○	×	×
36	○	○	○	×	×
37	○	○	○	×	×
38	○	○	○	○	○
39	○	○	△	×	×
40	○	○	○	×	×
41	-	-	-	-	-
42	-	-	-	-	-
43	○	○	○	○	×
44	○	○	○	×	×
45	○	○	○	×	×
46	-	-	-	-	-
47	-	-	-	-	-
48	-	-	-	-	-

3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	×	×	×	×	×
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○
12	○	○	○	○	○
13	○	○	△	○	○
14	○	○	○	○	○
15	○	○	○	○	○
16	○	○	○	○	○
17	○	○	○	○	○
18	○	○	○	○	○
19	○	○	○	○	○
20	○	○	○	○	○
21	○	○	○	○	○
22	○	○	○	○	○
23	○	○	○	○	○
24	○	○	○	○	○
25	○	○	○	○	○
26	○	○	○	○	○
27	○	×	×	○	○
28	○	○	○	○	○
29	○	○	○	○	○
30	○	○	○	○	○
31	○	○	○	○	○
32	○	○	○	○	○
33	○	○	○	○	○
34	○	○	○	○	○
35	○	○	○	○	○
36	○	○	○	○	○
37	○	○	○	○	○
38	○	○	○	○	○
39	○	○	○	○	○
40	○	○	○	○	○
41	○	○	○	○	○
42	○	○	○	○	○
43	○	○	○	○	○
44	○	○	○	○	○
45	○	○	○	○	○
46	○	○	○	○	○
47	○	○	△	○	○
48	-	-	-	-	-

△: small volume
×: no sample

Deployment

The RAS-A, SUNA and WQM were redeployed at BGOS-A. The settings are summarized in Tables 2 and 3. RAS was set to collect 48 of 450 mL seawater samples. 200 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 the RAS.

Table 2. BGOS-A RAS/SUNA/WQM settings.

	RAS	**SUNA**	**WQM**
serial No.	ML12905-02	SUNA-06	WQM-406
sampling start date	2015/10/8 3:00:00 (UTC)	2015/10/8 2:50:00 (UTC)	2015/10/8 2:45:00 (UTC)
sampling schedule	see table 3	every 12 hours	every 12 hours
other information	No filter	light frame 120 sec, wiper ON	sampling time 5 minutes

Table 3. RAS sampling schedule (UTC)

#	**time**				
1	2015/10/08 03:00	17	2016/02/03 03:00	33	2016/06/02 03:00
2	2015/10/08 03:00	18	2016/02/11 03:00	34	2016/06/10 03:00
3	2015/10/17 03:00	19	2016/02/19 03:00	35	2016/06/18 03:00
4	2015/10/26 03:00	20	2016/02/27 03:00	36	2016/06/26 03:00
5	2015/11/04 03:00	21	2016/03/06 03:00	37	2016/07/05 03:00
6	2015/11/13 03:00	22	2016/03/14 03:00	38	2016/07/14 03:00
7	2015/11/22 03:00	23	2016/03/22 03:00	39	2016/07/23 03:00
8	2015/12/01 03:00	24	2016/03/30 03:00	40	2016/08/01 03:00
9	2015/12/09 03:00	25	2016/04/07 03:00	41	2016/08/10 03:00
10	2015/12/17 03:00	26	2016/04/15 03:00	42	2016/08/10 03:00
11	2015/12/25 03:00	27	2016/04/15 03:00	43	2016/08/19 03:00
12	2015/12/25 03:00	28	2016/04/23 03:00	44	2016/08/28 03:00
13	2016/01/02 03:00	29	2016/05/01 03:00	45	2016/09/06 03:00
14	2016/01/10 03:00	30	2016/05/09 03:00	46	2016/09/15 03:00
15	2016/01/18 03:00	31	2016/05/17 03:00	47	2016/09/24 03:00
16	2016/01/26 03:00	32	2016/05/25 03:00	48	2016/10/03 03:00

2.10 Ice Watch Cruise Report 2015

P.I.: Jennifer Hutchings (OSU), Kazu Tateyama (KITAMI)

As in previous years, the ice observations recorded during the Louis S. St. Laurent 2015 cruise will provide detailed information for the interpretation of satellite imagery of the ice pack. Cores and transects were taken during the two ice stations, to further characterize the perennial ice.

Observations from the Bridge: Methodology

We split the ice watch into 6 hour shifts throughout the cruise. Shifts were maintained even when no ice was present, especially during the periods when new ice was forming and conditions could change from no ice to 100% cover in the period of an hour. We aimed to make an observation every hour, on the hour, for a 10 minute observation period. Ice conditions were noted within 1nm about the ship, when visibility allowed, along the ships track during the observation period. During night we relied upon the ships search lights to observe the ice, so the field of view was somewhat reduced. However RADAR did help with estimating ice area at night.

We follow the ASSIST observation protocol. ASSIST is based upon ASPECT (Worby & Alison 1999) bridge observation protocol, with additional information to characterize Arctic sea ice. Additional observables include melt pond characteristics, sediment on ice and an additional ice type – second year ice. As this cruise was after September 15 and freeze up had commenced, any ice recorded as second year (SY) would have been formed in the previous winter, having survived one summer. *However, please note that on the first few days of observation we were recording level MY ice as SY ice, as it was remarkably thin and uniformly level. Observing the ship overturning this ice we noted that it was a deep blue colour, suggesting it was older. On our first ice station we noted 60cm level MY ice with low salinities, We changed our observation for SY to be based on colour of overturned ice (greyer ice recorded as SY, bluer as MY) a few days into the cruise. Be aware that we observed large areas of thin level MY ice of indeterminate age.*

For more information on visual observations collected please see the document 'ASSISTv3_CheatSheets.xls'. Data is archived at icewatch.gina.alaska.edu and more information about the Ice Watch program and ASSIST can be found at www.iarc.uaf.edu/icewatch.

WebCams

As in previous years, two netcams were installed on the monkey island. Netcam imagery has been collected since 2007. One facing towards the bow recording images every minute. The other camera looking down over port side recording images every 10seconds.
Please note, this year we turned the port camera 90^o, so it is not longer looking at ice over turning but monitoring the ice moving under Kitami's crane mounted EM-31 and passive microwave radiometers. This was done for two reasons:

1. *a zodiac was moved a new location blocking the view of the overturning ice*
2. *we wished to monitor if ice was not being overturned under the em-31.*

Ice Stations

We followed the standard JOIS protocol of

1. collecting snow depth, ice thickness and freeboard data along transects and
2. collecting cores

at each ice station. In addition Kazu Tateyama recorded snow pit information at each station. Ed Wigglesworth-Blanchard used a sled mounted EM-31 to extend ice thickness measurements across each ice station floe.

See documents 'TransectInstructions.docx' and 'CoreInstructions.docx' describing the methodology.

Ice Station 1

Ice was accessed by helicopter.
Two 100m transects were laid at right angles to each other, sharing their origin at 0m.
Ice cores were collected at three sites. The first site was rafted (corer dropped in a void), so was abandoned. Second site was a few meters from the first site. Site three was at the location of thickest ice along the transects.

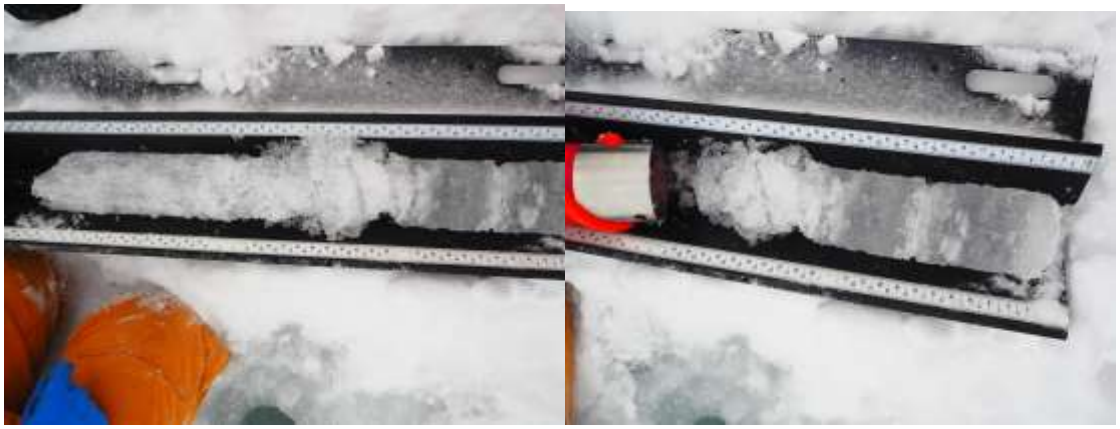
Ice Station 2

Ice was accessed by gangplank on ships port. Ship kept station with the ice.
Three transects were laid. A 100m transect parallel to the ship direction. A 50m transect 90 degrees to this, that ended at the buoy installation site. Then a third line was laid for 50m on the other side of the buoy site, continuing the direction of the second line.
Cores were collected at two relatively thin ice sites, characteristic of the floe, and one site with thicker ice.

Ice Cores

Ice Station	Site	Core	Purpose	PI
1	1	A	Abandoned	Hutchings
1	2	B	Temperature/Salinity	Hutchings
1	2	C	DNA	Onda
1	2	D	Microplastics	Quesnel
1	2		Barium Isotopes	Charles
1	2	E	Structure	Hutchings
1	3	F	Temperature/Salinity	Hutchings
1	3	G	DNA	Onda
1	3	H	Microplastics	Quesnel
1	3	I	Structure	Hutchings
2	1	A	Temperature/Salinity	Hutchings
2	1	B	DNA	Onda
2	1	C	Microplastics	Quesnel
2	1		Barium Isotopes	Charles
2	1	D	Structure	Hutchings
2	2	E	Temperature/Salinity	Hutchings

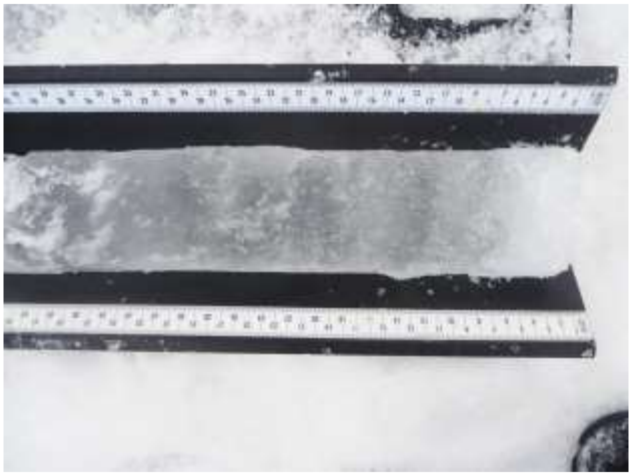
2	2	F	DNA	Onda
2	2	G	Microplastics	Quesnel
2	2	H	Structure	Hutchings
2	2		Barium Isotopes	Charles
2	3	I	Temperature/Salinity	Hutchings



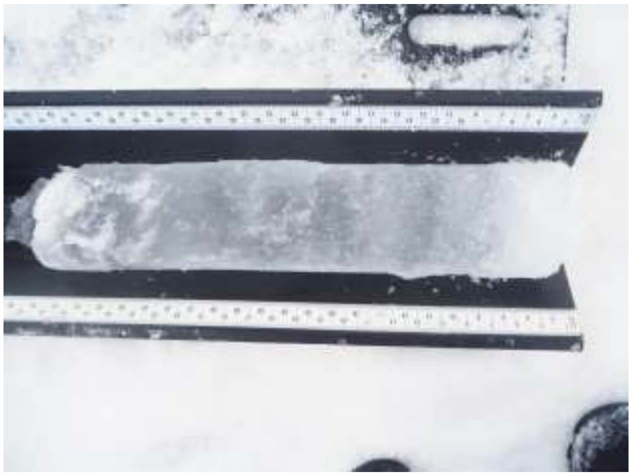
Ice Station 1, Site 1 Core A

Ice Station 1, Site 2 Core B

Note, the bottom section of this core, which is whiter and has large voids was very soft to drill. The top of the core took effort to drill.

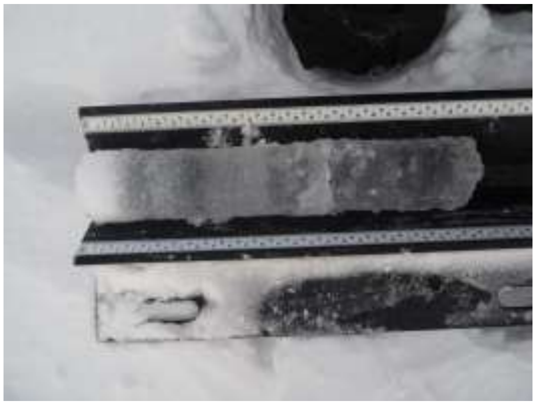


Ice Station 1, Site 2 Core C


Ice Station 1, Site 2 Core D

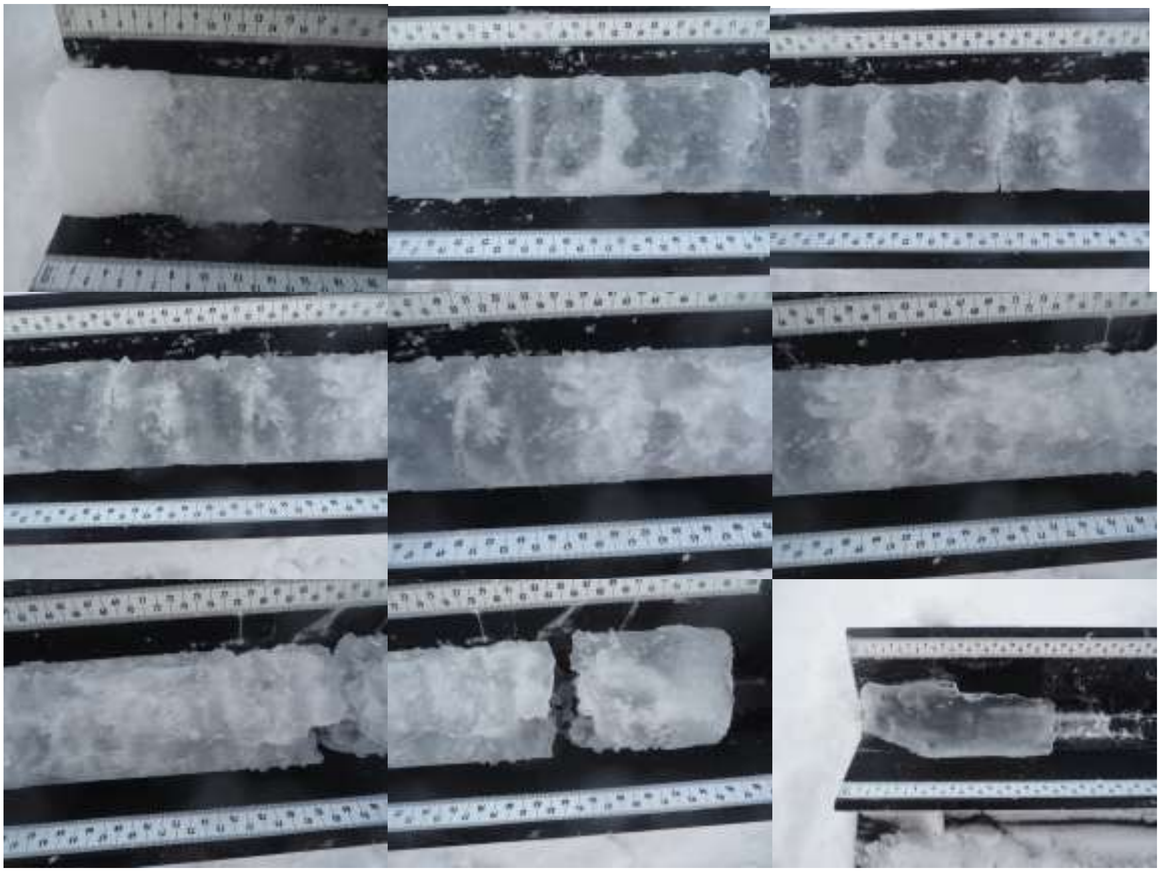

Ice Station 1, Site 2 Core E


Ice Station 1, Site 3


Ice Station 2, Site 1

Ice Station 2, Site 2, Temperature/Salinity Core

Ice Station 2, Site 2, Microstructure Core



Ice Station 2, Site 3, Temperature/Salinity Core

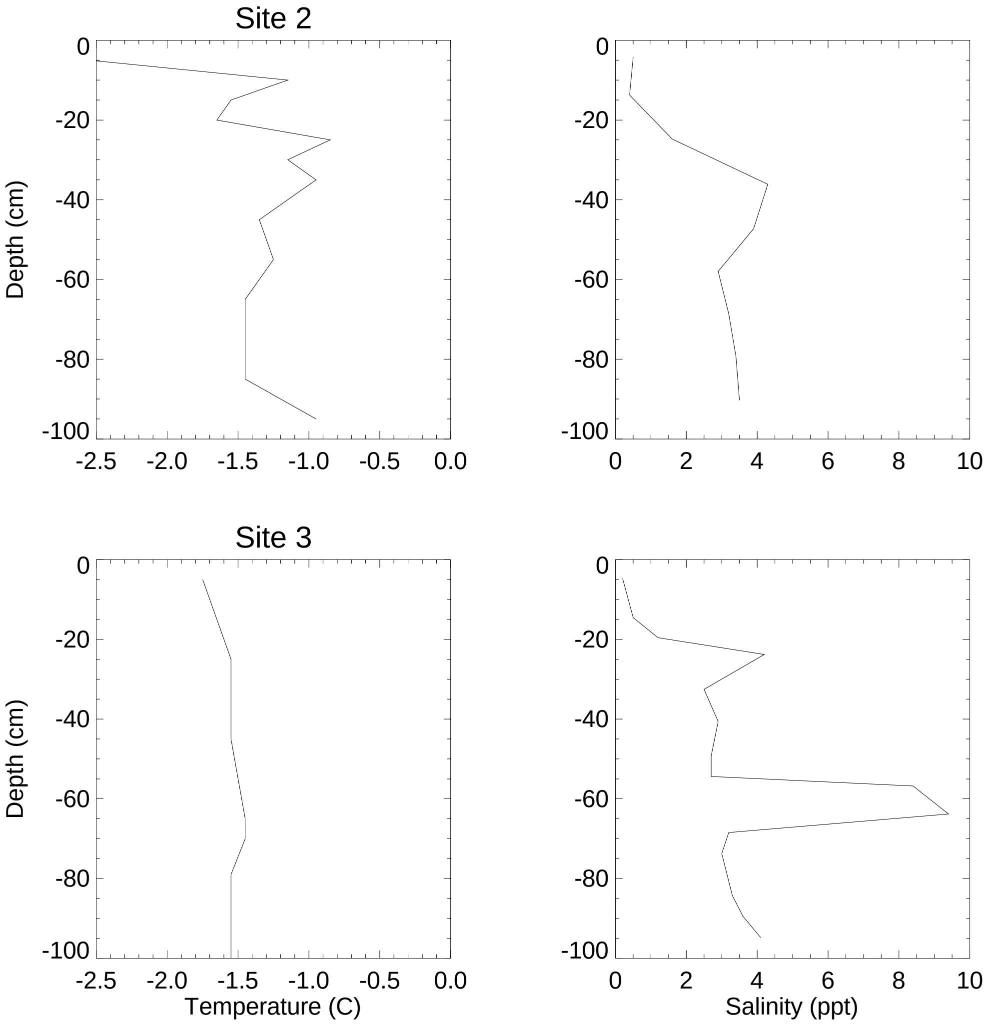
Temperature, Salinity and Density Profiles

Temperature, salinity and density profiles were measured at each core site following the methodology described in the ‘how-to’ document in the appendix. Delta-O18 samples were collected for every core section we have a salinity record.

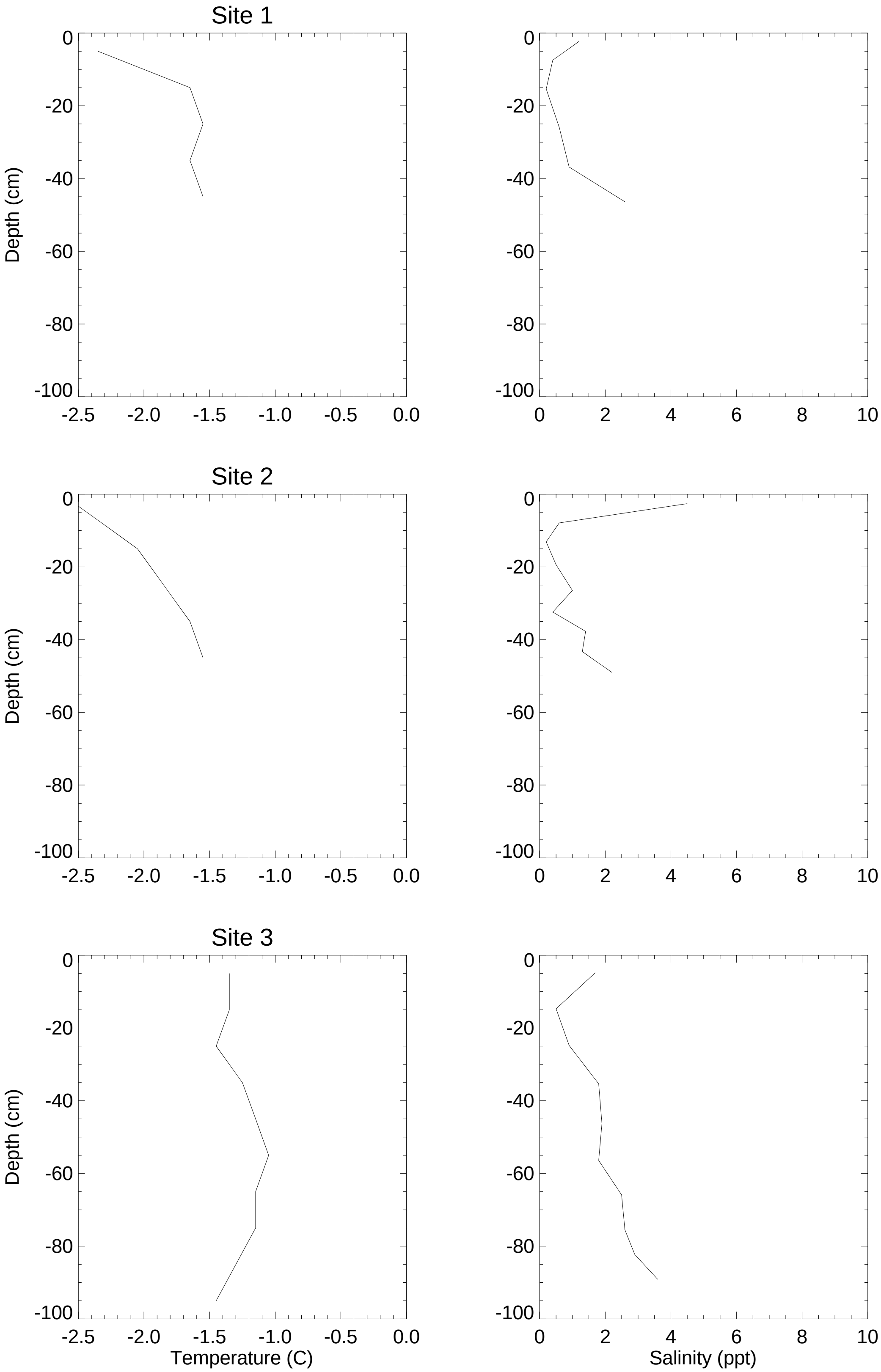
Density will be calculated at a later date, and it should be noted there are large errors associated with these density measurements (Hutchings et al. 2015), and the date is best used averaged across many cores. Our aim is to characterize bulk density of MY ice in the Beaufort region.

Calibration of thermistor
With a fresh water ice bath we determined the thermistor used for core sampling has a bias of 0.25C.

Calibration of salinometer
We calibrated the Kitami and OSU salinometers with a 34ppt standard and deionized water. The standard was cut in half, volume wise, with deionized water several times and measurements recorded for salinities in the range 0f 0-34ppt. See data spreadsheet SalinometerCalibration.xlsx.



Ice Core Profiles for Ice Station 1. Temperatures have bias in thermistor accounted for. Salinity bias is not estimate yet, but is probably close to zero.



Ice Core profiles from Ice Station 2. Temperatures have bias in thermistor accounted for. Salinity bias is not estimate yet, but is probably close to zero.

Structure Cores

This is the first time we have cut cores during JOIS. The work was done in the dairy/bread freezer with a hand saw. Given the limited workspace and tools the vertical thick sections we cut were not great, but they do a reasonable job at showing the structure of the ice.
For anyone interested in mosaics of more detailed photographs of each core, please contact Jenny Hutchings.

Ice Station 1, Core Site 2

Depth Range	Layer Description
0-4cm	Granular ice transformed by summer melt
4-5.5cm	large bubbles
5.5cm	Break in core
5.5-7cm	large bubbles
7cm	horizontal line
7-11 cm	large bubbles
11-27 cm	medium bubbles, some layered structure
27-42 cm	2cm brine channel structure, few medium bubbles
42cm	Break in core
42-51cm	large brine channels. 4x1cm, 8x1cm
52cm	milky Interface
52-58cm	Columner ice
58-61cm	milky Interface, break in core
61-91 cm	long brine channels

The transitions in the ice station 1 core suggests several different ages of ice in the core. There are three horizontal features that might suggest previous years melt back of the ice, at 52cm and possibly at 42cm. The ice from 52-91cm is clearly growth from winter 2014-2015 which has not been transformed to hard MY ice.

Ice Station 2, Core Site 1

Depth Range	Layer Description
0-4 cm	Granular ice transformed by summer melt
4-6 cm	Break in core, transition from granular to columnar ice
6-13 cm	Large air bubbles
13-19cm	small air bubbles
19-24cm	medium air bubbles
24-33 cm	small bubbles, several lines indicating fine brine channel structure
33-50 cm	milky, fewer bubbles
50-51 cm	vertical structure

Ice Station 2, Core Site 2

Depth Range	Layer Description
0-4 cm	Granular ice transformed by summer melt
4-6.5 cm	Break in core, transition from granular to columnar ice, vertical aligned bubbles
6.5-19.5 cm	Large air bubbles
19.5-20 cm	Line
20-31 cm	medium air bubbles
31-33 cm	vertical bubbles
33cm	break in core. Milky Layer??
33-53 cm	columnar ice, few small/medium bubbles

The cores at ice station 2 suggest a break between two years of MY ice at 33cm. , suggesting melt back to 33cm summer 2014 and melt back to 53cm in summer 2015.

The top 30cm of ice for all cores has very similar characteristics, suggesting the ice at all sites experienced a similar temperature history over the age of the oldest ice in the cores.

Effect of melt on samples

One core sample was allowed to partially melt by accident. As you can see from the photograph comparing this core to a core piece collected in an adjacent hole, the impact of melt is to transform the ice. Air bubbles are apparent in the melted and then refrozen sample. Net example of ‘artificial aging’.

Dreams for the Future

On future cruises it will be possible to make plots showing core structure in photographs along side temperature, salinity and density profiles. I did not bring the image analysis software to do this on this cruise. Also, with an improved freezer work space, band saw, light table and polarization films for cross polarizing, and a camera mount it would be possible to make thin sections and do detailed microstructure analysis on cores.

Transects

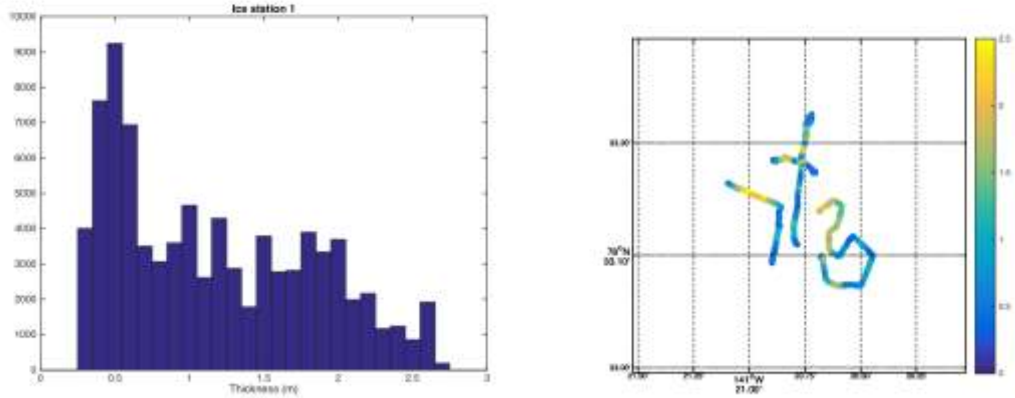
Where possible we followed the standard JOIS procedure of making 2 100m transects at right angles to each other with thickness and freeboard measurements every 10m. On ice station 2, the line perpendicular to the ship had to be split into two 50m transects with a break to accommodate the IBO bouy installations.

Snow Pits

- Kazu Tateyama made a snow pit at the 0/0m mark where transects 1 and 2 crossed on ice station 1.
- On ice station 2, two snow pits were made. One at the 0/0m mark, the other the 0m mark on transect 3.

Ice Thickness from EM-31

At both ice stations, ice thickness was measured with an EM-31 antenna mounted on a sled. The EM-31 data logger has an in-built GPS that recorded location. However, due to floe drift, the absolute position does not reflect the relative position on the floe of the EM-31 track, which was designed along the ‘L’ shaped transects and in zig-zag patterns around the floe. The ship’s GPS can be used to correct for floe drift *if* the ship is locked in to the ice floe – this was not the case at ice station 1. In the case of ice station 1, we use times at which the EM-31 is stationary to calculate the mean floe drift, and subtract this motion vector from the GPS location vector. The thickness gradient in *time* is used to define when the EM-31 is stationary (when d(thick_grad)/dt=0). At ice station 2, the ship was locked into the ice floe, and we use its GPS to illustrate the EM-31's track. *Ideally, a second GPS should be placed on the floe.*



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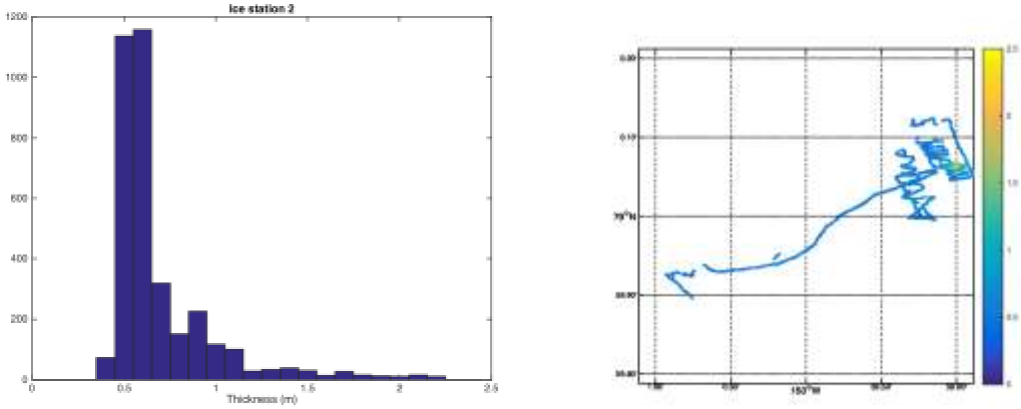
Histogram of ice thickness (left) and relative ice thickness track (right, the lat,lon origins are the mean location of all tracks combined) at ice station 1.

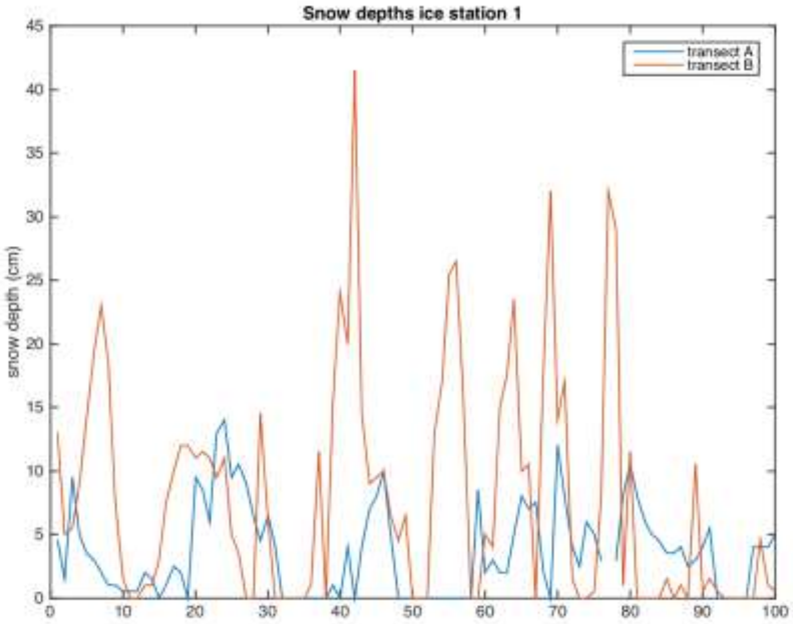


Histogram of ice thickness (left) and relative ice thickness track (right, the lat,lon origins are the mean location of all tracks combined) at ice station 2.

The modal ice thickness at both locations is similar (~0.5-0.6m), but there is much higher variability at ice station 1, with significant areas of thicker ice. This is reflected in the mean ice thickness at both ice stations (1.2m mean at IS1, 0.7m mean at IS2).

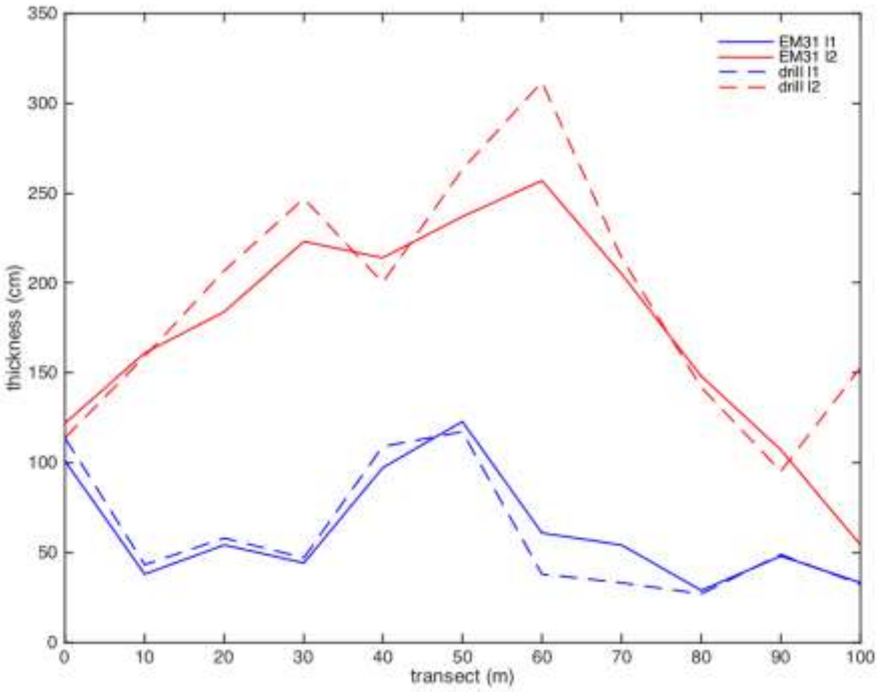
Snow depth measurements

Snow depth was measured at 1-m intervals along 100m transects at both ice stations. In ice station 1, snow depths were generally low (mean values 4-8cm), but with high spatial variability, with deep snow (40cm) measured in the lee of ice ridges. Flatter areas were generally bare or had

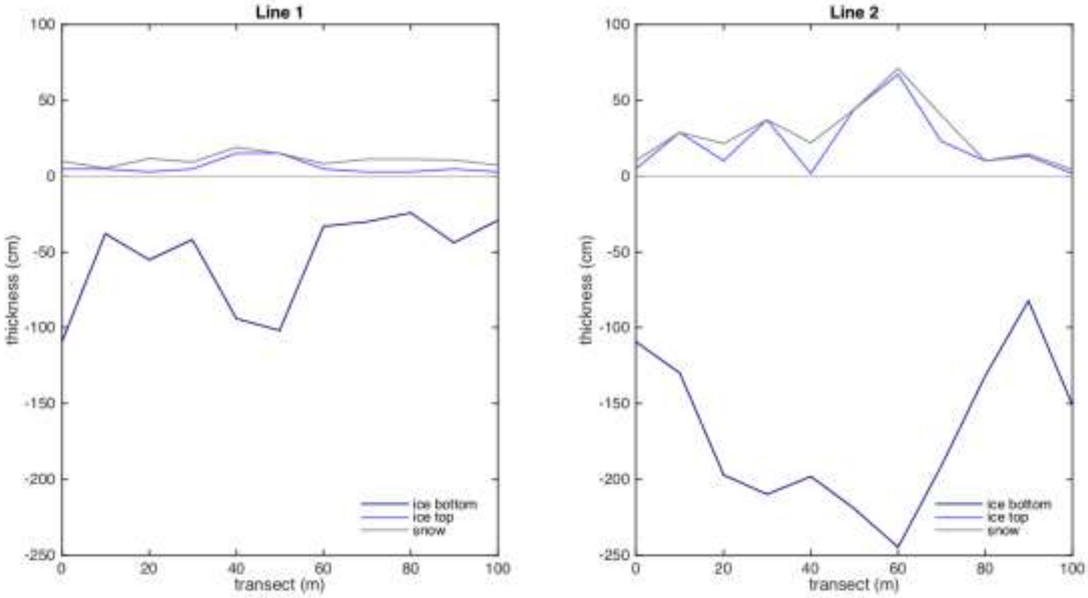


a low snow cover
Snow depth along transects 1 and 2 at Ice Station 1

Ice thickness: drill data
At both ice stations' transects, ice thickness was measured directly with the use of a drill. This was done every 10m along the transect. Snow depth and freeboard was also measured at these locations.

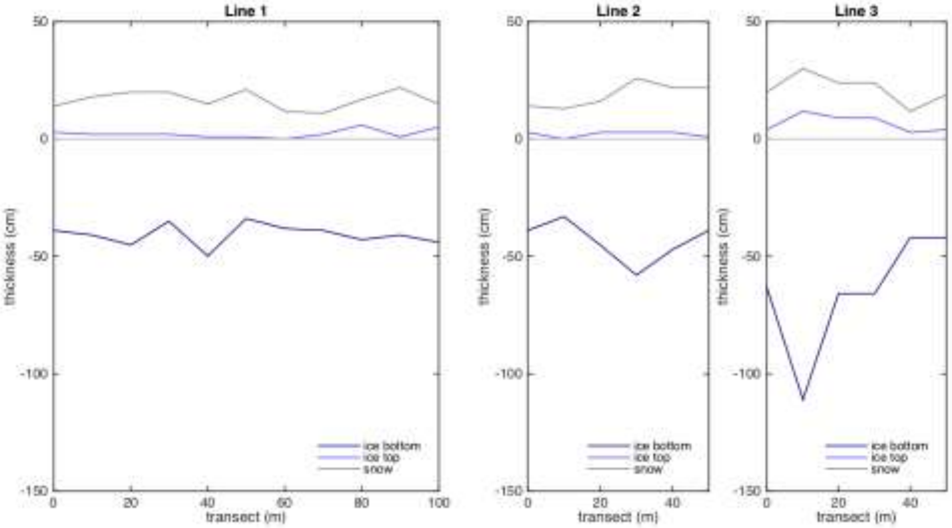


The drill and EM31 data compare favourably at Ice Station 1, especially over the thinner, more regular ice. Over line 1, drill and EM31 mean thickness are 61cm and 62cm, respectively. Over the thicker ice, the data do not agree as strongly. This could be due to high spatial heterogeneity in ice thickness and the drill and em31 readings not being aligned perfectly. Over line 2, drill and EM31 mean thickness are 191cm and 174cm, respectively.



Transects at Ice Station 1.

Plotting snowdepth and the water line (using the freeboard data), we see that generally thicker ice has a larger freeboard, as expected. Snow is deepest in the troughs between ridges, and thinnest or non-existent on the ridge tops.



Transects at ice station ***2***

Microcat

On ice station 2 a microcat was deployed at about 1m depth below the ice. The data from this is not that interesting, temperature and salinity did not vary during the station.

Nilas sample collection

October 6th the man basket was used to collect an sample of nilas. The sample was 8cm thick, had bulk salinity 8.9ppt on seawater with salinity 27ppt. Four horizontal sections of the nilas were cut in the freeze and a salinity profile recorded. Bottom 1cm of ice had salinity 16ppt, the top 2cm was 6.8ppt. Delta-O18 samples were collected for each horizontal layer. A vertical section was also cut and photographed.

Bottom surface of sample at 0cm.

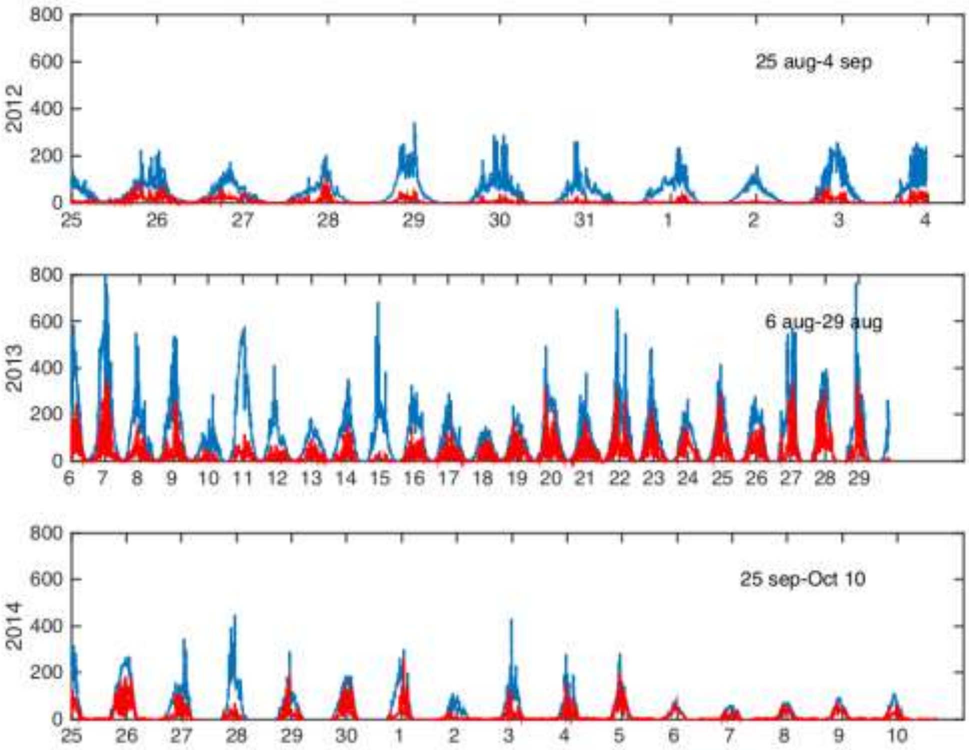
Radiometer

Kitami's radiometer that measures longwave and shortwave radiation, both downwelling and upwelling, and temperature, was mounted on a boom from the bow of the ship. Data was collected from September 26th until October 8th. On October 6th we noted icing on ship structures, and heavy icing on the radiometer.

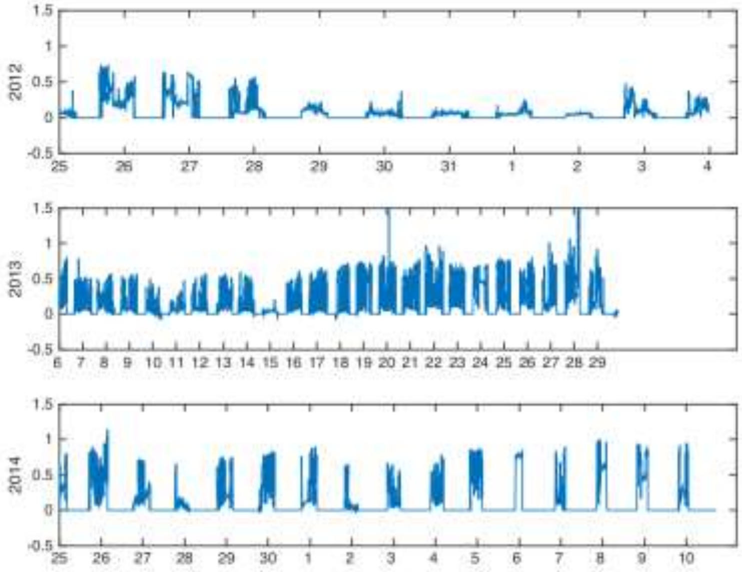
This data has been collected on every JOIS cruise since 2012.

Ed Blanchard-Wrigglesworth analysed the 2012-2014 data. This is shown in the three following figures.

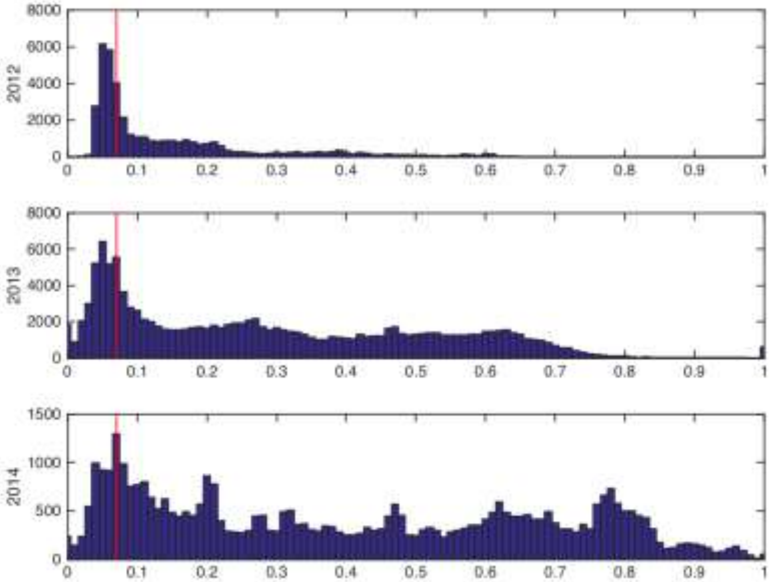
Calibration for 2013 and 2012 was updated, based on calibration documentation in the radiometer box. There was no documentation of what calibration numbers were used in 2014, so this data was left unchanged.



Downwelling (blue) and upwelling (red) shortwave radiation in 2012, 2013 and 2014.



Albedo estimated during daylight hours. Note that daylight is assumed when downwelling shortwave is greater than 30W/m^2.

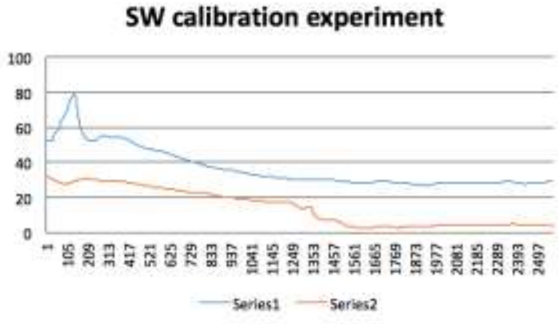


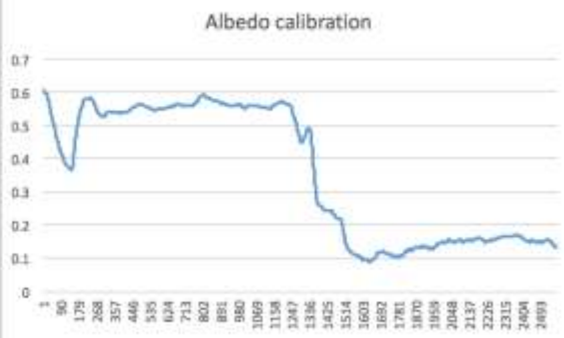
Histogram of albedo in each year.

During the record-low sea ice year of 2012 the JOIS cruise was dominated by open water, and this is reflected in the albedo measurements. 2014 in contrast shows the highest albedo values, which probably also reflects the alter dates of that cruise (late September early October). The red thin line is albedo 0.07, which is the albedo of open water. In all 3 years, low albedo values peak around 0.05 to 0.07, which serves to calibrate the radiometer, at least for low values.

Radiometer Calibration

We performed a calibration of the radiometer on three occasions, over open water (2015/10/08), shuga (2015/10/10) and nilas with light snow cover(2015/10/11). To calibrate the radiometer we collected data over open water with the radiometer placed upright and upside down. Comparing the two sensors. up an down, we can determine if there is a bias between the sensors.
The first data set, 2015/10/08, only includes shortwave channels and not the longwave channels.





The above plot shows one of the more interesting calibration measurements, taken on Oct 11th – going from sailing over thin ice to sailing in a lead as the light became darker – see the lowering values in downwelling SW (the whole transect is ~8 min long, readings every 0.2 secs). The albedo drops significantly as the ship sails over the lead. The fact values are greater than 0.07 over the lead might be due to frazil, or large amounts of diffuse light reaching the lower sensor. Note that the downwelling SW is around the 30Wm-2 cut-off used above.

Measuring ice thickness with digital camera and laser distance meter

Shin Toda

Shin Toda measured ice thickness with photography. A Digital camera and laser distance meter was used for this observation. See photo below.

When icebreaker goes through the ice and broken ice turns at the side of ship, picture of section of the ice was taken. In the same time, the distance meter measured the distance from camera to ice.

When we know the distance, we can know the scale of the picture.

Then, we can know ice thickness in the picture with counting the amount of pixels. Note the pixel counting was down by placing a rectangle over the region of ice thickness and snow, and the dimensions of this box provide a measure of thickness in pixels.

Distance meter and digital camera

Results

Data is presented as an excel spread sheet LaserCamera.xls.

Observation was occurred from September 26 to October 13.Result was written at excel file “LaserCamera.xls”. All time in table is UTC.

Start: The time and position of beginning the observation.

End: The time and position of ending the observation.

Laser distance: Distance from camera to ice measured by laser distance meter.

Picture number: Number of picture named by digital camera.

Magnification: How long 1 pixel means in the picture, calculated with distance from distance meter to ice.

Snow (pixel), ice thickness (pixel): How many pixels does section of ice and snow have in the picture.

Snow (m), ice thickness (m): Thickness of snow and ice calculated from pixel.

Total (m): snow (m)+ice thickness (m)

Remark: “star” means that the picture was taken at starboard side. “port” means that the picture was taken at portside.

In “ice type” ”snow(pixel)” ”ice thickness(pixel)” ,”-” means that we can’t find the result from picture because of darkness or camera shake

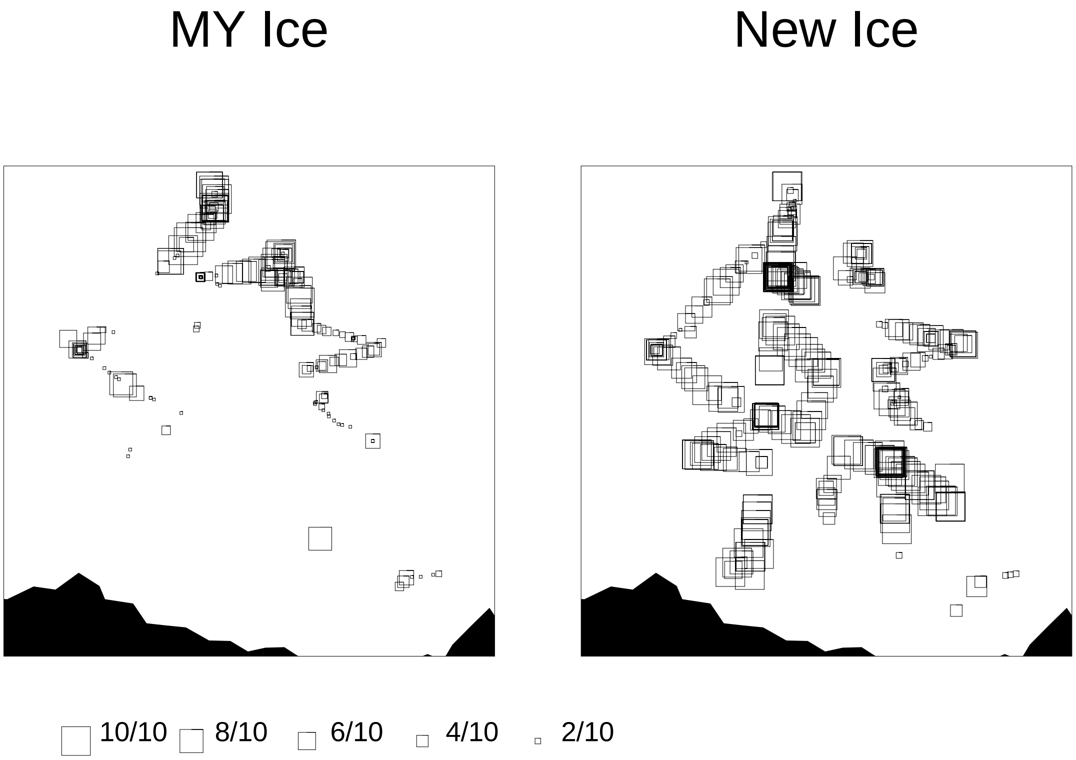
Summary of Ice Along the Cruise Track

This year we travelled ‘backwards’ around the JOIS loop, making the 145W line first, deploying ice stations in the north and then returning south between down the 150W line with some large zig-zags along the way. The made for a very different ice experience. Watch was held continuously on the cruise, except for during ice stations.

A typical view of MY ice encountered in the central Canada Basin region outside of the ice tongue of oldest ice.

We first encountered MY ice in small relatively thick floes, on entering the Beaufort (72N 132W). Traversing north we noted thinner MY ice (50-60cm, up to 100cm in places), that was small to medium floes of varying concentration. It was striking that the ice was exceptionally level, with less evidence of hummocking and ridges than you would expect from MY ice. This is the 3-4 year old ice that has recirculated in the center of the Beaufort Gyre. The thickest MY was encountered around the TUMET mooring (155W 75.5N). This ice was in small floes and at concentrations from 4/10 to 8/10. The Beaufort ice tongue was not present in the center of the Beaufort, and remained in the east and west. Thanks to the chief scientist for deciding an XCTD was needed in the southern part of the eastern old ice, so we could check this out on the way out of the Beaufort! We say thick (3-6m) small ice floes.

Young ice types were encountered through out the cruise. We arrived in the Beaufort around the onset of freeze. Every stage of new ice development from grease ice to young-white ice was observed. We noted formation in pancakes on occasion and formation as nilas. There was evidence for pancakes that became entrained into nilas and grey ice as the swell died down.



Data

lsloaa::sciencenet/2015-06-JOIS/Data/Ice

- IceStations

IceStation1SnowPit.xlsx
IceStation1Transect1.xlsx
IceStation1Transect2.xlsx
IceStation1_Cores.xls
IceStation2Snowpits.xlsx
IceStation2Transect1.xlsx

IceStation2Transect2.xlsx
IceStation2Transect3.xlsx
IceStation2_Cores.xlsx
ManBasketSamples.xlsx -Nilas sample

- Calibration

SalinometerCalibration.xlsx -Salinometer calibration information

- IceWatch

JOIS2015_IceWatch.xls
ASSISTv3_CheatSheets.xlsx - Description of data file, with header codes

- NetRad
- 2012 - Data reprocessed by Ed
- 2013 - Data reprocessed by Ed
- 2014
- 2015
- Calibration

Calibration_20151008.txt
Calibration_20151010.txt
Calibration_20151011.txt

- Photothickness

LaserCamera.xls
report(Toda).docx

- **EM** -KITAMI EM-31 ‘sushi’ data

JOIS2015_EM-GPS_0922_1518-0923_2056.csv
JOIS2015_EM-GPS_0923_2300-0924_1914.csv
JOIS2015_EM-GPS_0925_0043-0926_1924.csv
JOIS2015_EM-GPS_0926_2009-0929_1926.csv
JOIS2015_EM-GPS_0930_0051-0930_2023.csv
JOIS2015_EM-GPS_1001_0151-1002_1804.csv
JOIS2015_EM-GPS_1003_0255-1003_2328.csv
JOIS2015_EM-GPS_1003_2348-1004_1649.csv
JOIS2015_EM-GPS_1004_2110-1005_1805.csv

- PMR - KITAMI Passive Microwave Radiometer data

MMRS_JOIS2015_0924_2207-0926_1929.csv
MMRS_JOIS2015_0926_2137-0927_1916.csv
MMRS_JOIS2015_0927_2136-0929_1944.csv
MMRS_JOIS2015_0930_0034-0930_2030.csv
MMRS_JOIS2015_1001_0158-1002_1758.csv
MMRS_JOIS2015_1003_0301-1004_1651.csv
MMRS_JOIS2015_1004_2121-1005_2034.csv
MMRS_JOIS2015_1006_2037-1008_2134.csv
MMRS_JOIS2015_1009_2107-1010_2313.csv
MMRS_JOIS2015_1011_2326-1012_2237.csv

Many Thanks to the following volunteers who helped at ice stations:
Ice Station 1 coring – Deo Onda, Sigrid Salo
Ice Station 1 transects – Sarah Zimmermann, Mika Hasegawa and Geoff Oliver.
Ice Station 2 coring – David Walsh, Celine Geugeun

Ice Station 2 transects – Sarah Zimmermann, Sigrid Salo
Ice Station 2 em-31 – Deo Onda, Bill Williams
We could not collect this data without your help.

Please see report for more information

2.11 EM/PMR ice obsersvations Cruise Report

EM/PMR observations were carried out by following members

- Kazutaka Tataeyama, Associate Professor, Kitami Institute of Technology, Japan
- Shin Toda, Master course student, University of Tokyo, Japan

Measurements:
Following ship underway ice observations were conducted starting from CB1 to BGOS-A (EM) and BGOS-D (PMR) as shown in Fig.1.

1. Ice thickness measured by an electromagnetic induction device (EM)
2. Brightness temperatures measured by passive microwave radiometers (PMR),

Figure 1 Positions of EM and PMR sensors in 2015.

Purpose and methods:

An Electro-Magnetic induction device EM31/ICE (EM) and a laser altimeter LD90-3100HS were used for indirect sea-ice thickness measurement continuously. EM provides apparent conductivities (σ_a) in mS/m which can be converted to a distance between the instruments and sea water at sea-ice bottom (Z_E) by using inversion method. LD90-3100HS provides a distance between the instruments and snow/sea-ice surface (Z_L). The total thickness of snow and sea-ice (Z_{S+I}) can be derived by subtracting Z_L from Z_E. Ice concentration also can be measured by EM system.

Sea-ice thickness in the Canada Basin was recorded by EM system in order to research interannual thickness change. In addition, snow/sea-ice brightness temperatures and surface temperature also measured by portable PMRs were collected in order to validate and improve the algorithm for estimation of the Arctic snow/sea-ice total thickness by using satellite-borne passive microwave radiometer (PMR) [Krishfield et al., 2014]. The EM sensor covered by a yellow-orange colour water proof case was deployed from the foredeck's crane on the port side, collecting data while underway as shown in Fig.2.

The portable PMR, called MMRS2A, which had been developed by Mitsubishi Tokki System Co. Ltd., Japan, have 4 channels which consists of the vertically and horizontally polarized 6GHz and 36GHz. In addition, CCD cameras. The radiation thermometers IT550, which are developed by HORIBA Corp., Japan, were used. Those PMRs were mounted on the port side below of flight deck in 55 incident angle which is same angle as the satellite-borne passive microwave radiometer AQUA/AMSR2. PMRs look over the EM's measurement area and collected data every 1seconds synchronously. All data are collected every 1 second.

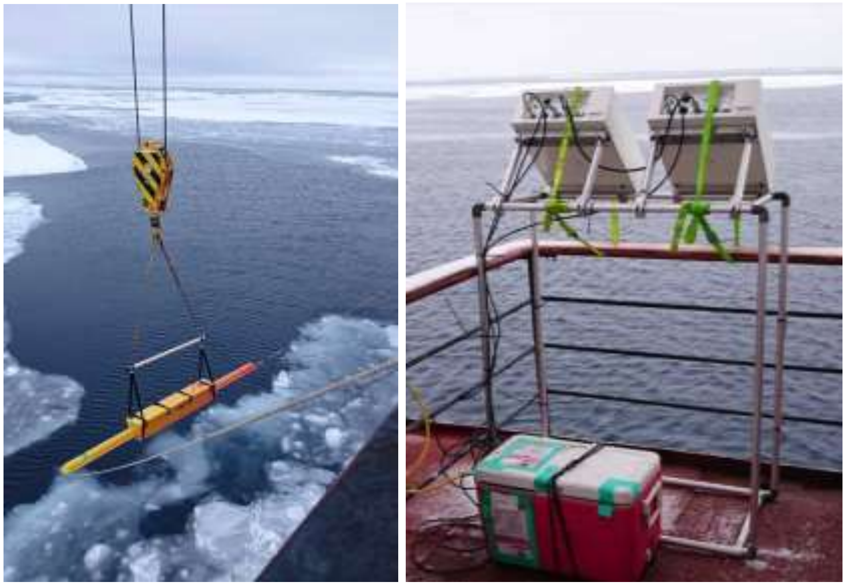


Figure 2 Pictures of EM and PMR installed on the starboard side of LSSL.

Results:

1. EM ice thickness profiles

EM observations were carried out during 22 September and 4 October (Fig.3). 9 profiles of EM survey were derived as summarized in table 1. The total distance of 9 profiles were 3,170 km. EM was calibrated over open water twice on 3 and 5 October as shown in Fig.4. Individual ice thickness profiles are indicated in Fig. 5a-c.

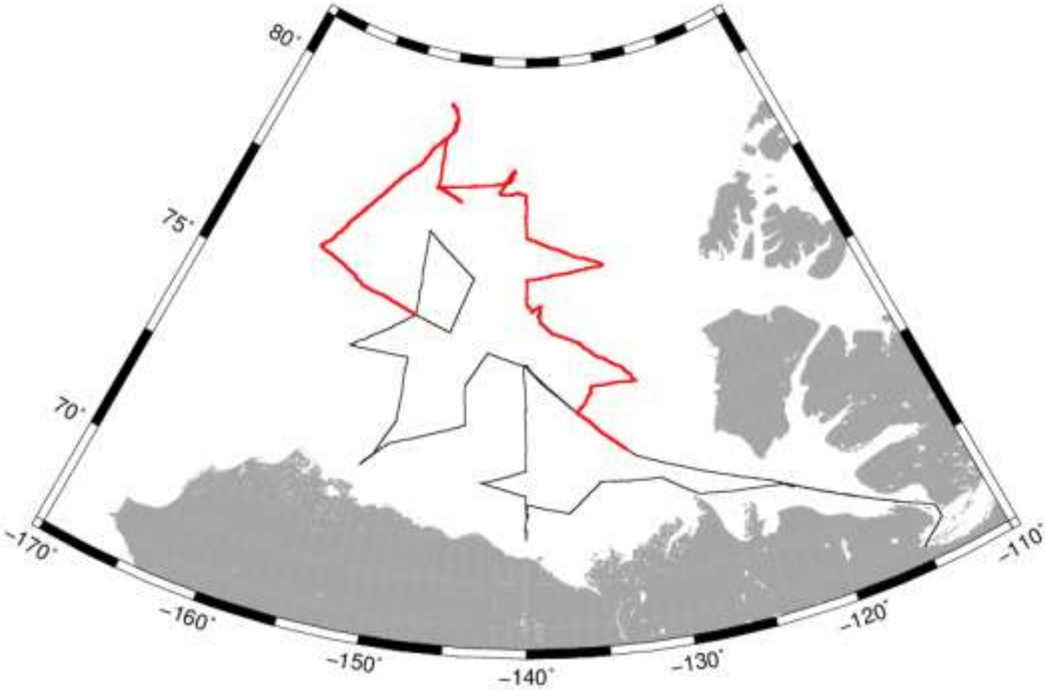


Figure 3 Ship track (Black line) during 19 September - 15 October, 2015 and EM survey track (red line) during 22 September - 4 October, 2015

Table 1. EM observation log.

Profile Number	Start Time(UTC)	Start Position	End Time(UTC)	End Position	Length of profile [km]
1	2015/9/22 15:18:19	71.950485N 132.508385W	2015/9/23 20:56:35	73.497809N 131.016827W	363.04
2	2015/09/23 23:00:40	73.515977N 131.150325W	2015/09/24 19:14:34	75.036639N 138.767115W	300.76
3	2015/9/25 0:43:27	75.412701N 138.640677W	2015/9/26 19:24:05	76.548434N 135.388892W	431.47
4	2015/09/26 20:09:16	76.582309N 135.671512W	2015/09/29 19:26:39	78.01189N 150.004053W	724.61
5	2015/09/30 00:51:35	78.005459N 149.911892W	2015/09/30 20:23:04	78.014529N 150.073656W	166.14
6	2015/10/01 01:51:17	78.008779N 149.97462W	2015/10/02 18:04:21	79.488201N 148.958279W	355.17
7	2015/10/03 02:55:34	79.427169N 148.973364W	2015/10/03 23:28:48	77.519152N 155.79577W	276.54
8	2015/10/03 23:48:10	77.51134N 155.795211W	2015/10/04 16:49:36	76.006248N 160.148674W	235.16
9	2015/10/04 21:10:15	75.986867N 160.085239W	2015/10/05 18:05:39	74.999057N 149.991394W	318.09

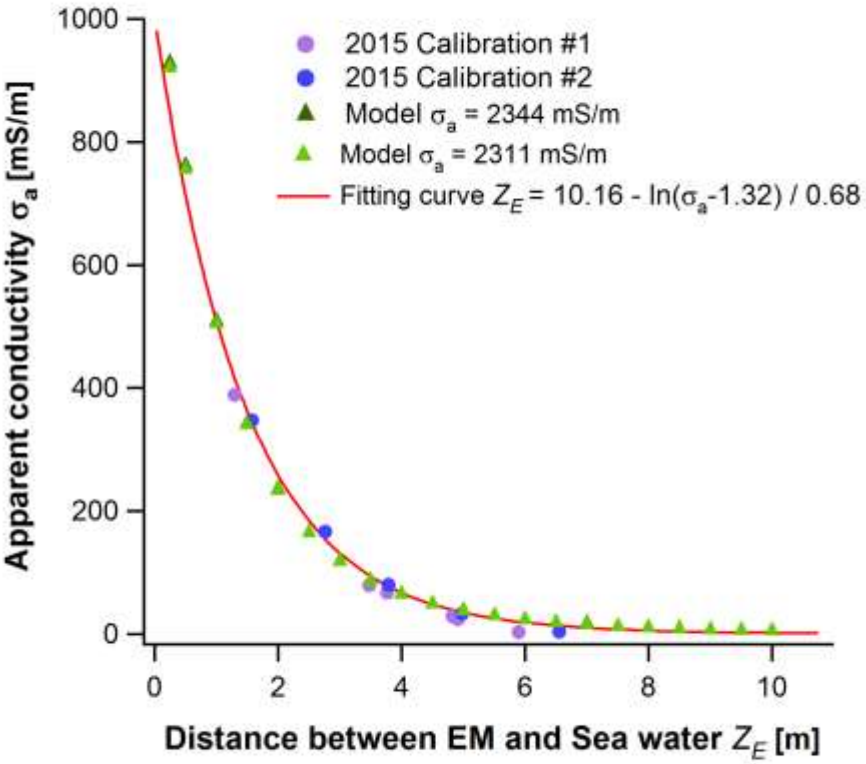


Figure 4 Result of EM calibrations over open water.

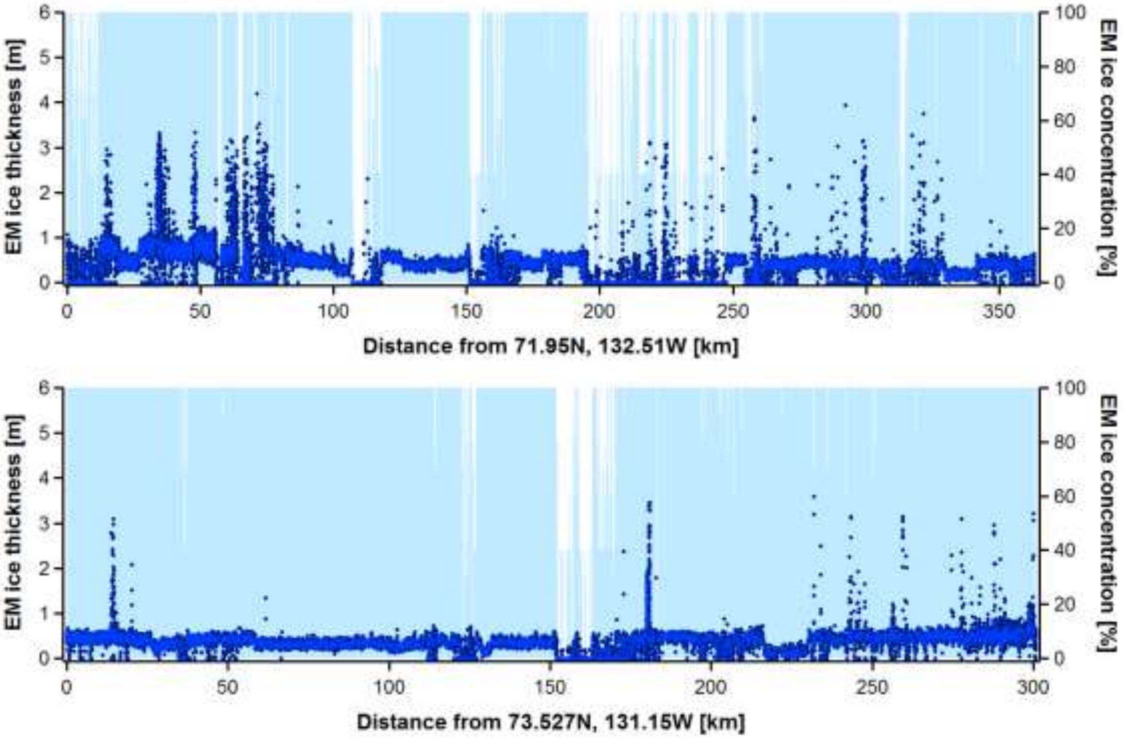


Figure 5a Profiles of EM observations.

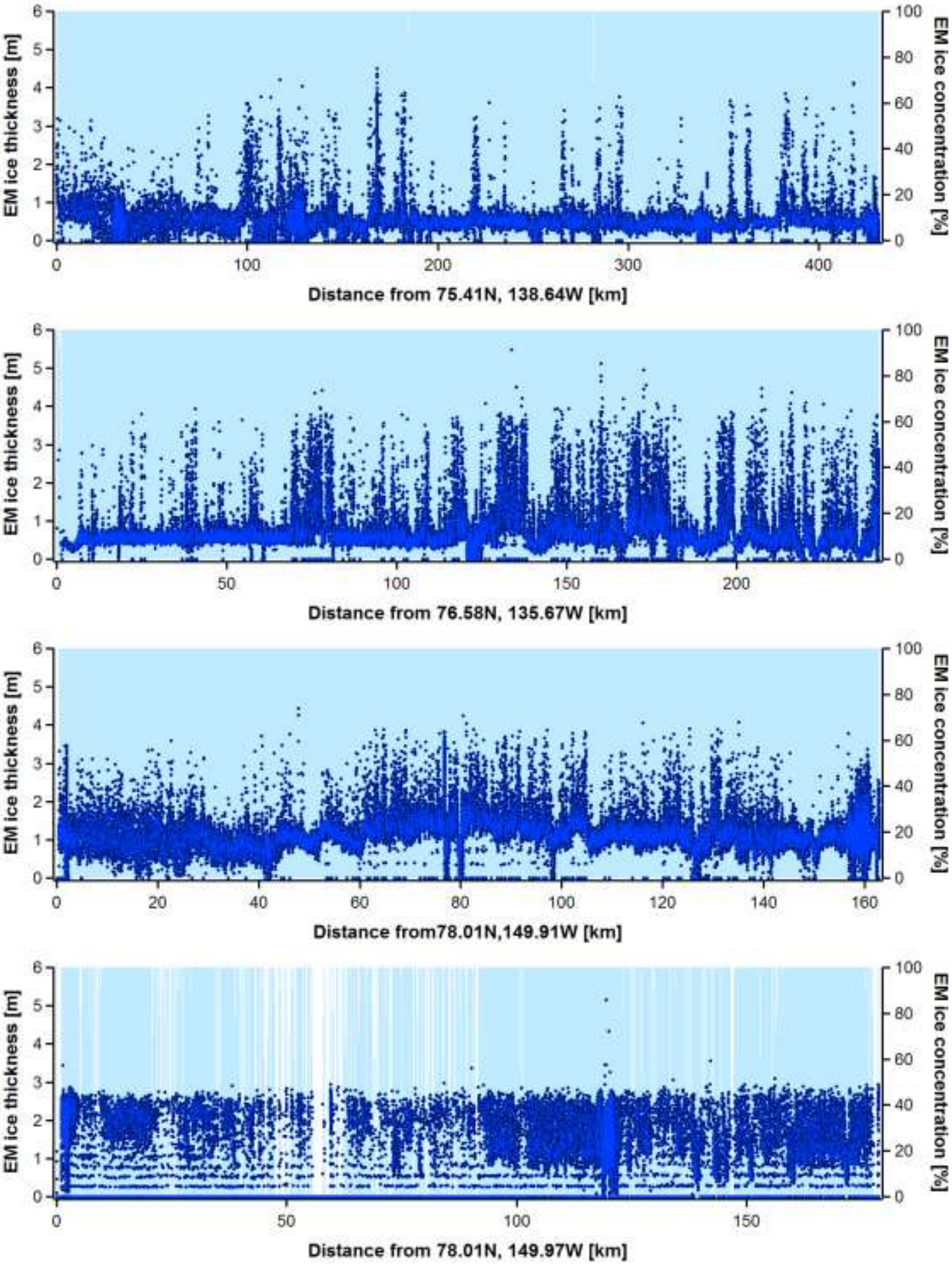


Figure 5b Profiles of EM observations

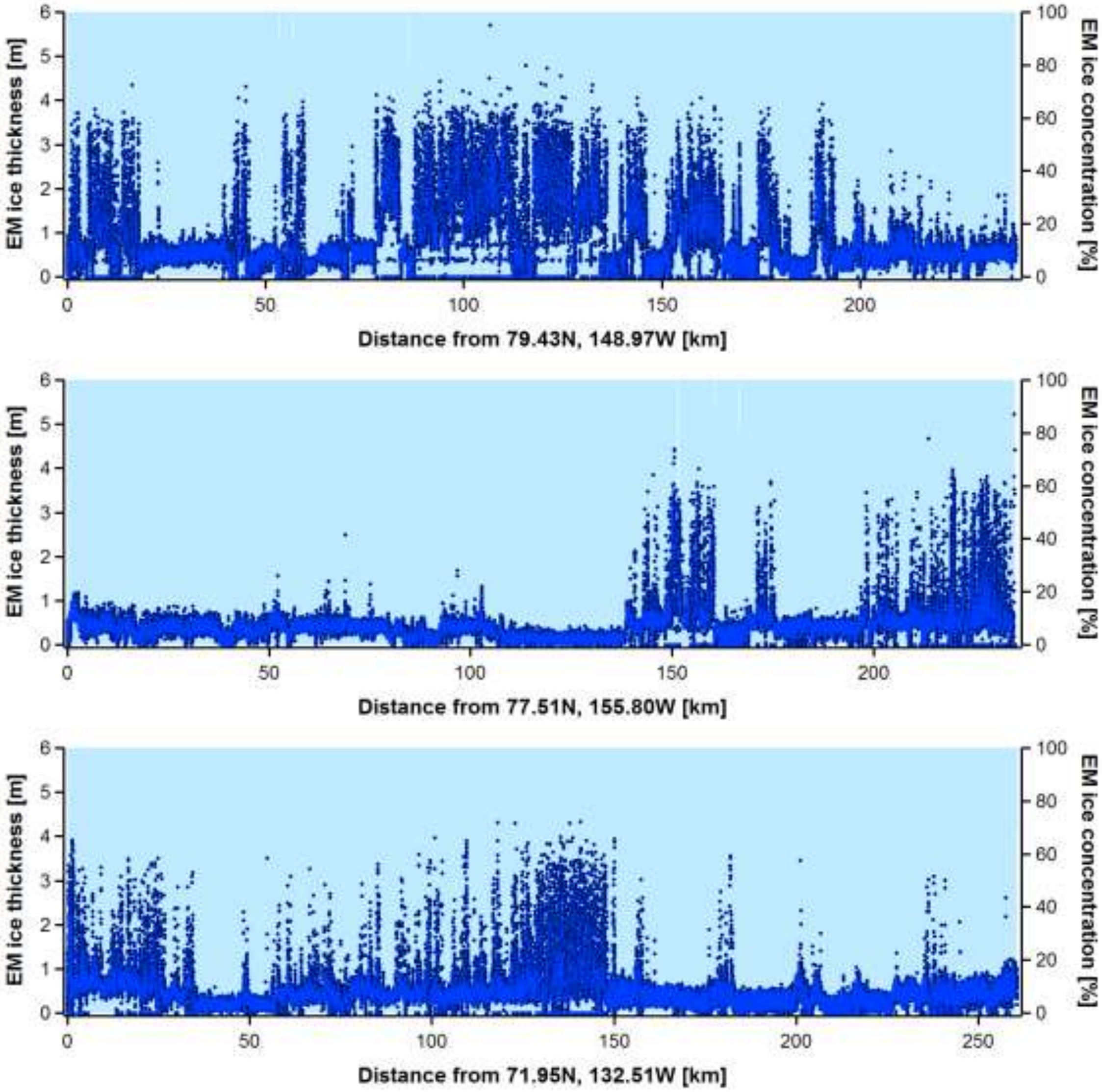


Figure 5c Profiles of EM observations.

2. PMR brightness temperatures observation

PMR were carried out during 24 September and 14 October. 10 profiles of PMR

Table 2. PMR observation log.

Profile Number	Start Time(UTC)	End Time(UTC)	Profile Number	Start Time(UTC)	End Time(UTC)
1	2015/9/24 22:07	2015/9/26 19:29	6	2015/10/3 03:01	2015/10/4 16:51
2	2015/9/26 21:37	2015/9/27 19:16	7	2015/010/4 21:21	2015/10/5 20:34
3	2015/9/27 21:36	2015/9/29 19:44	8	2015/10/6 20:37	2015/10/8 21:34
4	2015/9/30 00:34	2015/9/30 20:30	9	2015/10/9 21:07	2015/10/10 23:13
5	2015/10/1 01:58	2015/10/2 17:58	10	2015/10/11 23:26	2015/10/12 22:37

survey were derived as summarized in table 2. Fig.6 show the examples of brightness temperatures and surface temperature of water and ice.

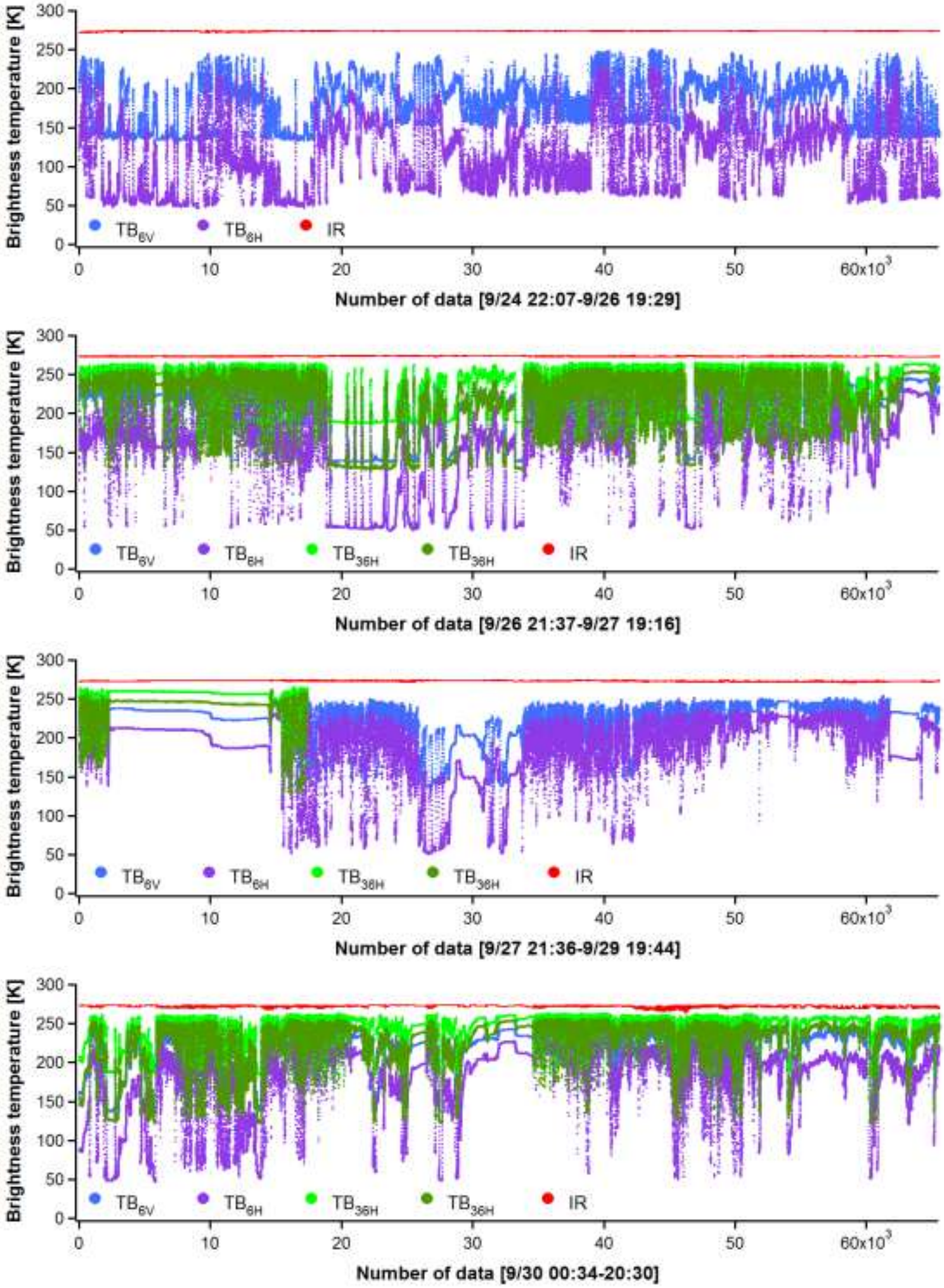


Figure 6 Examples of PMR observations.

2.12 Radiometer and Ceilometer Data

Sigrid Salo (PMEL/NOAA)

PI Dr. Kevin Wood, Dr. James Overland

Summary

Scientists from PMEL/NOAA measured weather parameters with two instruments. We continuously measured cloud layers and boundary level height with a Vaisala CL31 ceilometer, and deployed 35 radiosondes (weather balloons).

Ceilometer data

Ceilometers use LIDAR technology to obtain a time-series of clouds over the ship; 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. The CL31 backscatter profile contains 770 10-m bins.

We are using Vaisala's program BLView to collect and process the data. Blview creates two daily files, each with a line of data every 16 seconds. The first file contains the backscatter data, while the second file lists calculated cloud-base and boundary-level height.

The ceilometer needs to be in a position where its view of the sky is uninterruped, but it also needs to be securely strapped down, and must be within cable-length of the computer that records its data and a source of ship's power. It was mounted on the "Monkey Island" deck, but aft of the area where most antennas are located. Since it was near the stack, its record will be affected by smoke during some wind conditions - but that would be true anywhere on the ship.

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

Radiosondes

We launched weather balloons from the flight deck, since it is the largest open area on the ship and the helicopter hangar is the best place to inflate the balloons. The monitoring equipment was in the Ice office on the bridge level, and the antennas were mounted on "Monkey Island".

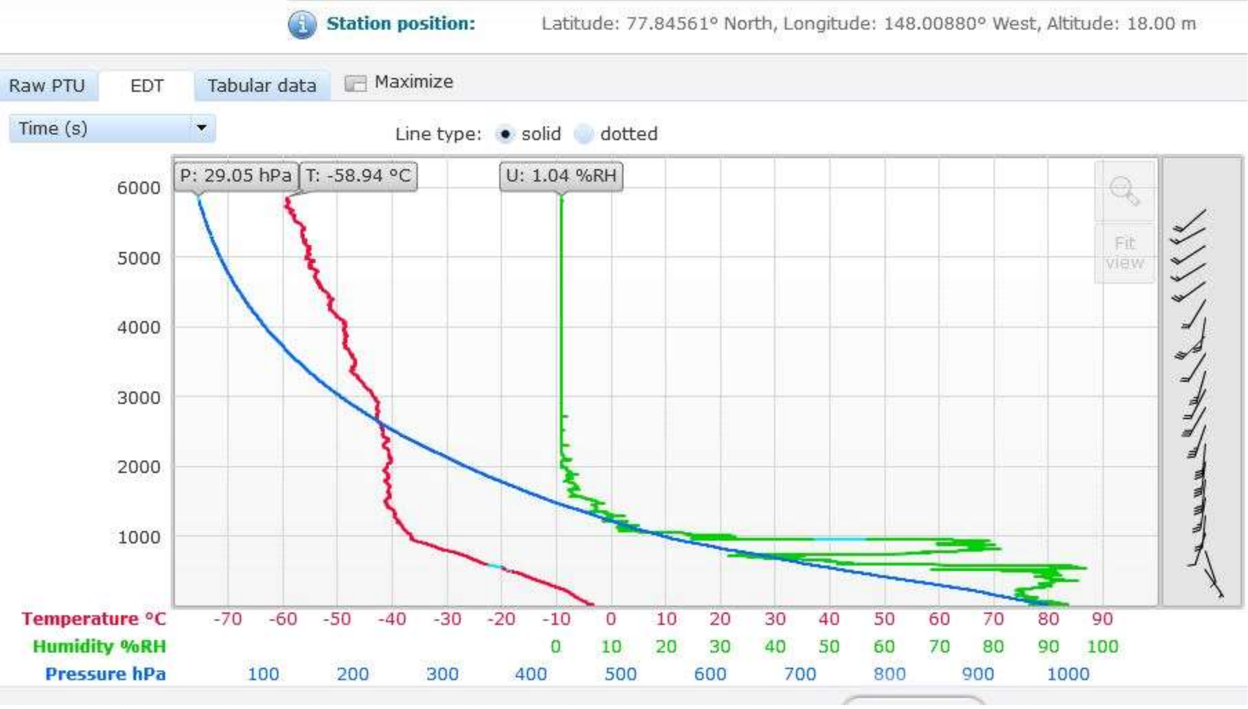
We launched the weather balloons at 0 and 12 GMT, in order to compare them to any shore-based weather balloon launches. The weather balloons used RS92-SGP radiosondes, with Vaisala's MW41 program to track the balloons and process the data. We measured pressure, temperature, relative humidity, and winds calculated from the radiosondes' GPS positions. The balloons reach an altitude near 20 km before they burst. Since they are displaced by the winds, they often move more than 30 km horizontally in that time.

Since the atmosphere varies over shorter time scales than the ocean, we won't be able to characterize the Beaufort Sea's atmosphere in the same way the CTD survey can create transects of oceanographic conditions here. We will be able to see how our atmospheric readings compare with the (few) other balloon launches in northern Alaska and Canada and with weather maps.

The instruments also provide important parameters to calculate heat and momentum transfer between the air, ice and ocean, using atmospheric data along with data from the ice survey and surface ocean temperature data.

Images of weather balloon and ceilometer data

1) The first set of images is for a radiosonde launched at 77.8 north, 148 west on September 30 in 8/10 ice cover; mainly thin (pancake) ice. We had been in intermittent snow flurries near the time of the launch, and winds were from the south near the surface, clocking to westerly above. The balloon shows high relative humidity near the surface, and - after a small gap - high again to near 500mb (~5000m). The ceilometer shows a cloud layer near the surface but only to about 300m at the time of the lauch. Either the density of returns near the surface hid the higher cloud/haze from the ceilometer, or it is possible that the balloon was blown laterally into snow flurries.

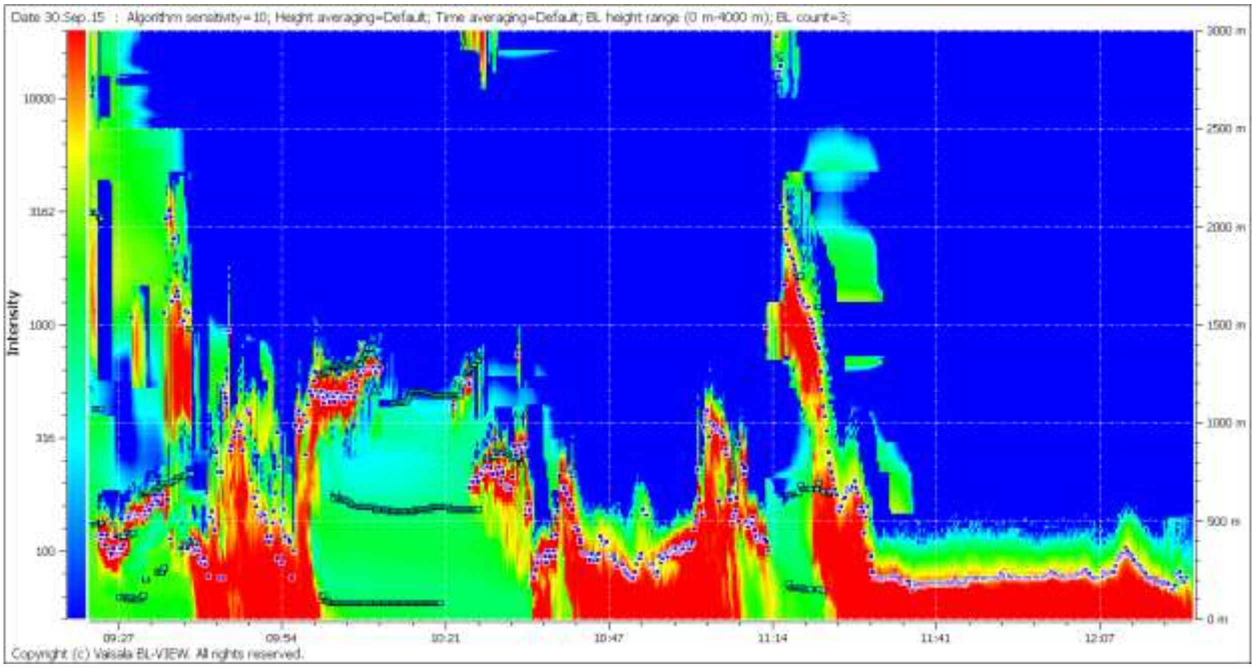


Station position: Latitude: 77.84561° North, Longitude: 148.00880° West, Altitude: 18.00 m

Time (s)

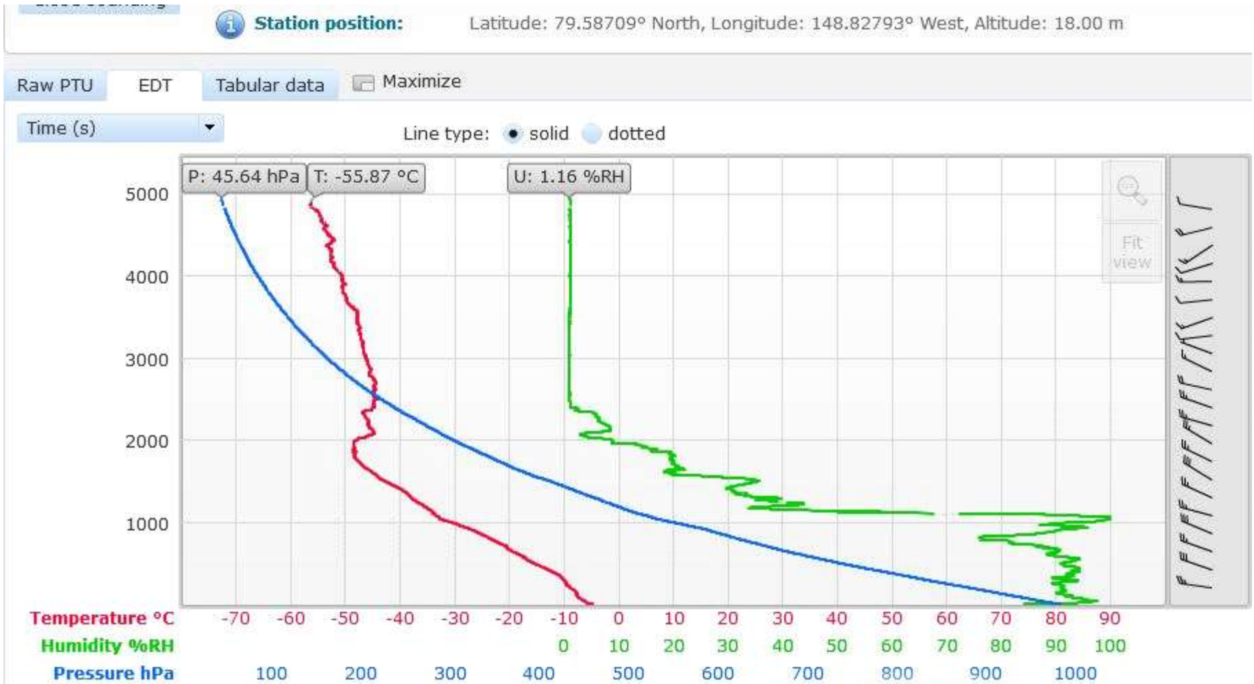
Line type: ● solid ○ dotted

P: 29.05 hPa T: -58.94 °C U: 1.04 %RH

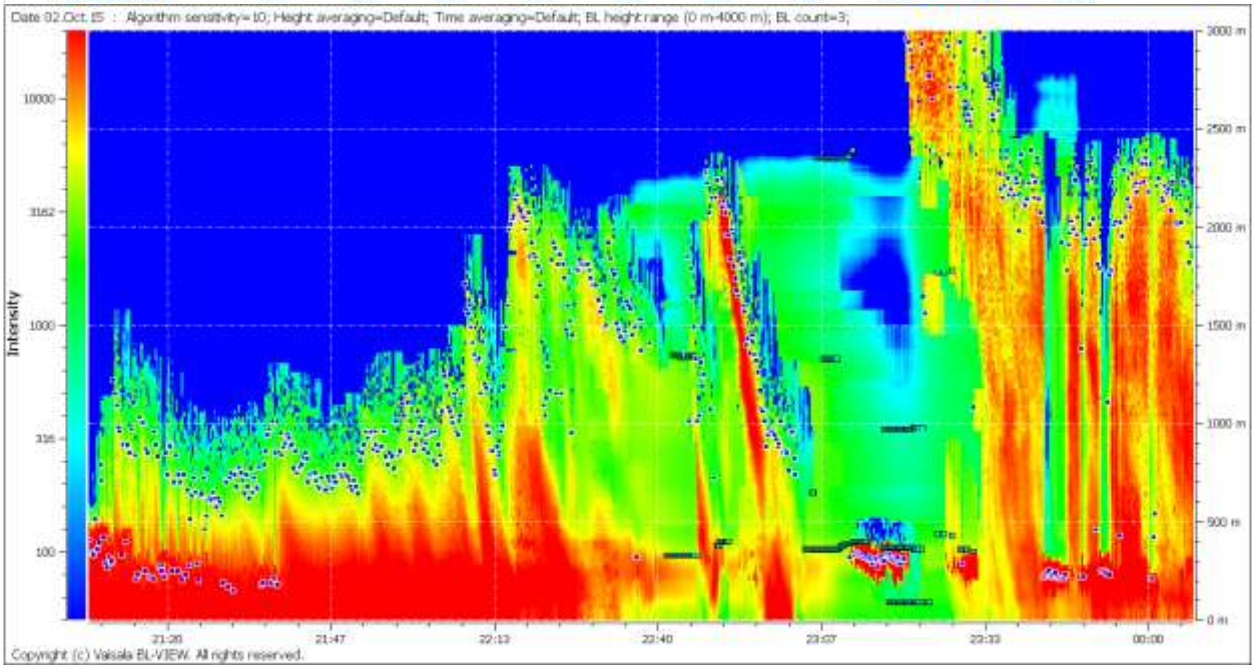


Date 30.Sep.15 : Algorithm sensitivity=10; Height averaging=Default; Time averaging=Default; BL height range (0 m-4000 m); BL count=3;

2) This balloon was launched at 79.5 degrees north at 0Z on October 2. We were in 9-10/10s ice, thick enough that we were having to back and ram at times. Weather was patchy thick fog interspersed with areas where you could see blue sky through thin fog. In this case, the balloon shows winds from the east throughout its trajectory, and high humidity up to 500 mb. The ceilometer also shows high (but variable) returns up to 2500 m.

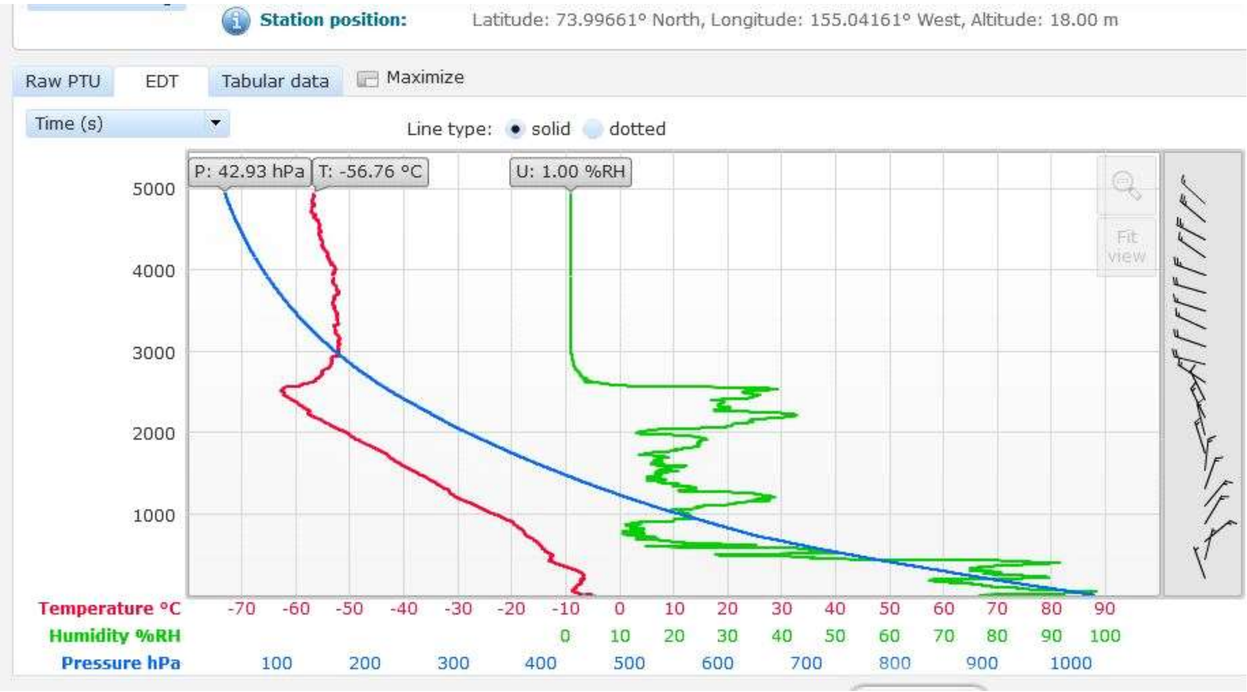


Station position: Latitude: 79.58709° North, Longitude: 148.82793° West, Altitude: 18.00 m



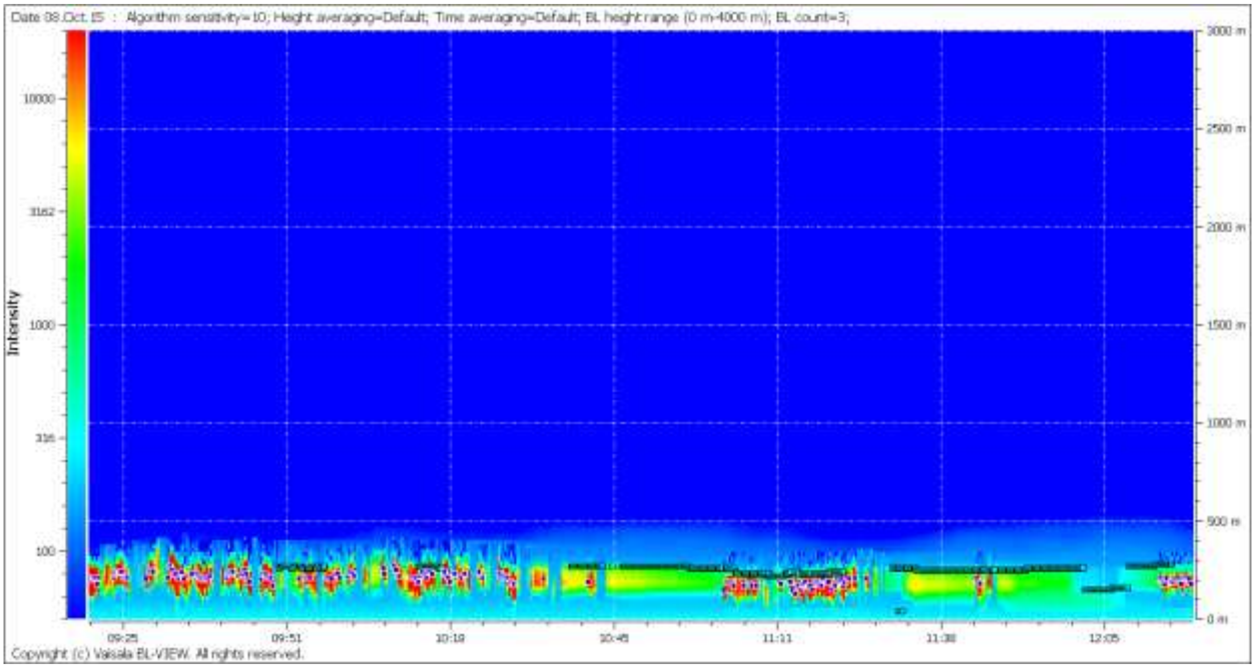
Date 02.Oct.15 : Algorithm sensitivity=10; Height averaging=Default; Time averaging=Default; BL height range (0 m-4000 m); BL count=3;

3) These images are from 74N, 155W at 12Z October 8. We were in maybe 5/10 ice although it was too dark to be sure. The ice I could see was thin enough to have a large patch of salt flowers on it. The sky was clear, we could see the northern lights and the moon. Relative humidity from the balloon was about 70-80% near the surface, but dropped quickly at about 800 mbar although it stayed at 20-30% up to 200 mbar. Surface winds were weak and northerly but made several shifts from 700 to 200 mbar, becoming westerly above that height.



Station position: Latitude: 73.99661° North, Longitude: 155.04161° West, Altitude: 18.00 m

Line type: ● solid ○ dotted



Date 08.Oct.15 : Algorithm sensitivity=10; Height averaging=Default; Time averaging=Default; BL height range (0 m-4000 m); BL count=3;

***

3. APPENDIX

1. SCIENCE PARTICIPANTS 2015-06

Table 3. Onboard Science Team for 2015-06.

Name	Affiliation	Role
Bill Williams	DFO-IOS	Chief Scientist and Program Lead
Sarah Zimmermann	DFO-IOS	Data, data QA/QC, CTD and Chemistry
Kenny Scozzafava	DFO-IOS	Dissolved Oxygen analyst
Marty Davelaar	DFO-IOS	DIC analyst
Sarah Ann Quesnel	DFO-IOS	Nutrients analyst/ Microplastic sampling /Lab supervisor
Hugh Maclean	DFO-IOS	Day watchleader / salinity analyst
Celine Gueguen	Trent U	Day watchstander / CDOM lead
Christopher Charles	U Ottawa	Day watchstander / radioisotope sampling
Michiyo Yamamoto-Kawai	TUMSAT	Day watchstander / alkalinity analyst / RAS P.I.
Mika Hasegawa	TUMSAT	day watchstander / alkalinity analyst / RAS
Mengnan Zhao	Yale U	Dispatches / Day watchstander
Mike Dempsey	DFO-IOS	Night watchleader / CTD technician
Edmand Fok	DFO-IOS	Night watchstander / IT
Sigrid Salo	NOAA	Night watchstander / Weather balloons/ Ceilometer
Jen Reeve	UVic	Night watchstander / ONAr sampling
Deo Florence Onda	U Laval	DNA/RNA sampling
David Walsh	Concordia U	DNA/RNA sampling
Kazu Tateyama	KIT	Ice observation lead + XCTD watch
Shin Toda	KIT	Ice observation + XCTD watch
Jenny Hutchings	OSU	OSU Ice observation lead + XCTD watch
Edward Blanchard-Wrigglesworth	U Washington	OSU Ice observation + XCTD watch
John "Wes" Halfacre	Perdue U	O-Buoy deployments + watch help
Rick Krishfield	WHOI	Moorings & ITPs & buoys / lead
John Kemp	WHOI	Moorings & ITPs & buoys
Jeff O'Brien	WHOI	Moorings & ITPs & buoys
Andy Davies	WHOI	Moorings & ITPs & buoys

Table 4. Principal Investigators Onshore for 2015-06

Name	Affiliation	Program
John Nelson	DFO-IOS/UVIC	Zooplankton net tows
John Smith	DFO-BIO	CTD/Rosette / ^{129}I / ^{137}Cs
Jack Cornett	UOttawa	CTD/Rosette / ^{129}I / ^{137}Cs / ^{236}U
Peter Ross	VAquarium	CTD/Rosette / Microplastics
Christopher Guay	PMST	CTD/Rosette / Barium
Connie Lovejoy	ULaval	CTD/Rosette / Microbial diversity / Bacteria
Rachel Stanley	WHOI/Wellesley College	CTD/Rosette / TOI and O_2/Ar
Roberta Hamme	Uvic	N_2AAr ratio
Andrey Proshutinsky	WHOI	CTD/Rosette / Moorings / ITP Buoys / XCTD
John Toole	WHOI	ITP Buoys
Mary-Louise Timmermans	Yale U.	ITP Buoys / Moorings
Motoyo Itoh	JAMSTEC	CTD/Rosette / XCTD
Koji Shimada	TUMSAT	Moorings
Don Perovich	CRREL	Ice Mass-Balance Buoy
Tim Stanton	NPS	Arctic Ocean Flux Buoy
Patricia Matrai	BLOS	Ozone Buoys
Shigeto Nishimo	JAMSTEC	CTD/Rosette
Jim Overland	NOAA	Radiosondes / Ceilometer
Kevin Wood	NOAA	Radiosondes / Ceilometer

Table 5. Affiliation Abbreviations.

Abbreviation	Definition
BIO	Bedford Institute of Oceanography, DFO, Dartmouth, NS, Canada
BLOS	Bigelow Laboratory for Ocean Sciences, Maine, USA
Concordia U	Concordia University, Montreal, Qc, Canada
CRREL	Cold Regions Research Laboratory, New Hampshire, USA
DFO	Department of Fisheries and Oceans, Canada
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
UOttawa	University of Ottawa, Ottawa, Ontario, Canada
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 6. Project websites

Project	Website Address
Beaufort Gyre Observing System	www.whoi.edu/beaufortgyre
Beaufort Gyre Observing System dispatches	www.whoi.edu/page.do?pid=147117
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	imb.erdc.dren.mil
O-buoy Project	www.o-buoy.org
Arctic Ocean Flux Buoy	www.oc.nps.navy.mil/~stanton/fluxbuoy

2. LOCATION OF SCIENCE STATIONS for JOIS 2015-06

The scientific crew boarded the *CCGS Louis S. St-Laurent* icebreaker in Cambridge Bay, NU, on 19 September, 2015 and returned to Kugluktuk, NU on 17 October, 2015. 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 Sensor Configuration

CTD Accuracy for Seabird SBE911plus CTD systems used during 2015-06

SBE9-0724 (Cast 2 to 70)				
Sensor (s/n)	**Accuracy**	**Lab Calibration**	**Correction to Lab Calibration**	**Comment**
Pressure (90559)		27 May 2009		
Temperature, Primary (SBE3 4397)		14 Nov 2014		Primary pump 5-3610
Temperature, Secondary (SBE3 4402)		14 Nov 2014		Secondary pump 5-3615
Conductivity, Primary (SBE4 2992)		13 Nov 2014		
Conductivity, Secondary (SBE4 2984)		13 Nov 2014		
SBE9-0756 (Cast 1)				
Sensor (s/n)	**Accuracy**	**Lab Calibration**	**Correction to Lab Calibration**	**Comment**
Pressure (91164)		9 Feb 2010		
Temperature, Primary (SBE3 4322)		19-Feb-2015		Primary pump 5-3869

Temperature, Secondary (SBE3 4239)		17-Dec-2014		Secondary pump 5-3871
Conductivity, Primary (SBE4 2809)		17-Dec-2014		
Conductivity, Secondary (SBE4 2810)		17-Dec-2014		
Other Sensors (All casts)				
Salinity calculated, Primary		NA		
Salinity calculated, Secondary		NA		
Oxygen (SBE 43 615)		16 Jan 2015		Plumbed with primary sensors. Casts 2 to 56.
Oxygen (SBE 43 1489)		13-Nov-2014		Plumbed with primary sensors. Casts 1, 57 to 70.
Transmission (Wetlabs CST-1666DR)		18 Jun 2014 (bench calibration)		
Fluorescence (Seapoint SCF 3652 with 30x gain)		Jun 2014		Plumbed with secondary sensors. Casts 1, 20 to70
Fluorescence (Seapoint SCF 2841 with 30x gain)		Fall 2006		Plumbed with secondary sensors. Cast 2 to 19.
Altimeter (Benthos Datasonics PSA-916D 1161)		31 Mar 2005		
Nitrate (Satlantic ISUS v2 #121)		27 May 2015 (bench validation)		Few casts
CDOM (Wetlabs FLCDRTD-1076)		6 Nov 2006		
PAR (Satlantic Cosine PAR LOG sn0517)				All except 7, 9 to 11
SPAR (QSR2200 sn20498)		8 Apr 2015		
SBE32 Water Sampler sn 498				Casts 12 to 70
SBE32 Water Sampler sn 452				Casts 1 to 11
SBE11+ Deck Unit sn 680				
SBE 11+ Deck Unit sn 649				

2.2 CTD/Rosette Station List

Table 7. CTD/Rosette cast

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample Numbers	Comments
1	AG5	2015-09-21 19:52	70.5512	122.9126	661	635	1-10	Rosette problems, DNA/RNA cast
2	AG5	2015-09-21 23:09	70.5409	122.9199	656	622	11-30	Main cast + 2 DNA/RNA bottles (total of 22 bottles)
3	CB1	2015-09-22 12:39	71.7791	131.8763	1154	1117	31-54	Stopped at 70 m and returned to the surface
4	CB31b	2015-09-22 20:17	72.3496	134.0039	2060	2055	55-78	
6	CB50	2015-09-23 11:12	73.4995	134.2517	2866	2873	103-126	
7	CB51	2015-09-23 20:38	73.4994	131.0150	2504	2509	127-150	No PAR
8	CB40	2015-09-24 8:56	74.5009	135.4312	3251	3241	151-174	Sounder not working, down to ALT-10, PAR installed, stop at 3105 m (up) to fix ice chummy, piece of wire came off @ 10:18 (cable at 3111 m)
9	CB18	2015-09-25 2:41	75.2536	139.5037	3663	3000	175-198	Didn't go to CB18, use this location as a replacement
10	CB17	2015-09-25 11:00	75.9995	139.9682	3696	600		Went to 600m with all sensors and tripped bottles without issue but no samples taken
11	CB17	2015-09-25 12:23	76.0029	139.9901	3696	3000	199-222	2nd cast with no auxillary sensors
12	PP6-2	2015-09-26 3:06	76.2678	132.5295	3066	1500	223-247	
13	PP6	2015-09-26 7:36	76.2856	132.6030	3097	3000	248-271	
14	PP7-2	2015-09-26 14:28	76.5420	135.6152	3571	1500	272-295	RNA/DNA/radioisotope cast
15	PP7	2015-09-26 16:39	76.5443	135.4003	3567	3000		Pylon not communicating, no bottles tripped
16	CB15-2	2015-09-27 3:07	76.9866	139.9916	3723	1500	296-319	
17	CB15	2015-09-27 4:56	76.9950	139.9538	3725	3000	320-343	
18	CB16	2015-09-27 14:00	78.0027	139.9884	3749	3000	394-417	Thought last cast ended at sample number 393
19	CB13N	2015-09-28 4:57	78.0137	142.9489	3791	3000	418-441	
20	CB9 (short)	2015-09-30 1:15	78.0083	149.8791	3821	600	442-464	
21	CB12-2	2015-09-30 6:29	77.7453	147.0864	3811	1500	465-488	

22	CB12	2015-09-30 8:13	77.7423	147.0686	3811	3000	489-512	
23	CB9	2015-09-30 15:55	78.0076	150.0065	3821	3000	513-536	
24	CB9-2	2015-10-01 2:15	78.0155	149.9547	3821	1500	537-560	
25	CB11	2015-10-01 10:16	78.9991	149.9880	3814	3000	561-584	Stop at 25m for cups
26	CB11N	2015-10-02 4:37	79.9998	149.9420	3812	3000	585-608	
27	CB11.5	2015-10-03 1:21	79.4639	148.8008	3817	1500	609-632	
28	CB10-2	2015-10-03 13:53	78.3011	153.2033	2443	1500	633-656	
29	CB10	2015-10-03 16:02	78.2715	153.2801	2497	2487	657-680	
30	TU1-2	2015-10-04 10:48	76.0012	160.0097	2061	1000	681-704	Calibration cast, down 1 up 2 down 1 (yo-yo)
31	TU1	2015-10-04 13:07	75.9896	159.9935	1993	1983	705-728	
32	CB5	2015-10-05 10:47	75.2998	153.2943	3787	3000	729-752	
33	CB-4short	2015-10-05 22:21	75.0047	149.9565	3826	600	753-775	TOI and nutrient repeat cast?
34	CB7	2015-10-06 3:31	75.9999	149.9959	3830	3000	776-799	
35	CB8	2015-10-06 11:59	76.9903	149.9822	3826	3000	800-823	
36	CBC	2015-10-06 23:36	75.9998	145.0044	3786	3000	824-847	Stopped at 3000m for a while for acoustic releases; chummy on ~3000m, release done by 00:53, chummy off ~20m.
37	CB6	2015-10-07 8:56	74.6982	146.7038	3782	3000	848-871	Missed bottle 24.
38	CB4	2015-10-07 16:31	75.0000	150.0013	3828	3000	872-895	
39	CB4-2	2015-10-08 1:10	74.9984	149.9885	3827	1000	896-919	Microplastic and DNA/RNA cast. Chummy put on at 776 m, stopped for a while. Chummy taken off at 20 m.
40	CBSW	2015-10-08 11:53	73.9967	155.0419	3851	3000	920-943	
41	CB3	2015-10-08 20:41	73.9995	150.0028	3825	3000	949-967	Chummy on at 3000 m. Acousic release test at max depth. Chummy off at 24 m.
42	CB2	2015-10-09 3:14	72.9978	149.9978	3750	3000	968-991	Depth sensor not woring properly for a while.
43	CB2a	2015-10-09 8:07	72.4975	150.0024	3726	3000		CTD only.
44	BL6	2015-10-09 14:08	71.6588	151.2306	2041	1941	992-1015	

45	BL1a	2015-10-09 17:27	71.3605	152.0631	85	75+5	1016-1023	Cast losest to shore for the BL shelf line.
46	BL2	2015-10-09 19:06	71.3886	151.9216	175	170	1024-1036	
47	BL3	2015-10-09 21:10	71.4663	151.7835	561-575	572		CTD only. T_{max} ~560m but a thick layer between 300 ~ bottom and T_{max} seems to increase. Chl_{max} at 27 m. Altimeter shows bottom-10m to be 572 m, but bottom depth display shows 575 m, and depth increases to 587 m when CTD goes up then decreased to 575 m at surface – on slope so bottom depth increased with time.
48	BL4	2015-10-09 23:21	71.5726	151.4976	1450	1440	1037-1060	Bottom depth display not on. Based on altimeter.
49	BL7	2015-10-10 2:20	71.8200	150.7681	2574	2552		CTD only. Chl_{max} ~ 59 m; T_{max} ~ 405 m.
50	BL8	2015-10-10 5:06	71.9633	150.2320	3004	2998	1061-1084	Chummy on.
51	STNA-2	2015-10-10 14:59	72.6013	144.6953	3414	1500	1085-1108	DNA/RNA cast? yo-yo cast.
52	STN-A	2015-10-10 17:11	72.6001	144.7006	3413	3000	1109-1132	
53	CBS	2015-10-10 23:06	73.5004	144.9989	3641	3000	1133-1156	Chummy on.
54	CB19	2015-10-11 5:06	74.3027	143.3027	3697	3000	1157-1180	Chummy on.
55	CB21	2015-10-11 11:55	74.0016	140.0119	3514	3000	1181-1204	Stopped @ 20 m for cups. Stopped @ 2978 to fix ice chummy on way up; no air pressure, replace hose. After cast 55: inspected pressure port-ice clean & re-fill with mineral oil; inspected, clean & re-grease adaptor and xmiss bulkhead connectors, no obvious signs of water ingression. ice chummy put back on. Resumed cast at 13:18.
56	CB23a-2	2015-10-12 6:28	72.9029	136.0175	2774	2747	1205-1228	Oxygen sensor had problem from 112 m to bottom. Mouse "click" problem on cast 56. SBE43 deltaO sensor bad. Replaced with S/N 2599 for cast 57. ConFile Changed to "…2015-10-12.XMLCON". Ice chummy on. Niskin 10 top seal leaked - no cracks or chips. Re-seated lid - maybe caused by ice?

57	CB22	2015-10-12 11:57	73.4524	138.0214	3135	3000	1229-1252	Mouse problem >>> hit once but triggered twice.
58	CB21-2	2015-10-12 17:54	74.0060	139.9796	3512	1000	1253-1276	Ice chummy on. Changed mouse after cast CB21-2.
59	CB21-short	2015-10-13 1:58	74.0042	140.1663	3523	593	1277-1299	TOI and nutrient repeat cast. ISUS is on CTD. Niskin 13 broken mount. Bottle slid down. Hit hull at 7m? Replaced with new Niskin. ISUS removed for cast 60.
60	CB27	2015-10-13 7:52	72.9998	139.9827	3218	3000	1300-1323	Ice chummy on.
61	CB29	2015-10-13 14:54	72.0014	140.0021	2685	2671	1324-1347	
62	MK6	2015-10-13 18:41	71.5845	139.9969	2489	2475	1348-1371	
63	MKW	2015-10-14 1:22	71.3002	143.2975	2929	2922	1372-1395	
64	CB28b	2015-10-14 8:55	70.9987	140.0245	2080	2067	1396-1419	Forgot to turn pump on until around 750 m, stopped & back to surface to restart. Start time 8:55.down to ALT-10.
65	MK3	2015-10-14 12:14	70.5734	139.9924	803	793	1420-1440	
66	CB28aa	2015-10-14 15:35	69.9987	139.9998	60	52	1441-1447	
67	MK1	2015-10-14 17:03	70.2311	140.0256	238	219	1448-1460	
68	MK2	2015-10-14 18:49	70.4011	140.0032	514	494	1461-1479	
69	MK3'	2015-10-14 20:46	70.6527	140.0019	1316	1300		CTD only, bottom - 8
70	MK4	2015-10-14 22:51	70.8124	139.9895	1558	1600	1480-1502	bottom – 10

2.3 XCTD

Table 8. XCTD cast deployment locations

Filename	Cast #	Cast Start Date and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)
C3_00131	X-80	2015-09-22 17:26	72.1586	133.2619	---	1100
132 Failed						
C3_00133	X-82	2015-09-23 0:39	72.6438	134.9905	2525	1100
C3_00134	X-83	2015-09-23 7:41	73.2040	135.1174	2805	1100
C3_00135	X-84	2015-09-23 16:56	73.5194	132.6086	2720	1100
C3_00136	X-85	2015-09-24 4:55	74.1615	133.7862	---	1100
C3_00137	X-86	2015-09-24 15:39	74.7632	137.7273	3413	1100
C3_00138	X-87	2015-09-25 7:26	75.3831	138.8368	3500	1100
C3_00139	X-88	2015-09-25 18:47	76.0071	138.0737	3623	1100
C3_00140	X-89	2015-09-25 22:04	76.1365	136.2905	3565	1100
C3_00141	X-90	2015-09-26 1:13	76.2003	134.3794	3395	1100
C3_00142	X91	2015-09-26 23:14	76.7722	137.6790	3665	1100
C3_00143	X-92	2015-09-27 10:30	77.5015	140.0135	3733	1100
C3_00144	X-93	2015-09-28 1:50	78.0257	141.4837	3882	1100
C5_00145	X-94	2015-09-28 11:55	78.5176	141.5950	3782	1000
C5_00146	X-95	2015-09-29 6:52	78.2060	143.6220	3798	1000
C5_00147	X-96	2015-09-29 9:15	78.1614	145.4821	3804	1000
C5_00148	X-97	2015-09-29 12:22	78.0777	147.0849	3816	1000
C5_00149	X-98	2015-09-30 4:18	77.8805	148.3162	3816	1000
C5_00150	X-99	2015-10-01 6:33	78.4935	149.8783	2049	1000
C5_00151	X-100	2015-10-01 22:25	79.4964	149.1294	3811	1000
C5_00152	X-101	2015-10-03 9:21	78.7007	151.6832	3826	1000
C5_00153	X-102	2015-10-03 20:36	77.9054	154.6871	1032	1000
C5_00154	X-103	2015-10-03 21:31	77.5172	155.7987	1033	1000
C5_00155	X-104	2015-10-04 1:57	77.1375	156.9917	503	503
C5_00156	X-105	2015-10-04 3:50	76.7563	158.0803	1167	1000
C5_00157	X-106	2015-10-04 6:17	78.3933	158.9197	1890	1000
C5_00158	X-107	2015-10-05 1:07	75.8035	158.1055	589	600
C5_00159	X-108	2015-10-05 4:07	75.6237	156.5797	1154	1000
C5_00160	X-109	2015-10-05 8:14	75.3870	155.0160	3788	1000
C5_00161.	X-110	2015-10-05 15:45	75.1658	151.6777	3784	1000
C5_00162.	X-111	2015-10-06 1:02	75.4682	149.9810	3829	1000
C5_00163	X-112	2015-10-06 8:34	76.4791	149.9736	3828	1000
C5_00164	X-113	2015-10-06 16:43	76.6670	148.3769	---	1000
C5_00165	X-114	2015-10-06 20:09	76.3170	179.2910	---	1000

C5_00166.	X-115	2015-10-07 5:34	75.0000	145.0000	3788	1000
C5_00167	X-116	2015-10-07 13:27	74.8559	148.3803	3810	1000
C5_00168	X-117	2015-10-08 4:56	74.7913	146.6202	3847	1000
C5_00169	X-118	2015-10-08 8:18	74.9987	149.9887	2918	1000
C5_00170	X-119	2015-10-08 17:24	74.0005	152.5240	3843	1000
C5_00171	X-120	2015-10-09 1:03	73.5020	150.0412	1479	1000
C5_00172	X-122	2015-10-10 9:04	72.1178	148.9127	---	1000
C5_00173	X-123	2015-10-10 10:59	72.2844	147.5007	---	1000
C5_00174	X-124	2015-10-10 12:52	72.4397	146.1260	---	1000
C5_00175	X-124	2015-10-10 21:04	73.0373	144.8890	3568	1000
C5_00176	X-125	2015-10-11 3:04	73.9263	144.1168	3694	1000
C5_00177	X-126	2015-10-11 9:16	74.0057	141.6161	3636	1000
C5_00178	X-127	2015-10-12 10:00	73.1664	136.9576	2850	1000
C5_00179	X-128	2015-10-12 15:59	73.7488	139.1022	3385	1000
C5_00180	X-129	2015-10-13 5:08	73.5155	140.1172	3410	1000
C5_00181	X-130	2015-10-13 12:23	72.5266	140.0126	---	1000
C5_00182	X-131	2015-10-14 5:54	73.4207	140.0975	2560	1000
C5_00183	X-132	2015-10-15 4:41	70.6012	136.9560	917	1000
C5_00184	X-133	2015-10-15 10:01	71.2351	134.6382	974	1000

2.4 Underway System

Underway system sensors

Discrete samples were collected from the underway system for CDOM, salinity, chlorophyll and microplastics. CDOM was sampled 4 times per day, salinity once every day and microplastics at selected station.

Parameter	Sensor, last cal date	S/N	Location
Thermosalinograph	SBE-21, 27Dec2013	3297	TSG lab
In-line thermometer	SBE-38, 28Dec2013	0319	Engine room, inline at 4 m from pump at intake
Chl-*a*	Seapoint fluorometer, Aug 2015	SCF-2979	TSG lab
CDOM	WetLabs CDOM, 24Aug2009	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 9. Zooplankton vertical bongo net hauls.

Net #	Associated CTD cast	Date and time of cast (UTC)	Latitude (°N)	Longitude (°W)	Bottom depth (m)	RBR depth (m)	mesh size (µm)	Preservation
1	1	2015-09-21 21:44	70.5500	122.9167	610	96	150	*formalin*
1	1		70.5500	122.9167	610	96	236	*EtOH*
2	1	2015-09-21 22:11	70.5500	122.9167	610	478	150	*formalin*
2	1		70.5500	122.9167	610	478	236	*EtOH*
3	7	2015-09-24 21:28	73.4966	131.0029	2509	100	150	*formalin*
3	7		73.4966	131.0029	2509	100	236	*EtOH*
4	7	2015-09-24 21:53	73.4956	131.0228	2509	501	150	*formalin*
4	7		73.4956	131.0228	2509	501	236	*EtOH*
5	18	2015-09-27 15:43	78.0037	139.9793	3749	516	150	*formalin*
5	18		78.0037	139.9793	3749	516	236	*EtOH*
6	18	2015-09-27 16:29	78.0046	139.9794	3749	103	150	*formalin*
6	18		78.0046	139.9794	3749	103	236	*EtOH*
7	23	2015-09-30 16:23	78.0064	150.0071	3821	505.1	150	*formalin*
7	23		78.0064	150.0071	3821	505.1	236	*EtOH*
8	23	2015-09-30 16:44	78.0064	150.0072	3821	106.7	150	*formalin*
8	23		78.0064	150.0072	3821	106.7	236	*EtOH*
9	25	2015-10-01 11:47	78.9978	149.9324	3850	495.5	150	*formalin*
9	25		78.9978	149.9324	3850	495.5	236	*EtOH*
10	26	2015-10-01 5:36	79.9978	149.8975	3812	491	150	*formalin*
10	26		79.9978	149.8975	3812	491	236	*EtOH*
11	30	2015-10-04 11:19	75.9992	160.0029	2061	509.7	150	*formalin*
11	30		75.9992	160.0029	2061	509.7	236	*EtOH*
12	30	2015-10-04 11:38	75.9983	159.9975	2061	98.7	150	*formalin*
12	30		75.9983	159.9975	2061	98.7	236	*EtOH*
13	*38*	2015-10-07 17:06	74.9950	150.0066	3828	492.7	150	*formalin*
13	*38*		74.9950	150.0066	3828	492.7	236	*EtOH*
14	*38*	2015-10-07 17:28	74.9933	150.0090	3828	99.3	150	*formalin*
14	*38*		74.9933	150.0090	3828	99.3	236	*EtOH*
15	*64*	2015-10-15 9:04	70.9984	140.0295	2070	489.3	150	*formalin*
15	*64*		70.9984	140.0295	2070	489.3	236	*EtOH*
15	*64*	2015-10-15 9:24	70.9985	140.0369	2070	101.6	150	*formalin*
15	*64*		70.9985	140.0369	2070	101.6	236	*EtOH*

2.6 Radiometer and Ceilometer (PMEL, NOAA)

Table 10. Location of radiosonde 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)
1	2015-09-24 0:03	73.6300	131.3580
2	2015-09-24 12:28	74.5350	135.6670
3	2015-09-25 0:06	75.4070	138.6370
4	2015-09-25 12:10	76.0030	139.9810
5	2015-09-25 23:52	76.1840	135.1820
6	2015-09-26 12:10	76.4650	134.1560
7	2015-09-27 0:00	76.8160	138.0520
8	2015-09-27 12:06	77.7280	139.9520
9	2015-09-27 23:58	78.0290	141.4740
10	215-09-28 12:07	78.5200	141.5860
Missing 0 Z and 12 Z on 2015-09-29 due to flight operations			
11	2015-09-29 23:52	78.0050	149.9500
12	2015-09-30 12:12	77.8650	148.1880
13	2015-09-30 23:53	77.9980	149.9780
14	2015-10-01 12:31	78.9980	149.9050
15	2015-10-01 23:57	79.6370	148.8050
16	2015-10-02 12:18	79.5250	149.1430
Missing 0 Z on 2015-10-03 due to flight operations			
17	2015-10-03 12:07	78.4220	152.5110
18	2015-10-04 0:00	77.5120	155.8680
19	2015-10-04 12:29	75.9930	159.9810
20	2015-10-04 23:57	75.8880	158.9140
21	2015-10-05 11:57	75.3000	153.2940
22	2015-10-05 23:55	75.2200	149.9330
23	2015-10-06 12:20	76.9890	149.9780
24	2015-10-07 0:00	75.9980	145.0060
25	2015-10-07 12:11	74.7790	147.5440
26	2015-10-08 0:00	75.0140	149.9140
27	2015-10-08 12:14	73.9950	155.0380
28	2015-10-09 0:01	73.7370	150.0430
29	2015-10-09 12:07	72.0540	150.7240
30	2015-10-10 0:04	71.5760	151.4270
31	2015-10-10 12:00	72.3680	146.7850
32	2015-10-10 23:57	73.5030	145.0070
33	2015-10-11 12:26	74.0020	140.0200
34	2015-10-12 0:03	73.8260	139.4530
35	2015-10-12 12:19	73.4540	138.0320

2.7 Mooring Operations

Table 11. Location of mooring recovery and deployments.

Mooring Name	Bottom Depth (m)	2014 Deployment	2014 Location	2015 Recovery	2015 Deployment	2015 Location
BGOS-A	3830	01-Oct 22:21 UTC	75° 0.1244' N 149° 57.3725' W	05-Oct 18:23 UTC	07-Oct 20:18 UTC	75° 0.670' N 149° 54.178' W
BGOS-B	3833	09-Oct 00:28 UTC	78° 0.6658' N 149° 59.8457' W	29-Sep 19:39 UTC	01-Oct 01:38 UTC	78° 0.063' N 149° 59.838' W
BGOS-D	3530	27-Sep 21:20 UTC	74° 1.6996' N 140° 3.1684' W	11-Oct 18:10 UTC	12-Oct 20:45 UTC	73° 59.988' N 140° 6.461' W
GAM-1	2102	03-Oct 22:39 UTC	76° 0.2440' N 160° 8.7865' W	04-Oct 18:02 UTC		

Table 12. 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	ITP88 / SIMB2/ O-Buoy13	2015-09-28 23:30	78° 34.0' N 141° 22.1' W
2	ITP89 / SIMB / O-Buoy14 / AOFB37	2015-10-02 23:46	79° 27.4' N 148° 49.3' W

Table 13. Ice-Tethered Profiler recovery summary

Recovery	ITP / Buoy	Date (UTC)	Location
1	AOFB30	2015-09-24 19:55	75° 1.8' N 138° 45.3' W
2	O-Buoy10	2015-09-24 18:33	75° 10.59' N 138° 57.24' W
3	ITP70 & ITM3	2015-09-25 0:35	75° 24.75’ N 138° 37.57’ W

2.8 Ice Observations

Table 14. EM31 observations from ship.

Profile Number	Start Time (UTC)	Start Position	End Time (UTC)	End Position	Length of profile [km]
1	2015-09-22 15:18	71.9505 N 132.5084 W	2015-09-23 20:56	73.4978 N 131.0168 W	363.04
2	2015-09-23 23:00	73.5160 N 131.1503 W	2015-09-24 19:14	75.0366 N 138.7671 W	300.76
3	2015-09-25 0:43	75.4127 N 138.6407 W	2015-09-26 19:24	76.5484 N 135.3889 W	431.47
4	2015-09-26 20:09	76.5823 N 135.6715 W	2015-09-29 19:26	78.0119 N 150.0041 W	724.61
5	2015-09-30 0:51	78.0055 N 149.9119 W	2015-09-30 20:23	78.0145 N 150.0737 W	166.14
6	2015-10-01 1:51	78.0088 N 149.9746 W	2015-10-02 18:04	79.4882 N 148.9583 W	355.17
7	2015-10-03 2:55	79.4272 N 148.9734 W	2015-10-03 23:28	77.5192 N 155.7958 W	276.54
8	2015-10-03 23:48	77.5113 N 155.7952 W	2015-10-04 16:49	76.0062 N 160.1487 W	235.16
9	2015-10-04 21:10	75.9869 N 160.0852 W	2015-10-05 18:05	74.9991 N 149.9914 W	318.09

Table 15. PMR Transects

End Time (UTC)	Profile Number	Start Time (UTC)	End Time (UTC)
2015-09-26 19:29	6	2015-10-03 3:01	2015-10-04 16:51
2015-09-27 19:16	7	2015/010/4 21:21	2015-10-05 20:34
2015-09-29 19:44	8	2015-10-06 20:37	2015-10-08 21:34
2015-09-30 20:30	9	2015-10-09 21:07	2015-10-10 23:13
2015-10-02 17:58	10	2015-10-11 23:26	2015-10-12 22:37

Table 16. 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 17. IBO ice core sample summary

T/S profiles = temperature/salinity profiles for Jenny Hutchings (OSU), Microbial Diversity for Connie Lovejoy (ULaval) and Microplastics for Peter Ross (VAquarium).

Date	Site	Core	Parameter	PI	Thickness (exact) (cm)	Snow depth (cm)	Freeboard (cm)
1	1	A	Abandoned	J. Hutchings	---	---	---
	2	B	T/S profiles	J. Hutchings	110	7.5	7
	2	C	Microbial diversity	C. Lovejoy	90	8.5	7
	2	D	Microplastics	P. Ross	91	3.5	7
	2		Barium Isotopes	J. Cornett	?	?	?
	2	E	Microstructure	J. Hutchings	88	8	7
	3	F	T/S profiles	J. Hutchings	135	9	12
	3	G	Microbial diversity	C. Lovejoy	135	13	12
	3	H	Microplastics	P. Ross	135	13	12
	3	I	Microstructure	J. Hutchings	?	?	?
2	1	A	T/S profiles	J. Hutchings	61	6.3	4.3
	1	B	Microbial diversity	C. Lovejoy	51	6	4
	1	C	Microplastics	P. Ross	51	6	4
	1		Barium Isotopes	J. Cornett	?	?	?
	1	D	Microstructure	J. Hutchings	51	6	4
	2	E	T/S profiles	J. Hutchings	55	14.8	1.3
	2	F	Microbial diversity	C. Lovejoy	57	15	1
	2	G	Microplastics	P. Ross	57	15	1
	2	H	Microstructure	J. Hutchings	57	15	1
	2		Barium Isotopes	J. Cornett	?	?	?
	3	I	T/S profiles	J. Hutchings	101	?	7

2.9 Microplastics

Table 18. 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
TU-1	4/10/2015	76.0012	1-3	1000	681-683	30.54	1000 m
	10:48:00	160.0097	4-6	466	684-686	30.54	T_{max}
			7-9	264	687-689	30.54	34.1
			10-12	217	690-692	30.54	33.1
			14, 16	70	694, 696	20.36	chl-a_{max} (SCM), bottle 15 didn't trigger
			20-22	5	700-702	30.54	5 m
CB-4	8/10/2015	74.9984	1-3	1000	896-898	30.54	1000 m
	01:10:00	149.9885	4-6	474	899-901	30.54	T_{max}
			7-9	264	902-904	30.54	34.1
			10-12	209	905-907	30.54	33.1
			14-16	79	909-911	30.54	chl-a_{max} (SCM)
			20-22	5	915-917	30.54	5 m
CB-21	12/10/2015	74.0060	1-3	1000	1253-1255	30.54	1000 m
	17:54:00	139.9796	4-6	445	1256-1258	30.54	T_{max}
			7-9	244	1259-1261	30.54	34.1
			10-12	193	1262-1264	30.54	33.1
			14-16	57	1266-1268	30.54	chl-a_{max} (SCM)
			20-22	5	1272-1274	30.54	5 m

Table 19. 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	2015-09-21	loop 144	start	70.543	122.934	20.09	7.61	153.64
			end	70.584	123.137			

CB-1	2015-09-22	loop 146	start	71.718	131.433	20.02	7.60	152.25
			end	71.759	131.729			
TU-1	2015-10-04	loop 173	start	75.988	160.094	20.03	7.43	148.96
			end	75.980	160.059			
CB-4	2015-10-08	loop 184	start	74.848	150.718	19.66	7.41	150.52
			end	74.800	150.908			
BL-1	2015-10-09	loop 190	start	71.365	152.047	20.23	7.24	148.24
			end	71.374	151.983			
CB-21	2015-10-11	loop 199	start	74.030	140.136	20.02	4.21	84.18
			end	73.975	139.954			
CB-28aa	2015-10-14	loop 207	start	70.008	139.987	20.03	3.56	71.33
			end	70.089	139.979			

Table 20. Microplastic ice core sample summary.

See Table 22 for ice core location within the ice-based observatory.

IBO	Date	Latitude (°N)	Longitude (°W)	Snow depth (cm)	Free board (cm)	Core piece	core section length (cm)	Date melted	Volume sieved (mL)	T°$_{\text{melted sample}}$ (°C)
1	28/09/2015	78.567	141.368	13	12	1	135	29/09/2015	8.5	13.1
2	2/10/2015	79.457	148.822	6	4	1	20	5/10/2015	3	17.1
						2	31		3.02	18.1