Joint Ocean Ice Study (JOIS) 2017
Cruise Report

Photo by Dave Jones

Report on the oceanographic research conducted aboard the *CCGS Louis S. St-Laurent,* September 7 to October 2, 2017 IOS Cruise ID 2017-11

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2017 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 2017, JOIS also includes collaborations with researchers from:

Japan:
- 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.
- University of Montana, Missoula, Montana.

Canada:
- Trent University, Peterborough, Ontario.
- Université Laval, Quebec City, Quebec.
- University of British Columbia, Vancouver, British Columbia.
- Concordia University, Montreal, Quebec
- University of Victoria, Victoria, British Columbia
- Vancouver Aquarium, Vancouver, 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.

2. CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S. St-Laurent* began September 7th and finished October 2nd, 2017. The research was conducted in the Canada Basin from the Beaufort Slope in the south to 81°N by a research team of 28 people of which 6 were students. 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. Surface drifters were deployed to track ocean currents. 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.

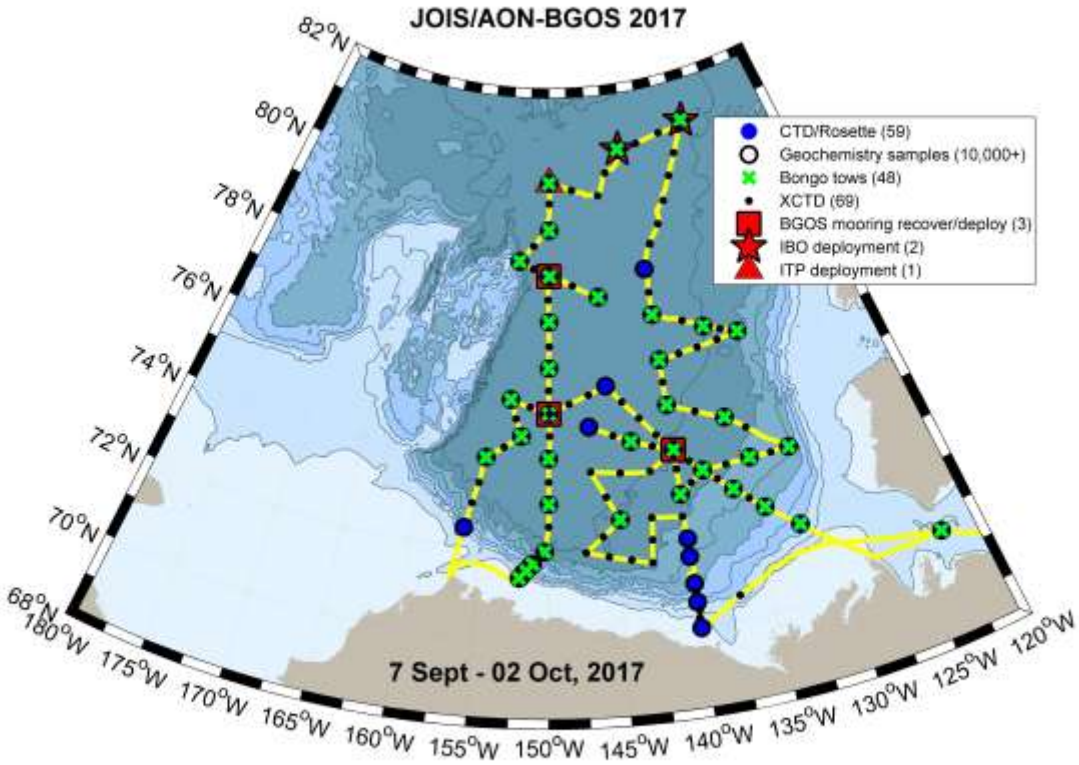

Figure 1.The JOIS-2017 cruise track showing the location of science stations.

2.1 Program Components

Measurements:

- At CTD/Rosette Stations:
  - 59 CTD/Rosette Casts at 50 Stations (DFO) with 1323 Niskin bottle water samples collected for hydrography, geochemistry and pelagic biology (bacteria, microbial diversity and phytoplankton) analysis (DFO, Trent U, TUMSAT, WHOI, U Laval, Concordia, UBC, U Victoria, Vancouver Aquarium). Water samples taken:
    - At all full depth stations: Salinity, dissolved O_2 gas, Nutrients (NO_3, PO_4, SiO_4), Barium, ^{18}O isotope in H_2O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Coloured Dissolved Organic Matter (CDOM), Chlorophyll-a
    - At selected stations: microbial diversity, ammonium, microplastics, N_2O/CH_4, Dissolved Organic Material (DOM), ^{129}I and ^{134}Cs.
  - Mounted on the CTD/Rosette frame was an upward and downward looking ADCP to measure ocean currents and a fiber-optic gyro to determine accurate instrument heading for the ADCPs (WHOI). Additionaly, a Microrider MR6000 was installed to measure turbulence using 2 shear probes, 2 fast thermistors and a conductivity sensor (WHOI).
  - 48 Vertical Net Casts at 37 select CTD/Rosette stations with one cast to 100m and if possible an additional cast to 500m per station. The two nets per cast have a mesh size of 150 µm and 236 µm. (DFO)

- 71 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 Ice-Station with:
    1 Ice-Tethered Profiler (ITP101, WHOI)
    1 Seasonal Ice Mass Balance Buoy (SIMBB, CRREL)
  - 1 Ice-Station with:
    1 Ice-Tethered Profiler (ITP108, WHOI)
    1 Seasonal Ice Mass Balance Buoy (SIMBB, CRREL)
  - 1 Ice Tethered Profilers deployed over the side of the ship in open water (ITP101, 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 looking down on the EM31).

Underway ice thickness measurements electromagnetic inductive sensor (EM31-ICE).
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 the ice-stations including:
-EM31 ice thickness transects
-Drill-hole ice thickness transects
-Ice-cores for temperature, salinity and structure profiles
-Ice-cores for microdiversity and microplastics.
-Snow pit

- Underway collection of meteorological, depth, and navigation data, surface photosynthetically active radiation (PAR), and near-surface seawater measurements of salinity, temperature, chlorophyll-a fluorescence, CDOM fluorescence as well as pCO2 (DFO, UMontana). Water samples were collected at 124 locations from the underway seawater loop for salinity, ^{18}O, nutrients, chlorophyll-a, DIC, Alkalinity (DFO), CDOM (TrentU), microplastics (Vancouver Aquarium) and salinity for satellite ground-truthing (VNA) (TUMSAT).

- Daily dispatches to the web (WHOI)

- Surface Drifters
  12 Spot Messenger Trace surface drifter were deployed in open water in 3 groups of 4 one near Cape Bathurst, one mid-way across the shelf and one at the offshore shelfbreak.

2.2 Comments on Operation

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We steamed anti-clockwise around the Beaufort Gyre this year, first steaming north along our standard eastern stations (around 140W), then pushing 180nm farther north to reach suitable ice for the ice-stations, then heading west and back south along the western stations (around 150W). Our last mooring operations were at BGOS-D and the final CTD/Rosette stations were on the southern end of 140W over the slope of the Canadian Beaufort Shelf. The anti-clockwise route has the advantages of:

- completion of the northern on-ice work (i.e. installing ice-buoys) as early in the cruise as possible to take advantage of the longer days, warmer temperatures and lower wind. The length of daylight decreases rapidly in the Arctic for several weeks on either side of the Autumnal equinox, and, along with it, temperatures drop and storms increase.,
- more time for new ice to form over the southern stations to minimize the work performed in open seas.
- Shelf/slope stations are planned towards the end of the expedition. As a lower priority, their number can be reduced if we become time-limited by weather and operations. .

See the figures below for details of the ice cover during the expedition.

Since the expedition was in September to early October, there were several storms during the expedition (see the ship's AVOS weather station data plotted in Figure 2g) and the effect of the storms can be seen in the data from the southern end of the 150 and 140W sections. A storm over the southern Beaufort occurred as we approached the southern end of the 150W section towards the end of the expedition (see Figure 2f) . We delayed our transit, adding in stations of interest, and were able to complete the line by arriving just as the seas were starting to settle.

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.

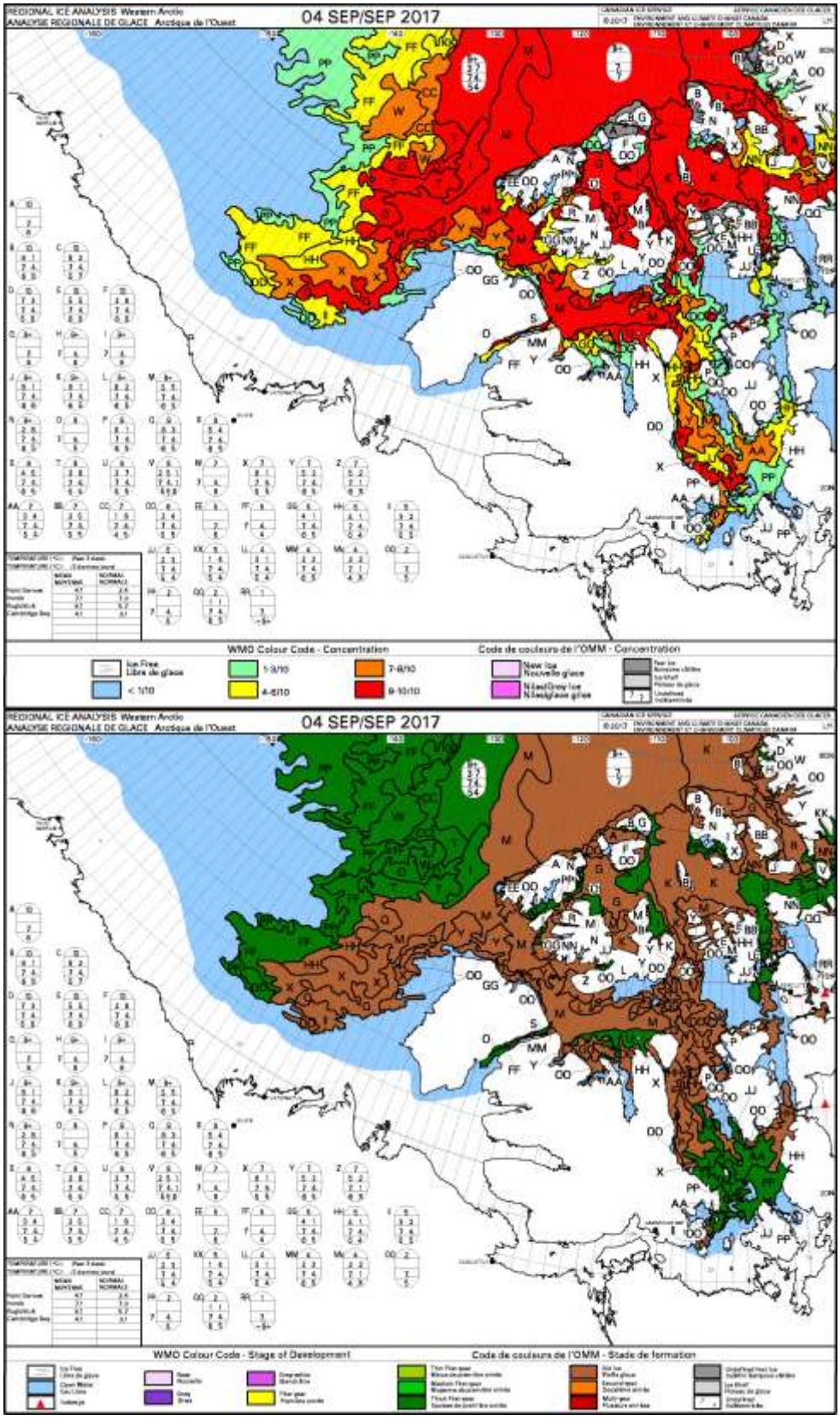


Figure 2a: Canadian Ice Service ice concentration and stage charts from the beginning of the cruise.

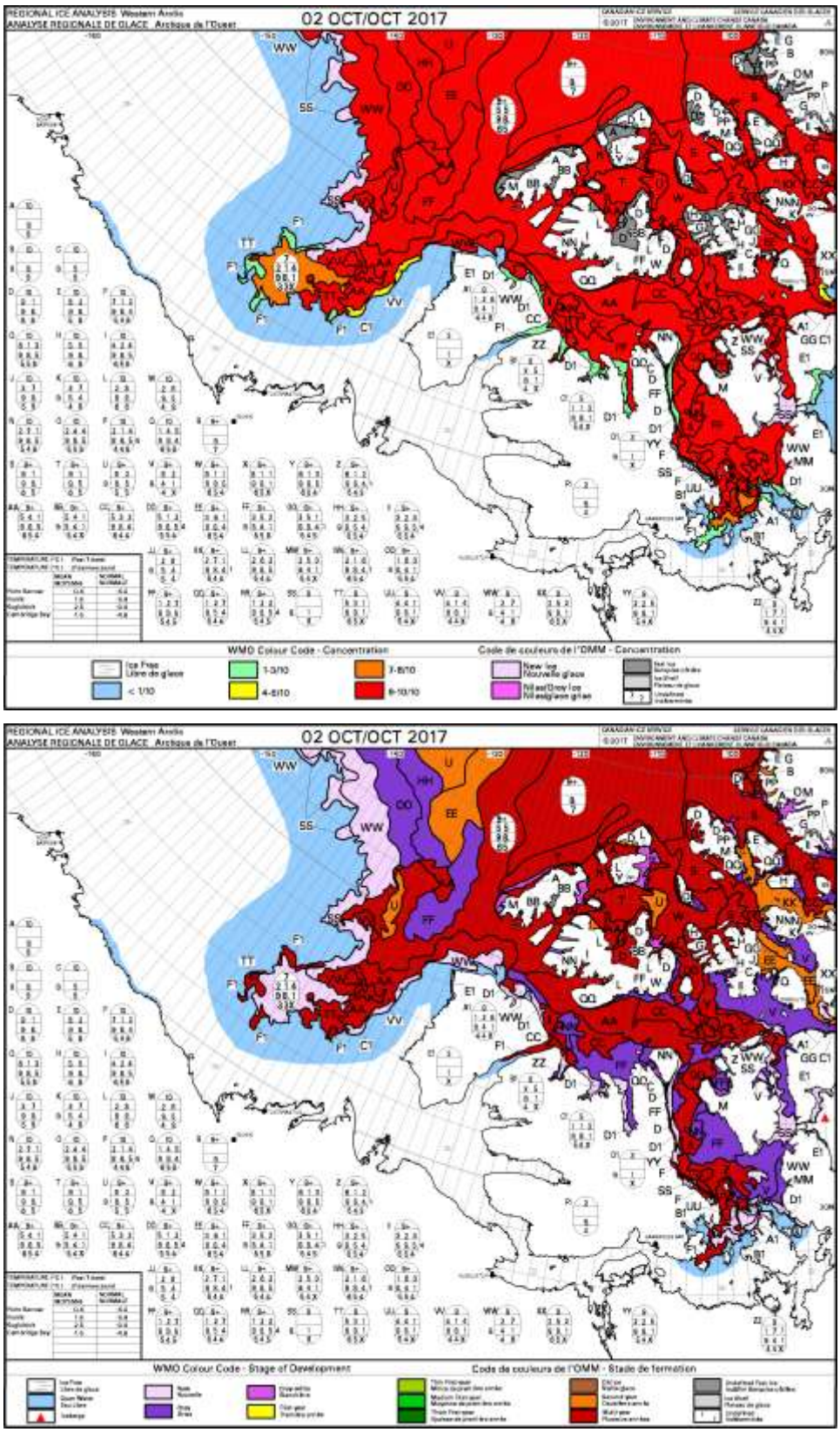


Figure 2b. Canadian Ice Service ice concentration and stage charts for the end of cruise. Note the large areas of new ice. On Oct 1st the ice 'ages' increase by a year.

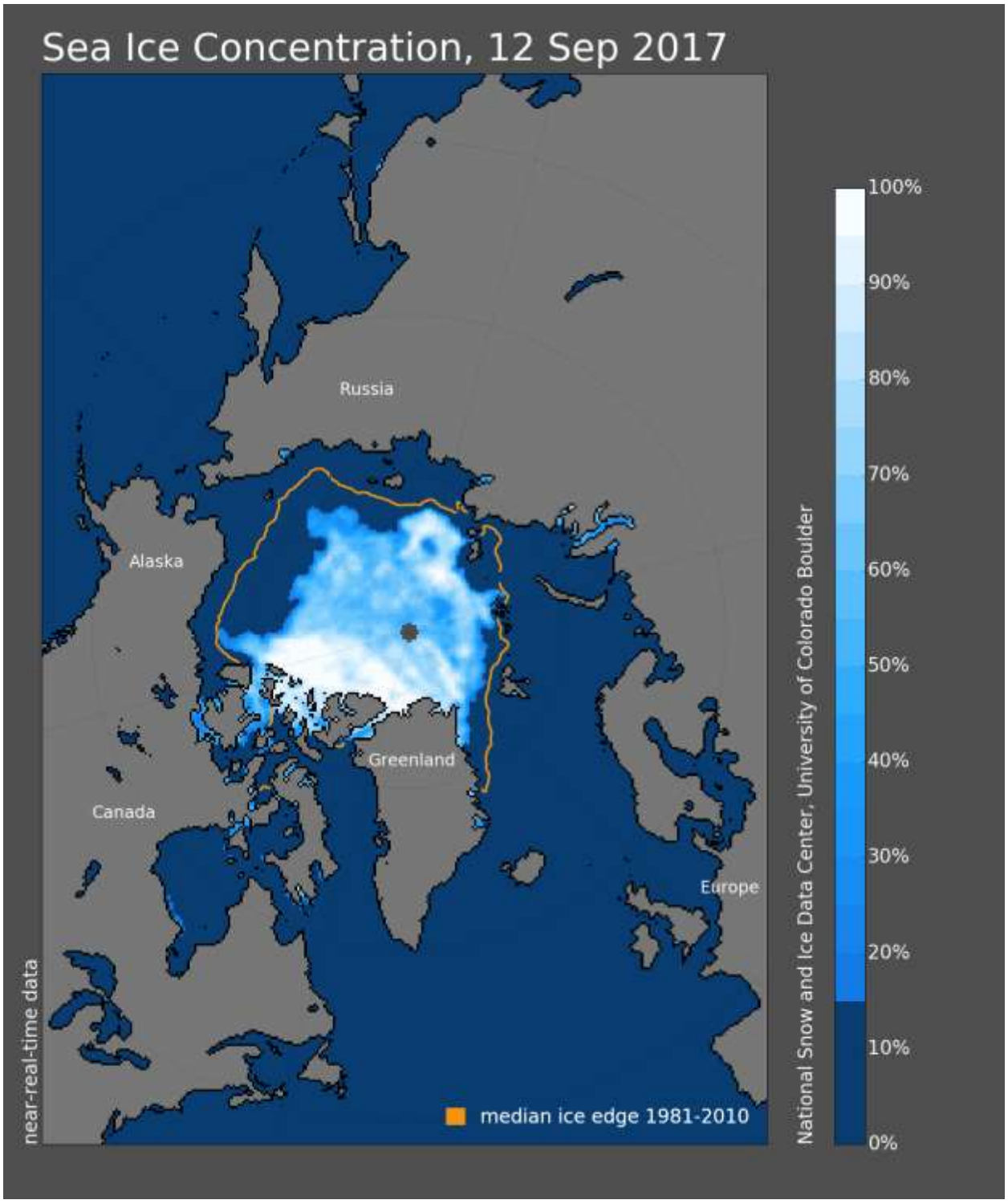


Figure 2c: Ice concentration and extent on 12th September 2018 from the National Snow and Ice Data Center. The median ice edge on this date for 1981 to 2010 is shown for comparison.

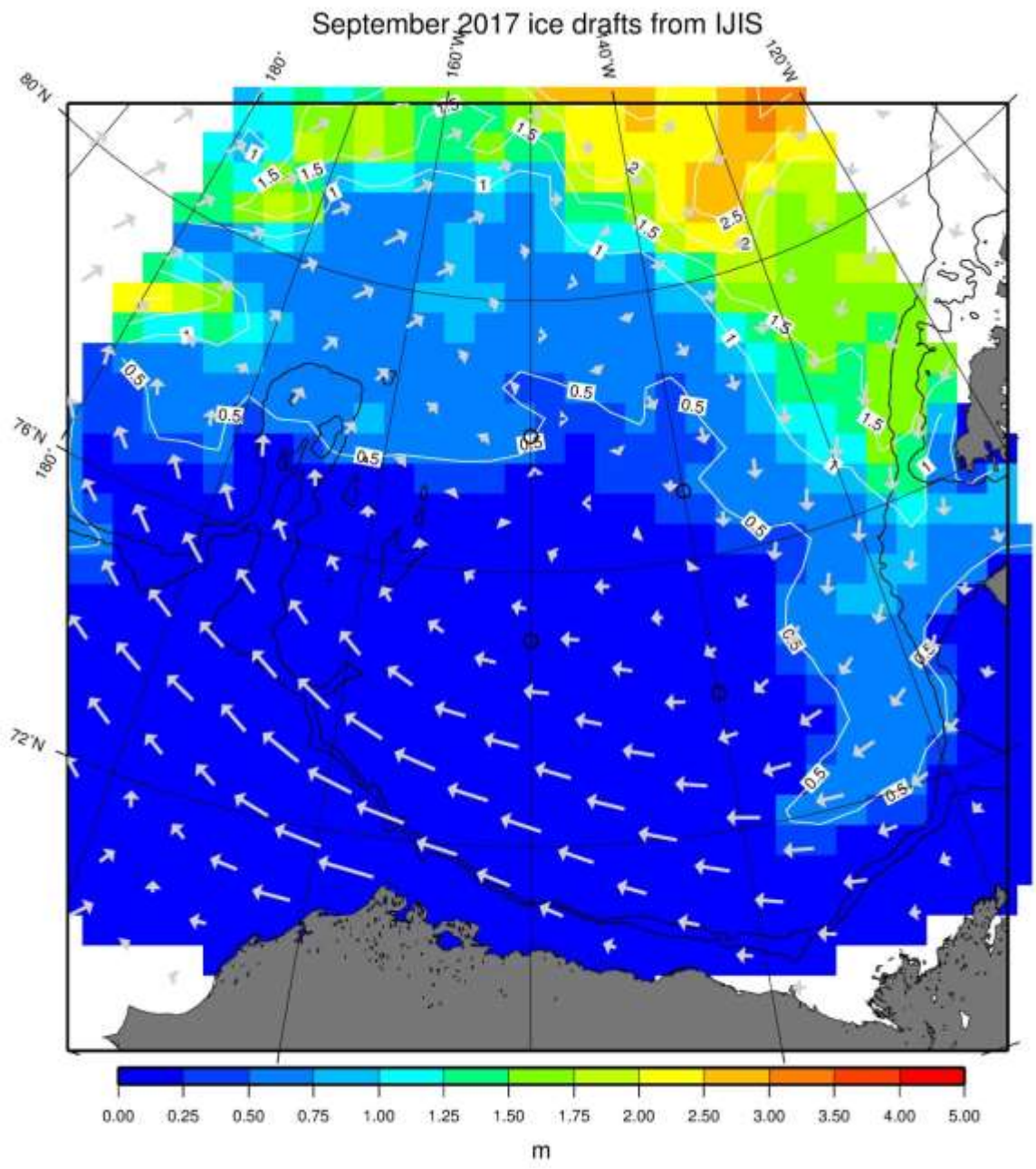


Figure 2d: Sea ice thickness in meters for September 2018 from the IARC-JAXA Information System (IJIS).

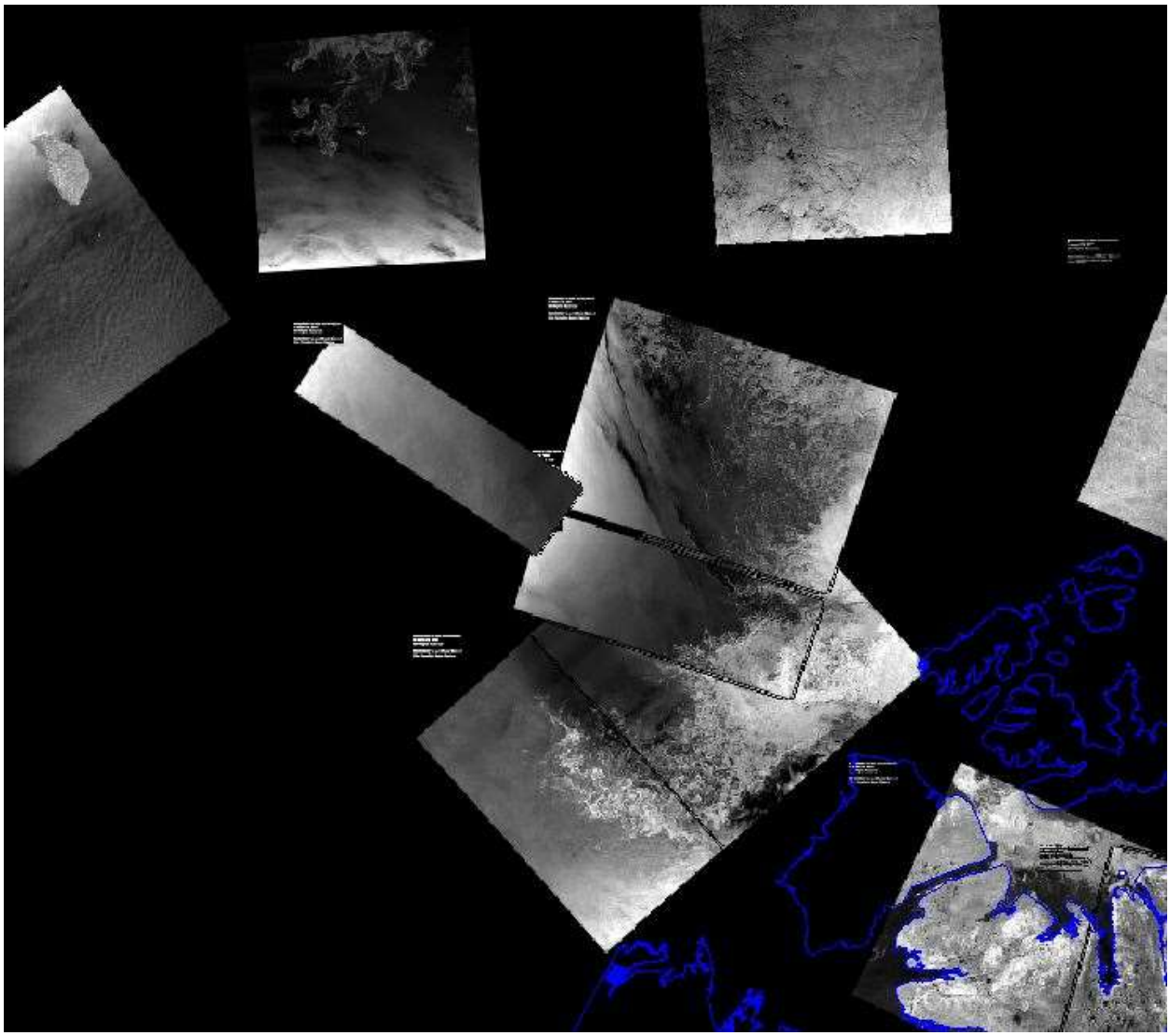


Figure 2e: A mosaic of RADARSAT images provided during the mission to aid with operational decisions.

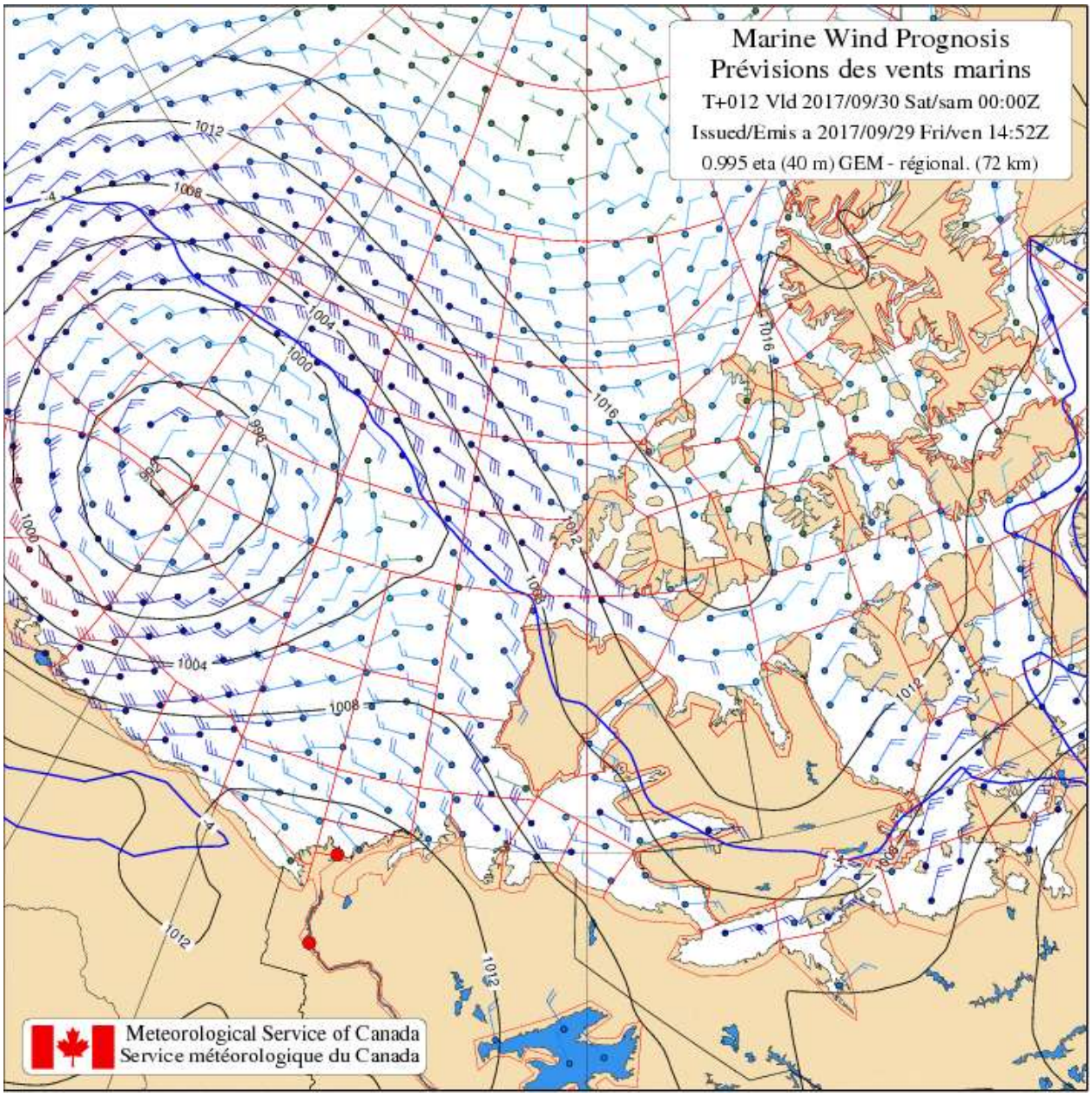


Figure 2f: A marine weather forecast for 30th September 2017 from the Meteorological Service of Canada, showing the storm with 30 to 40kt winds that impacted sampling at the southern end of 140W near the end of the expedition.

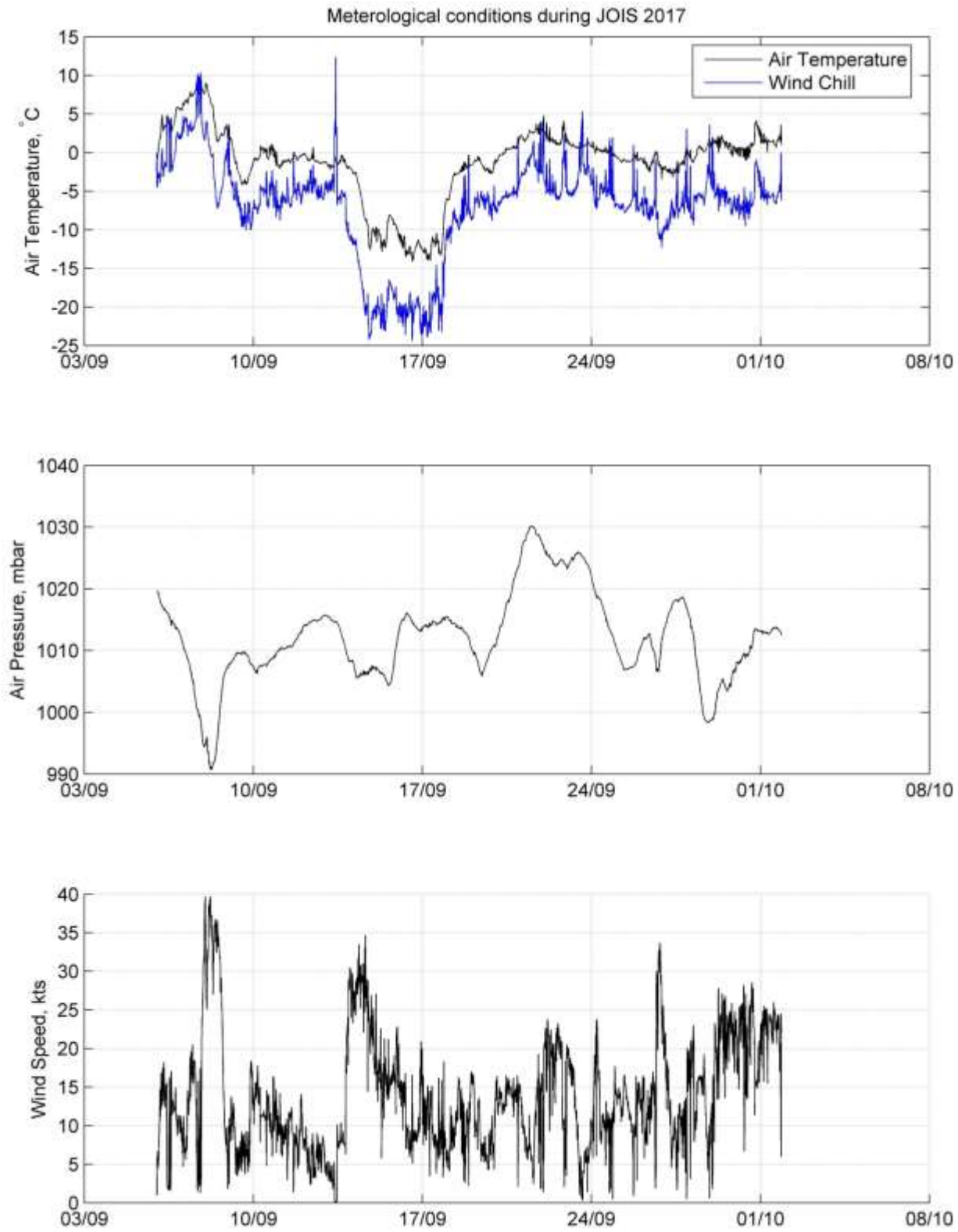


Figure 2g: Temperature, air pressure and wind speed for the duration of the expedition from the AVOS weather station above the bridge of the *CCGS Louis S. St-Laurent*.

Completion of planned activities:

Our primary goals were met during this successful program due to efficient multitasking and above average transit speeds in light ice, which maximized the time available for sampling and spatial coverage. We were also fortunate to have minimal mechanical delays and no medevac or search and rescue this year. We were fortunate to only need to reposition one planned station to allow for the northern trek into solid ice, and additional stations from previous years were added back in, as time became available towards the end of the expedition.

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.

3. ACKNOWLEDGMENTS

The science team would like to thank Captains Jim Chmiel and Wayne Duffett 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. At sea, we were very grateful for everyone's 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. We would also like to thank the deck crew for their assistance. It was a pleasure to work with the helicopter pilot and mechanic 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 15th annual expedition and the exciting and valuable results are a direct result of working with such experienced, well trained and professional crews.

4. PROGRAM COMPONENT DESCRIPTIONS

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

4.1 Rosette/CTD Casts

PI: Bill Williams (DFO-IOS)
Mike Dempsey (DFO-IOS)
Chris Clarke (DFO-IOS)

Overview

A Seabird SBE9 s/n 724 was used for the entire cruise with s/n 756 in reserve as a spare. The CTD was 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. This year, the rosette was modified to accommodate extra instrumentation by adding an extension on the bottom of the frame. The data were collected real-time using the SBE 11+ deck unit and computer running Seasave V7.26.6.26 acquisition software. The CTD was set up with two temperature sensors, two conductivity sensors, dissolved oxygen sensor with pumped flow, a chlorophyll fluorometer with pumped flow, a transmissometer, CDOM fluorometer, cosine PAR and altimeter. New instruments this year added by the Woods Hole Oceanographic Institute (WHOI) were upward and downward facing ADCPs, a gyro (Casts 11 to 59), microrider (Casts 1 to 3 only), and battery pack. A surface reference PAR sensor connected to the CTD deck unit was integrated into the CTD data. 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 data are reported with the underway suite of sensors.

During a typical station there would be a CTD cast to 10 m off the bottom. While in the water, at most stations a 100m zooplankton vertical net hauls would occur from the foredeck. At select stations there would also be a 500m zooplankton cast. On several occasions, repeat CTD casts were carried out to 1000m or less for specialty large volume water sampling (microbial diversity, microplastics and Cs isotope). Casts were also done at some BGOS mooring sites for calibration of the SAMI and WQM instruments installed on the moorings.

During a typical deployment

On deck, the transmissometer and CDOM sensor windows were sprayed with deionised water and wiped with a Kimwipe prior to each deployment. The CTD/Rosette was lowered to 10 m and the pumps turned on. This soak cools the sensors to ambient sea water temperature and removes 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. Routinely, the winch was switched from low to high gear and vice versa anywhere from 500m-300m to make operation smoother. Most Niskin bottles were normally closed during the upcast without a stop. For surface bottles, calibration casts, and some shorter high volume casts, the rosette was "yo-yo'd" to mechanically flush the bottle, meaning it was stopped for 30sec, lowered 1 m, raised 2 m, lowered 1 m and stopped again for 30 seconds before bottle closure. The instrumented sheave (Brook Ocean Technology) provided a read out to the winch operator, CTD operator, main lab and bridge, allowing all to monitor cable out, wire angle, tension and CTD depth. It is to be noted that we encountered an issue with the sheave's readout – the PORT and STARBOARD readings were swapped. This issue was unable to be resolved during the cruise, and was a consideration for those involved in deployment and recovery of the rosette.

It is noted that the WHOI instrumentation, specifically the gyro and microrider, is tied into some of our SBE9 connections. The gyro is tied into our secondary SBE3plus temperature and SBE4c conductivity sensors via y-cables in order to recieve this data. The microrider is tied into CH4 (CDOM) via a y-cable to get power from the SBE9. This did not affect the functionality or performance of any of our sensors.

Performance notes

Winch

Before the cruise the winch was serviced and hydraulic brake system repaired. The winch worked well during the cruise.

Wire (Conducting Cable)

During recovery on Cast 56, the conducting wire was kinked at about 15m due to the rough seas causing a tension snap. This did not affect the performance of the wire. It was decided to use the wire for Cast 57 as it was a short (60m) cast. On our longer steam to AG5 before the last casts 58 and 59 of JOIS, the wire was re-terminated. There were several strands standing proud further up the wire, so approximately 150m of wire was cut off to avoid further damage.

Instrumented Sheave (BOT Block)

Prior to Cast 38, it was noticed that the BOT block roller's nut had come loose, so the man-basket was used to raise a person up to re-tighten the nut. Note that these nuts should be Nylock nuts to avoid this issue.

Throughout the cruise, the BOT block was reading PORT/STARBOARD backwards. This was somehow wired incorrectly during repairs prior to the cruise, but everyone adjusted to the new configuration for the cruise.

Rosette Frame

During Cast 9, part of the rosettes's new frame addition imploded. This was an oversight in design, and holes should have been drilled in the aluminum tubing to allow water to infiltrate the bottom frame. Luckily, no damage was done to the instrumentation or rest of the rosette frame, and it was still structurally sound. Holes were drilled in the bottom ring to avoid this from happening in the future.

WHOI additions Microrider and Gyro

The micro rider was installed from Cast 1 to Cast 3, and then failed. Upon further inspection, the microrider had flooded likely via the top cap seal, and was removed for the rest of the cruise. The repositioned CDOM sensor was left in its new position.

Before Cast 11, WHOI's gyro was mounted on the rosette. It had not been mounted previously due to communication issues. Niskin 6 was replaced at the same time due to a broken mounting bracket.

Niskin Bottles

Due to the added instrumentation on the rosette this year, we had to cock some of the Niskins bottom end caps to the side rather than straight back. This was something to double check each deployment, as there were more ways to catch the Niskin's lanyard than usual.

Prior to Cast 11, Niskin 6 was replaced due to a broken mounting bracket.

Pror to Cast 24 The lanyard on Niskin 11 was shortened, as there had been a few incidents where it got caught on Niskin 12's end cap. This is due to the LADCP being close behind the Niskins, and having to cock the bottom end cap's to the side rather than straight back.

Prior to Cast 38, Niskin 9 was replaced due to a chipped bottle lip, and Niskin 10 had it's o-rings replaced. These had been leaking slightly for a few casts prior.

Prior to Cast 49, Niskin 18 was replaced. There were bottle closure and sealing issues.

Water Sampler

Cast 1, Pylon s/n452: Problems were encountered on the cast with Niskins 2, 9,13, 20, 23, and 24 not closing, and 15 appeared to have closed near the surface based on temperature of the Niskin's water. This was caused by the incorrect installation of a Delran riser under the SBE32 pylon. This caused 13 and 23 to be physically limited, and it is suspected the others did not close due to the new (horizontal) angle created by this riser. The Delran riser was removed before Cast 2.

By Cast 3, there were still issues with Niskin 20 not closing. It appeared that the magnetic solenoid on the SBE32 pylon in position 20 had water intrusion and the epoxy seal had "bubbled", hindering full movement of the trigger mechanism. It was decided to change the pylon from s/n 452 to s/n 498.

Prior to Cast 6 CTD acquisition failed on deck before. After considerable diagnostics, it was determined that the pylon was the issue. It was decided to swap pylons (s/n 498 to s/n 452). In order to avoid further bottle closure issues, the "bubbled" epoxy on solenoid in position 20 was shaved down to be flush with the rest of the solenoid. This seemed to solve the issue of bottle closure. Pylon 498 was opened up, and it was found that the internal electronics had all come loose. This was all re-tightened and Loctite was applied on all screws. This solved the issues we experienced, but it was decided to leave Pylon 452 on the rosette. We would continually check solenoid 20 to make sure the issue did not progress. Also of note – s/n 452 has 3 of 6 head screws sheared off, and s/n 498 has 1 of 6 head screws sheared off. This shouldn't affect performance, but needs to be rectified before next year.

Prior to cast 24, the pylon trigger was removed and washed in hot soapy water due to a misfire on cast 23.

Prior to cast 52, pylon s/n 452 was swapped out and s/n 498 was installed. The trigger mechanism was not switched. This was a preemptive swap, as we were not experiencing issues, but solenoid #20 seemed to have gotten a bit worse over the course of the cruise (epoxy slightly more bubbled). This way we could also test s/n 498 at depth after being fixed earlier in the cruise. Pylon 498 works fine, and was left on the rosette for remainder of cruise.

Casts	Pylon	Trigger mechanism
Cast 1 to 3	452	452
Cast 4 to 5	498	452
Cast 6 to 51	452	452
Cast 52 to 71	498	452

CTD

While setting up the rosette pre-cruise, it was determined that the primary SBE9 (s/n 756) has a bad bulkhead connector. This could not be fixed at the time due to lack of spare parts, so the spare SBE9 (s/n 724) was installed as the primary CTD for the cruise. SBE9 s/n 724 was tested without issue once installed. Spare bulkhead connectors and parts were brought up in case we ran into problems during the cruise. However, as this was the backup CTD, the calibrations on the temperature and conductivity sensors were 2 years old and there were clear differences between the primary and secondary sets of sensors. Before Cast 44 the secondary set of sensors, s/n 4402 and 2984 were swapped with SBE9 s/n756's recently calibrated sensors s/n 4322 and 2809. This configuration was used for the rest of the cruise.

Altimeter

For Cast 1 the altimeter s/n 62670 did not work. Prior to Cast 2 the altimeter was replaced with s/n 1161 and moved to a new location to reduce possible interference from new instrumentation on the frame although there were still jumping values. The altimeter was repositioned lower and worked well however it did continue to pick up a periodic signal from the LADCP. Sensor s/n62670 was sent out for repair after the cruise and found to have a cracked capacitor.

Fluorometer

The fluorometer data was problematic from cast 2 to cast 5. Cables were changed prior to cast 6 but the problems persisted. Prior to Cast 7 sensor s/n 2979 was removed and s/n 3654 was installed along with a "SeaConn" to "Impulse" jumper cable. The data were good from Cast 7 onwards.

Transmissomter and CDOM sensors

Two sensors were moved to new locations on the rosette from their standard place in previous years. Before the first cast, the transmissometer was moved to a location that was further away from the CTD temperature and conductivity sensors, reducing turbulent flow around them. The new location was within 20cm vertically of where it had been and continued to be mounted horizontally.

Prior to Cast 2 the CDOM sensor was moved so it would be father away from the delicate sensors of the Microrider. It was mounted vertically within 20cm of where it had been mounted.

Figure. Brooke Ocean Technology IMS winch display
Figurre. Operation of the Hawbolt oceanographic winch

See appendix for CTD sensor configuration and calibration information.

4.2 LADCP, FOGLogger, Microrider Report

Daniel J. Torres, Marshall Swartz (WHOI)

Figure 1. CTD Rosette with LADCP, FOGLogger, and Microrider (not all visible).

LADCP/FOGLogger System

On JOIS 2017, the CTD rosette was outfitted with a Lowered ADCP (LADCP) system primarily designed to measure currents to determine absolute velocity current profiles. The LADCP system consists of an upward facing Teledyne RDI 300 kHz ADCP, a downward facing 150 kHz ADCP, and an external 48 V rechargeable AGM lead-acid battery pack. Additionally, a fiber-optic gyro instrument was also mounted to the CTD frame in order to determine accurate instrument heading at high latitudes for the ADCP measurements. The gyro system (FOGLogger) consists of a KVH 1775 3-axis

fiber-optic gyro, 3-axis magnetometer, and a 3-axis accelerometer. Additionally, the FOGLogger has an on-board PC104 based Linux computer running Ubuntu 16.05 Server Edition with a 1 TB SSD drive for logging the gyro and ADCP data streams. A data acquisition program was deployed on the PC104 to log the gyro data at 5 kHz rate and the ADCP data coming in at 1 Hz. Each sample was uniquely time stamped with a clock from the PC104 computer, synchronized prior to each cast. The Sea-Bird 9/11+ CTD system was configured with dual temperature and conductivity sensors and a Sea-Bird

oxygen sensor. The CTD was mounted horizontally on an ice-strengthened rosette frame with a 24-position SBE-32 pylon and 24 10L Niskin bottles having internal stainless steel springs. The CTD data were collected in real-time using the SBE 11+ deck unit and computer running SeaSave Ver. 7 acquisition and processing software.

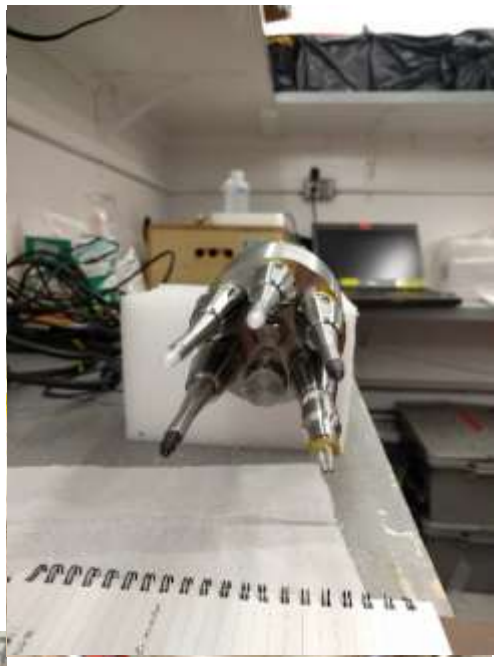


Figure 2. Clockwise from top-left. (a) 150 kHz ADCP; (b) 300 kHz ADCP; (c) FOGLogger top-view; (d) FOGLogger side-view.

Microrider System

The Microrider MR6000 from Rockland Scientific provides turbulence microstructure measurements. The Microrider was configured with 2 shear probes, 2 fast thermistors and a conductivity sensor. Y-cables were used to connect the Microrider to the Seabird SBE9+ CTD for power and to acquire the CTD's secondary temperature and conductivity frequency inputs directly from those sensors.

Figure 3. Rockland Scientific Microrider.

Deployment Procedure

The FOGLogger system has an Ethernet interface to communicate with the PC104, the KVH gyro and the ADCPs. A direct connect Ethernet extension cable ran from the CTD data acquisition shack to the CTD hangar. In the CTD hangar, the Ethernet cable connected to a data transfer pigtail mounted on the rosette and connected to the FOGLogger endcap (blue cable). In the CTD acquisition shack, the Ethernet cable connected to an Ethernet port on a Slimpro Mini-PC running Ubuntu Linux 16.30. SSH was used to communicate with the PC104 Linux operating system on the FOGLogger. Once connected, a series of programs were initiated to start the ADCPs and gyro. Each of those instruments were set up to stream their data to the PC104. Another program was initiated to time stamp each gyro and ADCP record from the PC104 clock. A battery charging cable was run from the CTD hangar to the CTD acquisition shack, where an American Reliance LPS-305 power supply provided power to the FOGLogger on deck. On the CTD rosette side that cable was connected to a pigtail to the FOGLogger endcap. In between casts, that power supply was used to recharge the DSPL battery used to power the ADCPs and FOGLogger system during casts. Once data acquisition programs were confirmed to be running, the, Ethernet and charge cables were disconnected and replaced with dummy plugs just prior to deployment. The LADCP and gyro data were logged continuously during the cast on the PC104 computer. Following CTD rosette recovery, data and power cables were re-connected and the PC104 logging programs were gracefully ended. A program based on the Linux utility rsync was used to transfer data from the FOGLogger PC104 to the data acquisition computer in the CTD shack. The LADCP/FOGLogger collected approximately 10.6 GB data per 1 hour of cast time, with a typical 3500m cast collecting approximately 32 GB data. Data were transferred using Ethernet data rate of approximately 1.5 GB/ Minute. A 35 GB station took approximately 23 minutes to download.

Data Collected

A total of 59 CTD casts were taken on the cruise. LADCP data were collected from all stations. Unfortunately, the Microrider main housing partially flooded on the third station. The instrument was removed from the rosette and rinsed with fresh water and alcohol. All attempts at reviving the instrument were unsuccessful due to board damage, but the memory card was undamaged and recovered. The FOGLogger was not mounted on the rosette for the first 10 stations while undergoing troubleshooting. The problem was resolved and the FOGLogger successfully collected data for stations 11 – 59 without further issues.

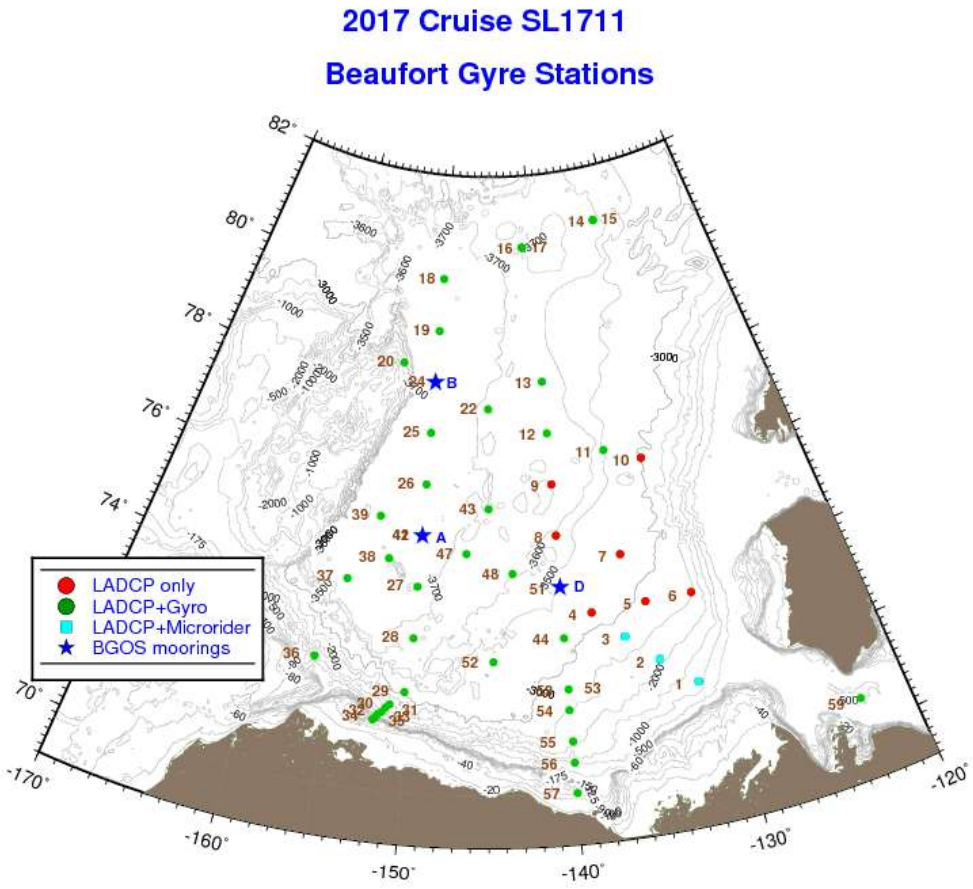


Figure 4. LADCP, FOGLogger, Microrider station map.

To do / suggestions for next year

- Bring timeserver for LADCP.
- Bring spare Microrider

4.3 Chemistry Sampling

The table below shows what properties were sampled and at what stations.
Please see the Rosette Sample Log for the full list of each sample drawn.

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)

N_2O / CH_4	Select	Full depth	Shore lab	Philippe Tortell (UBC)
DIC, alkalinity	All	Full depth on 140W and moorings, else 300m	Onboard	Bill Williams (IOS)
CDOM	All	5-1500	Shore lab	Celine Gueguen (UTrent)
DOM	Select		Shore Lab	Celine Gueguen (UTrent)
Chl-*a*	All	Top 300 with occasional deeper	Shore lab	Bill Williams (IOS)
Bacteria	All	Full depth	Shore lab	Connie Lovejoy (Ulaval)
Nutrients	All	Full depth	Onboard	Bill Williams (IOS)
Ammonium	Stations near shelf		Onboard	Bill Williams (IOS)
Salinity	All	Full depth	Onboard	Bill Williams (IOS)
$\delta^{18}O$	All	Top 300m	Shore lab	Bill Williams (IOS)
Barium	All	Top 300m	Shore lab/may not analyse	Bill Williams (IOS)
DNA/RNA and Microdiversity	Select		Shore lab	Connie Lovejoy (Ulaval)
^{134}Cs, ^{129}I	Select		Shore lab	John Smith (DFO-BIO)
Microplastics	Select		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.

4.3.1 Methane and Nitrous Oxide in the Arctic

Sampled by CTD Watch
PI: Lindsey Fenwick, Cara Manning 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.
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.

4.3.2 Dissolved Organic Matter Sampling

Celine Guéguen (Trent University), Cassie DeFrancesco (Trent University)
P.I.: Celine Guéguen (Trent University)

Summary

Chromophoric Dissolved Organic Matter (CDOM) samples were collected for Celine Guéguen (TrentU), following the protocol given below. A total of 542 samples were collected at 51 stations and 66 from the underway seawater loop system between September 6th and October 1st, 2017 on board the CCGS Louis S. St-Laurent during the Joint Ocean Ice Study (JOIS) 2017 (Figure 1).

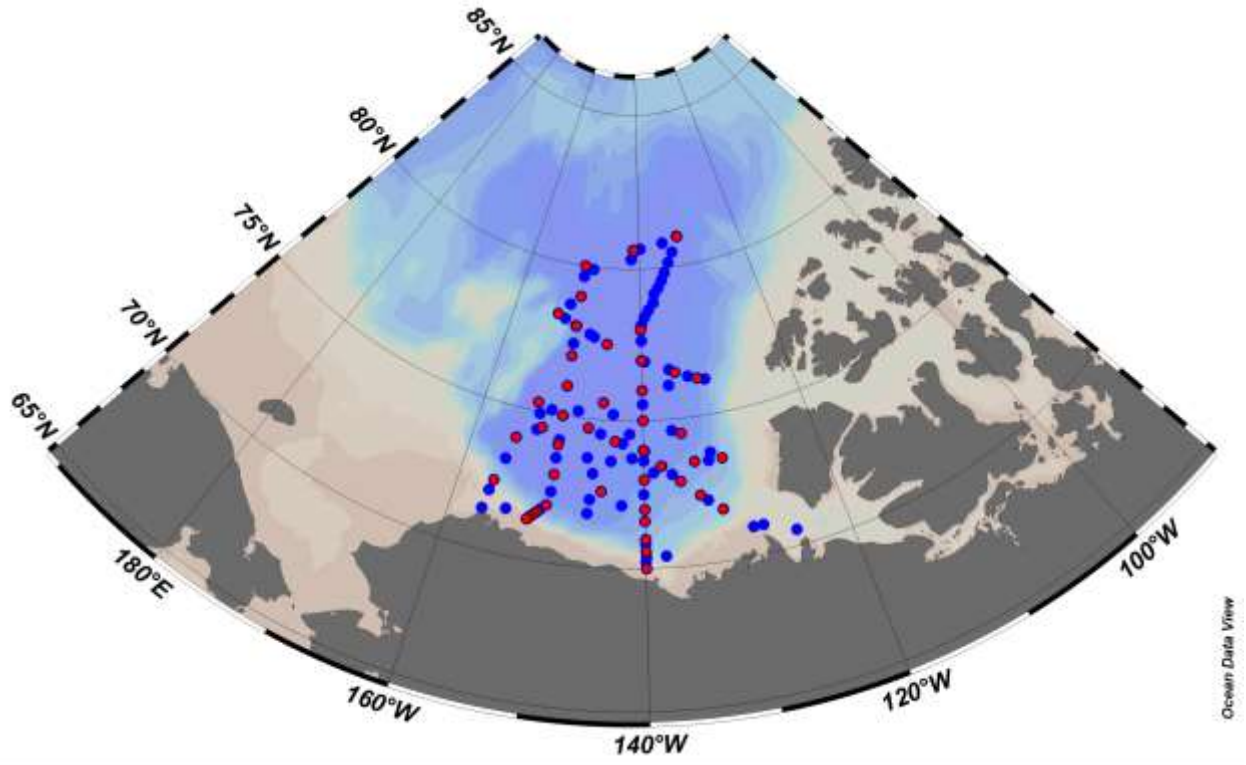


Figure 2. CTD/Rosette (red) and loop (blue) samples location during JOIS 2017-11

Rosette Casts Samples

CDOM Samples >200 m

The bottom spigot of the Niskin was opened to allow stream of seawater to rinse cap and vial 3X three times before collecting the actual sample.

CDOM Samples <200 m

Samples from depths shallower than 200 m were filtered in line through a pre-combusted 0.3 um glass fiber filter, held in a swinnex filter holder after the amber glass vials and caps were rinsed three times with the filtered seawater. Approximately 5 mL of seawater was forced through the filter before rinsing and sample collection.

DOM Samples

Samples from 5 m, Chlmax and 33.1 PSU were filtered in line through a pre-combusted 0.3 um glass fiber filter, held in a swinnex filter holder after the 1 L acid cleaned polypropylene bottles and caps were rinsed three times with the filtered seawater. DOM samples were also collected at 8 depths (5m, 20m, Chlmax, 32.6, 33.1, Tmax, 1000m, Bottom-100) at five 'super sites' (CBN3, CB9, CB4, CB21 and AG5) as part of the FICUS JGI-EMSL funded project 'Towards a molecular-level understanding of terrestrial organic matter transformations by microbes in a rapidly changing Arctic Ocean' (Walsh, Guéguen, Lovejoy). Approximately 20 mL of seawater was forced through the filter before rinsing and sample collection.

The samples were immediately acidified to a pH of 2 with concentrated HCl and stored in a 4°C fridge for a few hours prior to the solid phase extraction using PPL cartridge following Dittmar et al. (2007). Briefly, after loading the sample on the cartridge, the salts were removed using 0.01 M HCl and DOM was eluted with HPLC grade methanol into scintillation vials. The DOM extracts were stored in a -80°C freezer until transport to Trent University.

Underway Samples

Sixty-six CDOM samples were collected from the underway system while the ship was steaming, at a frequency of approximately 2-3X per day. Seawater from the TSG outlet was used to rinse vial and cap 3X before collecting the actual sample. Upon collection of each sample from the underway system, latitude, longitude, UTC time, sample ID etc. were recorded.

Storage

After collection, CDOM samples were immediately transported to the 4°C walk-in fridge where they were stored in the dark until the end of the cruise for analysis

onshore at Trent University. The DOM extracts were stored in the -80°C freezer until the end of the cruise for analysis at Trent University.

4.3.3 Oxygen Isotope Ratio ($\delta^{18}O$)

Sampled by CTD Watch
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 $\delta^{18}O$) slightly. River water is fed from meteoric sources and thus the $\delta^{18}O$ is a valuable tool used in the Arctic Ocean to distinguish between fresh water from river (meteoric) sources and from sea-ice melt.

4.4 XCTD Profiles

Operators: Seita Hoshino (KITAMI) and CTD Watch
PI: Andrey Proshutinsky (WHOI), Motoyo Itoh (JAMSTEC), Bill Williams (DFO-IOS)

Overview
Profiles of temperature and salinity were measured using expendable probes capable of being deployed while the ship was underway. Profiles were collected at 71 locations along the ship's track between the CTD stations.

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)

See Appendix for table of stations.

4.5 Zooplankton Vertical Net Haul.

Gina Nickoloff, Glenn Cooper, Jasmine Wietzke, Chris Clark (DFO-IOS);
PI: John Nelson, Bill Williams (DFO-IOS)

Sampling

Zooplankton sampling and preservation for JOIS 2017-11 were conducted on board by Glenn Cooper and Jasmine Wietzke (day watch, DFO-IOS), and Chris Clarke and Gina Nickoloff (night watch, DFO-IOS). A standard Bongo net system was used with a fitted 150 um net on one side and a fitted 236 um net on the other. 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. Chris Clarke deploys bongo nets during JOIS 2017.

A total of 48 bongo vertical net hauls were completed at 37 stations (see Appendix). The sampling strategy followed 2015 sampling 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. Sampling was to 100m and 500m vertical tows at select stations. Given past sample record and limited time available, 100 metre tows were attempted if possible at all stations, resulting in 37 stations with 100 metre tows. Both

500m and 100m vertical net tows were conducted at 10 stations. No 1000m casts were possible as time was limited, conditions were often rough, and crew preference was to limit bongo line out as a danger of entanglement with the rosette.

Bongos were deployed on the foredeck using a Swann 310 hydraulic winch and 3/16" wire through the forward starboard A-frame. Rinsing of the nets was accomplished by attaching a hose to the salt-water tap on the port side near the outer door near the lounge. Water was left running during the cast to prevent the hose from freezing.

Samples collected from the 236 μm mesh nets were preserved in 95% ethanol, and 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. Hose froze at times but was replaced with an alternate hose.

Issues and solutions

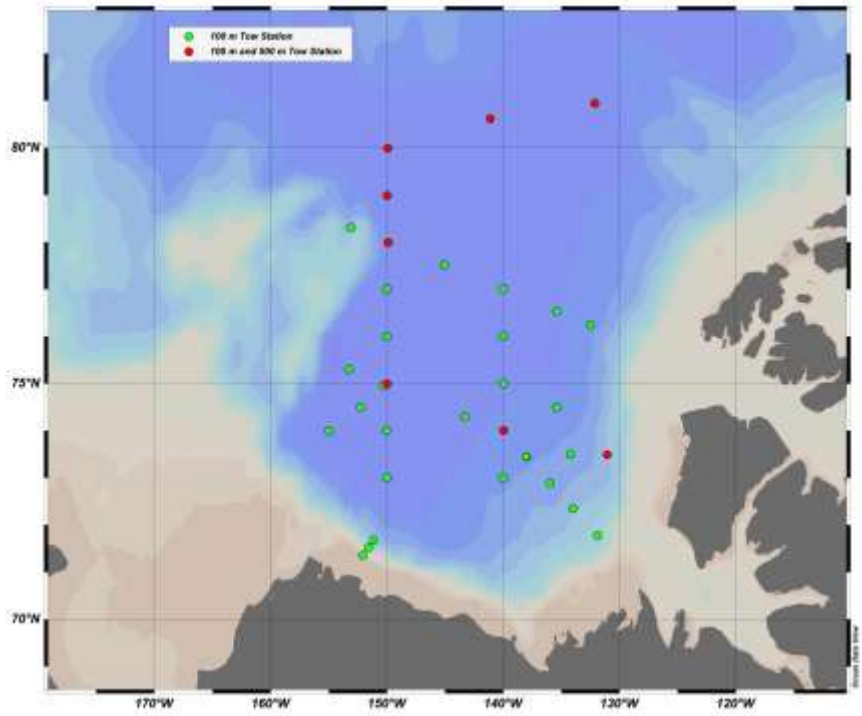
The wooden box used to house the bongo nets should be replaced with an aluminum box, as the wooden one is very heavy (especially once soaked with water) and is falling apart.

One of the two 236 um cod ends was replaced after the BL line as there was a tear in the mesh screen.

Flowmeter #7085 often showed a lag in the 100's hand, causing flowmeter end readings to often be misread as 100 less than the next tow's starting number. To solve this greater care was taken to compare flowmeters during readings and deduce what the proper reading should be.

Packed items such as the 50 um nets and many extra cod ends should be excluded from the packing for JOIS 2018. A total of 4 cod ends maximum were needed. Updating packing lists to solely bring supplies for the updated procedures will minimize room taken up in small spaces on the ship.

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 exceeded 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.



Missing from graphic: 500m tow at BL8, 500 and 100m tows at AG5.

See Appendix for table of samples and stations.

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

Connie Lovejoy (P. I., ULaval) and Arthi Ramachandran (PhD Candidate, Concordia University)
P.I.: Connie Lovejoy (ULaval), David Walsh (Concordia)

Introduction and objectives

Marine microbial communities, which are made up of phytoplankton and heterotrophic protists, referred to as microbial eukaryotes, Bacteria and Archaea are the base of oceanographic food chains and mediate many of the steps in global biogeochemical cycles. The microbial communities of the Arctic Ocean are taxonomically distinct from other oceans (Lovejoy et al 2017), suggesting vulnerability due recent climate related changes. The biological and chemical dynamics of the Canada Basin are influenced by physical oceanography at multiple scales (McLaughlin and Carmack, 2010; Nishino et al., 2011) and oceanographic conditions follow regional differences in summer ice extent and freshwater input into the Arctic. Changes in the Arctic will affect phytoplankton and other microbial communities in a number of ways, for example; altered nutrient supply, lower mixed layer salinities, and increased

variability in surface temperatures (Thoisen et al., 2015, Pedros-Alio et al. 2015). In the Canada Basin smaller phytoplankton species are becoming more prevalent (Li et al., 2009), which has implications on the feeding ecology of calenoid zooplankton by limiting the range and size of prey items available. Smaller average phytoplankton size also has an effect on the net carbon flux in the Arctic Ocean and the carbon cycle generally. 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). Such changes signal the development of a more complex microbial foodweb where unicellular microzooplankton and bacteria become relatively more central in the transfer of energy and carbon to higher food webs compared to classical diatom, copepod based food chains (Sherr et al., 2012). However, despite the ecological importance, apparent abundance and wide distribution of these microorganisms, most aspects of their ecology, diversity and oceanography are poorly understood. As change continues, knowledge of the taxonomic and functional diversity of microbial life will become critical for predicting consequences of a fresher, more stratified Arctic Ocean.

Lovejoy and colleagues have previously characterized the taxonomic composition of arctic microbial communities (Bacteria, Archaea, microbial eukaryotes) using mostly molecular techniques and in the last few years using targeted high throughput sequencing (HTS) approaches (Monier et al., 2015, Comeau et al 2016, Onda et al. 2017). Past JOIS and other Arctic 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, to further broaden our understanding and prevalence of ecological functions, knowledge of microbial metabolic activities and characteristics are needed. For this reason since 2015 Lovejoy and Walsh have combined forces. Walsh has been using metagenomics along with metaproteomics to study the metabolic diversity and activity of marine Bacteria and Archaea (Georges et al., 2014). Thus, for JOIS 2015 and onwards, the two laboratories (Lovejoy and Walsh) have been collecting samples for targeted sequencing, metagenomic and metatranscriptomic approaches to gain insights on Arctic microbial communities. In collaboration, we aim to generate and analyze select 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 (DCM). This physical stratification impacts the vertical structure of microbial communities. Therefore, we will analyze samples from different layers to maximize the microbial diversity represented in our datasets and to facilitate comparative metagenomic studies. For JOIS 2017, we have expanded to a collaborative study between the Lovejoy, Walsh, and Guéguen (Trent University, see the CDOM and DOM report) on the Canada Basin. For 2017, we have sequencing and molecular analytical support from the DOE-JGI and EMSL under the FICUS project "Advancing the molecular-level understanding of terrestrial dissolved organic matter transformations by microbes in a rapidly changing Arctic Ocean", which will form the basis of a new initiative “Canada Basin Organics and Microbes” (CBOmics). CBOmics aims to understand microbial metabolism and the transformation of terrestrial dissolved organic matter (tDOM) in the Arctic Ocean. We will combine multiple meta-omics approaches, used to functionally and taxonomically

identify microbial communities, with molecular-level characterization of dissolved organic matter. The aim is to characterize Arctic microbes, including phytoplankton that produce and degrade marine DOM and compare these with the rare set of microbes capable of metabolizing different components of tDOM in the Arctic. The DOM remaining from tDOM transformation would be susceptible to further degradation by more common marine heterotrophic bacteria. Knowledge of these steps is key to predicting aspects of carbon and energy balances in the Arctic needed for the other JOIS collaborators.

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 and coastal regions, there is little metagenomic representation the open Arctic Ocean. Hence the availability of a metagenomic and metaproteiomic datasets from the various watermasses of the Arctic Ocean will also fill an important void in metagenomic coverage of the global oceans. The Arctic samples enable construction of a nonredundant protein sequence database 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.

Methodology

Water column samples were collected at 29 stations (Figure 1) to cover a range of previously visited stations (in 2012-2016) and some new stations to fill gaps. In addition an effort was made to extend into to deeper waters including: 100m from the bottom, Arctic Deep Water, Atlantic Water, the core of the Pacific Winter Water (salinity of 33.1). Samples were routinely collected at 6 depths per station to include the understudied deep waters, the DCM and surface waters. At five designated stations, CBN3, CB9, CB4, CB21, and AG5 eight depths were sampled to include intermediate depths (waters with a salinity of 32.3 and 20 m for DNA/RNA. We also sampled for proteins at these sites for the CBOmics collaborative study between the Lovejoy, Walsh, and Guéguen. Samples for population cell sorting preserved in DMSO (LiveFCM), microscopy samples (DAPI, FISH) and alternative FCM samples (chlFISH) preserved in glutaraldehyde and pigment samples (HPLC) were collected at these sites and some of the other sites. One sample from 2 ice cores (bottom 30 cm) were also collected near CBN3 for DNA/RNA (Table 1)

All sampled depths were selected based on water column characteristics profiled by the downcast of the CTD of the rosette. Nucleic acid (DNA/RNA) was taken for all casts.

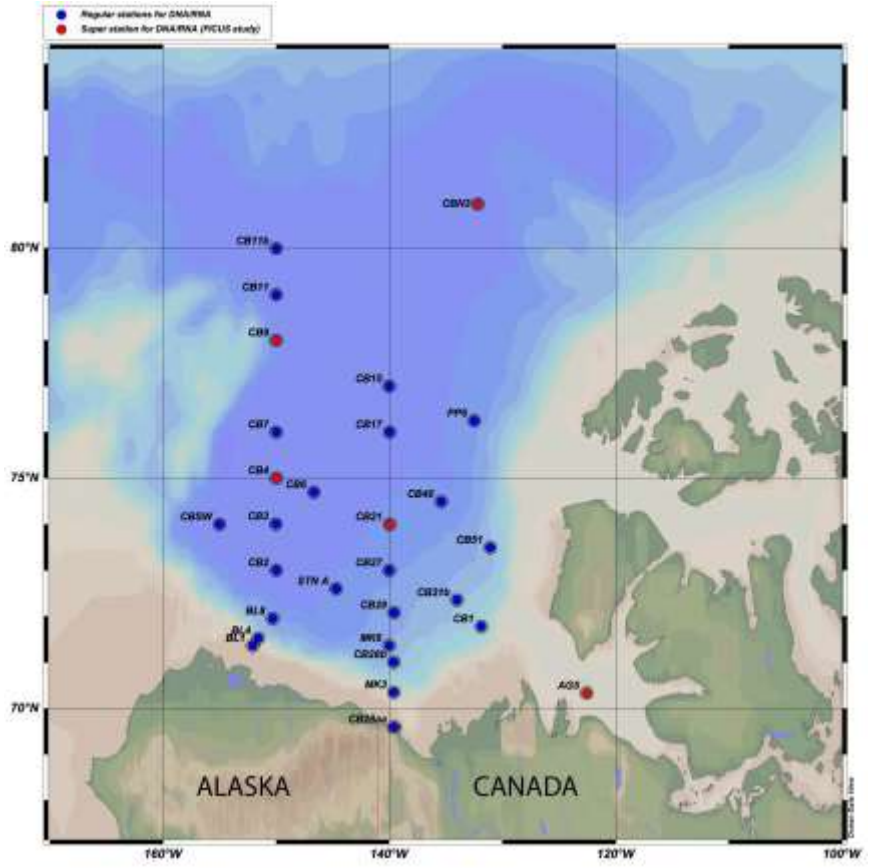


Figure 1 Sites sampled by the DNA group in 2017, blue dots 6 depths, Red dots are the CBOmics stations ("Super Stations") with 8 depths, see Table in appendix.

DNA/RNA and protein

DNA/RNA samples from large (>3 µm) and small (0.22 -3 µm) fractions were collected by filtering 4-13 L (typically 7) 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. Filter samples were immersed in RNAlater solution (Ambio) and left for at least 15 minutes at room temperature before being stored at -80°C. Since more stations were sampled than originally anticipated additional station for DNA/RNA were filtered to dry and put immediately into the -80 freezer. DNA/RNA and protein samples taken at the 5 designated sites were collected by filtering around 13 L of seawater at room temperature preserved in RNAlater as above and stored at -80.

Once onshore, DNA and RNA material will be simultaneously extracted from the filters as described by Dasilva et al. (2014). RNA will be first converted to cDNA before

being used for targeted sequencing (Comeau et al., 2011). DNA from selected depths and stations will be used to generate metagenomes. The metagenomes 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 concentrations, and the quantity and source of organic carbon on the metabolic diversity and capabilities of microbial communities. We will also aim to assemble microbial eukaryote genomes of abundant small species following the approach of Joli et al. (2017). All metagenomes will be put in an environmental context (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 potential response of microbes to environmental change.

HPLC

Samples for algal pigments were collected from the CBOmics sites by filtering ca. 2 L of seawater from the upper 4 depths onto 0.7 µm GF/F filters (Millipore). All samples were wrapped in foil, labelled and stored at -80°C and will be extracted and pigments identified using high pressure liquid chromatography (HPLC) 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 the majority of stations and depths sampled. In summary, 50 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. Because of a shortage of fliters no slides were made at Station AG5, as an alternative, 225 ml of seawater was preserved in buffered formalin, to preserve silica frustules of diatoms, microscopic cover slips were added (Table 1, Phyto).

Fluorescent in situ Hybridization (FISH)

FISH is a technique that uses fluorescent-labelled nucleic acid probes to identify specific phylogenetic groups under the microscope. Samples for FISH were collected at some of the CBOmics stations and depths. Seawater was fixed with 3.7 % (final concentration) formaldehyde (Sigma-Adrich) and processed within 6-12 hours after

sampling. For eukaryotic organisms, 150 mL of fixed sample was filtered onto a 0.8 µm polycarbonate filters (AMDM) and for bacteria, duplicate 50 mL aliquots were filtered onto 0.2 µm polycarbonate filters (AMDM). Filters were air-dried and stored at -20ºC to be analysed onshore, following probe development and selection.

Target metagenomics (LiveFCM)

For potential cell population metagenomics, 1.4 ml of DMSO was added to 13.5 mL of water sample in 15-ml Falcon tubes. Samples were left 10-20 minutes at 4 ºC before being stored placed into the -20 freezer for slow freezing. Cells preserved in this manner will be sorted using a BD Melody Flow cytometer (Ulaval) and used for genetics/genomic studies.

Bacterial and pico/nanoeukaryote cell count

Cell counts of both prokaryotic (<2 µm) and photosynthetic pico- and nanoeukaryotes (2-10 µm) will also be estimated by flow cytometry. For this 1.8 mL seawater were added to 45 µl of 50% glutaraldehyde in 2 mL cryogenic vials. Samples were first left for several hours at 4 ºC then flash frozen in liquid nitrogen before being finally stored in -80 until transportation to ULaval. Before counting, bacterial nuclear material is stained with a Sybr dye (Life Sciences), while photosynthetic eukaryotic cells are detected by chlorophyll autofluorescence.

Summary

A total of 178 depths at **28** 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.

Comments

As with JOIS 2015 and 2016, the RNA/DNA group was provided with 2 dedicated bottles primarily for collecting in the DCM and near the surface during full casts and 8 bottles in special casts for the CBOmics sites. For the other stations we collected remaining water in designated bottles from the routine IOS geochemistry casts, which was greatly appreciated. We took advantage of opportunity stations to have a wider coverage of the Canada Basin than planned. In part because of this, we were short of some disposables near the end of the mission and suggest that next year more contingency and redundancy be built into materials that are ordered. We ran out of certain types of filters and were unable to process ancillary samples for all stations. In addition, due to the late information on where the ship would be loaded, the timing was very tight for shipping chemicals and caused some problems with material not arriving or arriving only just on time after using emergency shipping services. The failure of the

cartridge for the MilliQ water system in the last week of the cruise was unfortunate but we feel we have been able to continue to work clean, using less water. We thank the chief scientist and the IOS team for support and consideration.

The ship performed extremely well for sampling and the CCGS crew and officers are professional and excellent. A small suggestion would be to verify the all doors on the ship. Many of the inside doors to the outer decks are sticky and there were sometimes problems opening them quickly. This could be a problem in an emergency.

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4.7 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 2017 expedition was 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, as logistics permitted.

In total, 24 depth profile sieved samples were collected from 4 stations (NE-1.5, CB-9, CB-4, CB-21) for depth profiles, 8 samples were collected from the seawater loop system at 8 stations (CB-1, CB-9, BL-1, CB-4, CB-21, Stn-A, CB-28aa and AG-5) for surface distribution and 4 samples were collected from 4 ice cores at 2 Ice-Based Observatory

(IBO,). A set of blanks were also collected for the different sample collection procedures.

See appendix for sample information.

4.8 Underway Measurements

Edmand Fok , Sarah Zimmermann, Jane Eert (DFO-IOS)
P.I.s: Bill Williams, Celine Gueguen (TrentU), Mike DeGrandpre (UMontana), Peter Ross (Vancouver Aquarium)

Underway measurements summary

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

- The seawater loop system:
    a. Electronic measurements of surface salinity, temperature (inlet and lab), fluorescence for Chlorophyll-a, and fluorescence for CDOM.
    b. Water samples were drawn for
        - Salinity, Nutrients, O18, Chlorophyll, Dissolved Inorganic Carbon, Alkalinity, and Oxygen (IOS/DFO)
        - Coloured Disolved Organic Matter (*Celine Gueguen, TrentU*)
        - Microplastics (*Peter Ross, Vancouver Aquarium*)
        - Vector Network Analysis (provides comparison for Satellite salinity measurements) (*Kohei Mizobzta, Tokyo University of Marine Science and Technology)*
    c. Measurements of partial pressure of carbon dioxide (pCO_2) (*Mike DeGrandpre, UMontana)*
- The Shipboard Computer System (SCS) was used to log
    a. From the ship's GPS: the NMEA strings $GPGGA, $GPVTG, and $GPZDA. Giving position, time, date and course and speed over ground.
    b. AVOS weather observations of: air temperature, humidity, wind speed and direction, and barometric pressure ($AVRTE)
    c. Heading from the ship's Gyro ($HEHDT)
    d. Sounder depth and applied ship's draft and sound speed ($SDDBT)
    e. Surface Photosynthetically Active Radiation (PAR)
    f. And similarly timestamped logging of the above listed TSG (item 1a), and the inlet sea surface temperature from the SBE38 that is also given in the TSG data stream.

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 current pump was installed August, 2016. 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.

Figure 4. Seawater loop system - 2017

The seawater loop provides uncontaminated seawater from 9m depth to the science lab for underway measurements. This is the configuration during 2017-11 (JOIS). The pCO2 system under the plastic sheet was installed for Leg2 (JOIS) only.

Figure 5. TSG and water manifold in lab

Figure 6. The Moyno pump installed in the engine room. Seawater passes through a filter before going to the pump When the ship is in sea-ice the flow is switched from one filter to the other to allow the necessary frequent clearing out of slush from the filter. This pictures are from a previous year but is the same strainer configuration for 2017.

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 7. Honeywell controller for the pump. Controller is located in the TSG lab.

On one of the seawater manifold arms is a Kate's mechanical flow rate controller followed by a vortex debubbler, installed inline to remove bubbles in the supply to the SBE-21 thermosalinograph (TSG).

SBE21 Seacat Thermosalinograph s/n 3297

Instruments used in the TSG:

Temperature and Conductivity s/n 3297, calibrated 18May2017
Seapoint Chlorophyll Fluorometer s/n SCF 3652, calibrated Jun2014, using gain setting of 30x (0 to 5ug/l range)

WETLabs CDOM Fluorometer s/n WSCD-1281, calibration 9 Jun 2011
SBE38 Inlet Temperature s/n 0319, calibrated 5 Jan 2017

The SBE38 Inlet Temperature is connected to the TSG remotely. It is installed in-line, approximately 4m from pump at intake in the engine room. This is the closest measurement to actual sea temperature.

Figure 8. SBE38 temperature sensor in the engine room. This picture is from a previous year and during the winter refit 2016-2017 changes were made to the plumbing but essentially this is the same configuration.

The data were collected through SeaBird's Seasave acquisition program v. 7.26.6.26 onto a laptop using a serial to usb adapter cable. 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 computer also provided a means to use the ship's science LAN to pass ship's GPS for integration into sensor files, to pass the SBE38 (inlet temperature) data from the engine room to the TSG instrument, and to pass the TSG and SBE38 data to the ship's data collection system (SCS). The software program GPSgate was used to facilitate the conversion between USB, TCP/IP, and virtual and real comm ports.

The fluorometer and CDOM sensors were plumbed off a second manifold output. No debubbling or extra flow controls were in place.

On a third arm of the manifold, an automated system for measurements of pCO2 from the seawater and atmosphere was used. This year's measurements were made with a new Sunburst *SuperCO2* system.. This was the system's first use, set up and run onboard by Mike deGrandpre (UMontana), and appears to have worked well. Data were recorded through the cruise with discreet DIC, Alkalinity and Oxygen water samples drawn for comparison. For more information please see the report: 2017-11_pCO2_pH_DeGrandpre.docx

Flow rate was measured manually several times on the three manifold lines in use: TSG line, Fluorometer line and pCO2 line. It was also measured using an in-line sensor on the fluorometer line. The sensor measures spin revolutions with time and logged to a text file using an interface box to the computer running the program TracerDAQ. The flowrate data needs calibration to manual flow measurements and to be matched by time to the TSG data.

For 2017:
Using the Honeywell controller, pressure set point was 18 PSI.

Measured flow rates to the sensors were approximately:

TSG	3.2s/L (18.5 L/min)
Fluorometer pair	
Leg 1 (C3O)	6 s/L (10 L/min)
Leg 2 and 3, (JOIS and Bellot St)	30 s/L (2.0 L/min)
pCO2	17.2s/L (3.5 L/min)

Discrete water samples were collected from the fluorometer line. Samples were assigned a consecutive "Loop" number which was unique by time, i..e. if 4 different properties were measured at the same time, they received the same Loop number.

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.

Note the AVOS, TSG and PAR data are also logged through their own software programs.

The SCS system on a shipboard computer called the "NOAA server" collects *RAW files. The files typically contain a day's worth of data, restarting at midnight.

The list of *.RAW files and order of variables within the data string are given in the Appendix.

Issues with the underway system and data

AVOS – The logging of the AVRTE string did not begin until Aug 29th 1326 due to delays in finding and connecting the datastream to the NOAA Server.
Previous years have had icing problems with the anemometer resulting in inaccurate wind speed. This year the instrument was observed daily and no problems were noted.

Sounder – The sounder typically did not pick up the bottom depth while underway, even in ice-free conditions. If the settings were not updated during the quickly changing depths on the slopes, the min/max allowed depths were sometimes surpassed resulting in incorrect depth values.
Aug 27th 1724 (start of records) to Aug 27th 1731
3.5kHz sounder with no draft
Aug 27th 1756 to end of program
12kHz sounder w/ 9m draft

Gyro – The logging of the Gyro string did not begin until Aug 29th 1326 due to delays in finding and connecting the datastream to the NOAA Server.

PAR installed at start of JOIS leg. Data exist starting Sep 8th 1332

TSG- The logging of the first good data on the TSG string (SCS) did not begin until Sep 7 0515 due to problems with TSG data collection setup (primarily computer related). Similarly, on the TSG computer, the first good file is TSG-2017-09-07_0459.hex.
The laptop initially had battery problems and then Windows10 update problems. The laptop was swapped out to a Windows7 computer but issues with first the flowmeter reading stopping and then the latitude and longitude in Seasave "freezing" resulted in moving the flowmeter software to a separate computer. Seasave ran well after this.

SBE38 Intake Temperature, unlike the TSG data, was working and logging from the start of the program so data are good as long as the pump was running.

Flowmeter – Flow meter was losing communication with computer ("lost connection on Dev0"). Flow meter would intermittently log no flow when there was flow…it did not seem connected to flow speed. Cleaning did not help. Typically it would log no flow, the program would be restarted, and the flow rate might return. It is thought there is a problem with the interface box between the sensor and the computer. Thus – when flow data report flow, it is believable, but when reporting no-flow this could be due to

communication problems. After leaving the ice Sep 20th, there was continuous flow through the system so 'no-flow' data can be ignored.

Flow – Besides the flowmenter, methods for identifying poor flow would be spiky salinity data due to air bubbles being sucked through the system when the intake strainers are clogged and large differences between the intake and lab temperature readings (ie over 2C) due to sluggish or stopped water warming at different rates at the sensors.

Sea Water Pump and TSG data – Notes are recorded primarily in the TSG Log Book and some information is also given in the Loop Sample Log Sheets. Highlights below:

Aug 29th Pump is turned on. There is a slow drip off the lab manifold which the engine room fixes

Aug 30th Flow meter logging software turned on ("TracerDAQ")

Aug 30th Valve was checked to make sure it was opened for the SBE38 intake temperature sensor. Although pump flow is on, it could be bypassing the SBE38.
Pump flow adjusted to 18 PSI with 30% output.

Sep 4th 1902 to Sep 5th 1307 Pump off as ship was near Pond Inlet.

Aug 29th to Sep 5th Problems with computer shutting down on its own. Swapped out laptop "Beaufort" and put in Marty's Windows 7 laptop for Leg 2 (JOIS).

Sep 7th 1132 Flow had stopped on fluorometer lines, perhaps due to addition of pCO2 system. Flow increased on fluorometer, reduced slightly on TSG so sink drain can keep up with flow from all 3 hoses.

Sep 9th 2048 NoSleep.exe started on TSG computer to try and keep TracerDAQ software from stopping its logging however this seems to be associated with incoming NMEA on GPSgate to close. Stopping and starting the GPSgate NMEA instance works to renew the NMEA string but then after a short period the feed stops again.

Sep 11th 0728 Power management changed on Marty's laptop but GPS/NMEA feed still stops.

Sep 11th 2113 Install flowmeter software on "Beaufort" (following Win10 workaround).

Sep 11th 2154 Started new TSG file on laptop but can't get data to SCS system (laptop's ip address picked up by another computer, so first we swapped to different ip address and then after finding who had the "tsg" address we swapped back. Also, GPSgate in memory was removed…in anycase the feed to SCS was fixed at some point).

Sep 14 0827 to 20th Sep intermittently in ice with variable flow rate and sucking bubbles due to clogged strainer.

Sep 21 0100 Ship's power cycled which may have turned off pump, reset PSI setpoint, and broken connection to VLINX (SBE38).

Sep 21 0140 Pump restarted

Sep 21 0900 SBE38 feed to TSG laptop and SCS on again (had been off from ~ Julian day 293.944 (Sep 20 2300))

4.9 Moorings and Buoys

Andrey Proshutinsky and Rick Krishfield (P.I.s), Jim Ryder, Jeff O'Brien, Josh Mitchell and Mike DeGrandpre (U Montana).
P.I.s not in attendance: John Toole (WHOI) and Mary-Louise Timmermanns (Yale U)

Summary

As part of the Beaufort Gyre Observing System (BGOS), three bottom-tethered moorings deployed in 2015 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in September 2017 from the *CCGS Louis S. St. Laurent* during the JOIS 2016-16 Expedition. Furthermore, three Ice-Tethered Profiler (ITP) buoys were deployed: two on ice floes with Seasonal Ice Mass Balance Buoys (SIMB), and one over the side of the ship in open water. A summary of moorings and buoys recovered, serviced and deployed are listed in Tables 1 and 2.

Table 1. Mooring recovery and deployment summary.

Mooring Name	2016 Location	2017 Recovery	2017 Deployment	2017 Location	Bottom Depth (m)
BGOS-A	75° 0.0270' N 149° 59.9659' W	20-Sep 18:34 UTC	24-Sep 22:45 UTC	75° 1.10' N 150° 8.43' W	3825
BGOS-B	77° 59.8615' N 149° 57.6695' W	18-Sep 17:43 UTC	19-Sep 23:53 UTC	78° 1.07' N 149° 58.48' W	3827
BGOS-D	74° 0.0007' N 140° 0.0606' W	25-Sep 21:03 UTC	27-Sep 22:49 UTC	74° 0.26' N 139° 59.96' W	3513

Table 2. Ice-Based Observatory buoy deployment summary.

IBO	ITP / Buoy System	Date	Location
1	ITP101 / SIMB	15-Sep 15:00	80° 53.8' N 132° 23.0' W
2	ITP108 / SIMB	16-Sep 18:00	80° 32.2' N 140° 44.8'

			W
3	ITP100	17-Sep 18:00	79° 59.1' N 149° 43.5' 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, a vertical profiling CTD and velocity instruments which samples the water column from 50 to 2050 m twice every two days, assorted Microcat CTDs, 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, acoustic wave and current profilers (AWAC) provided by the University of Washington are included on moorings A and D, a McLane Remote Access Sampler (RAS) on mooring A for the Tokyo University of Marine Science and Technology (TUMSAT), and SAMI-CO_2 and SAMI-pH instruments for the University of Montana on all of the moorings.

Fourteen 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 2003-2016 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, and all-time highs were attained in 2015 and 2016, suggesting that the historic cyclical nature of freshwater accumulation and release in the BG may no longer pertain.

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 3 Ice-Tethered Profiler buoys (or ITPs), and two US Army CRREL Seasonal IMBBs. The combination of multiple platforms at one location is called an Ice Based Observatory (IBO).

The centerpiece ITPs obtain profiles of seawater temperature and salinity from 7 to 760 m twice each day and broadcast that information back by satellite telephone. The ice mass balance buoys measure the variations in ice and snow thickness, and obtain surface meteorological data. Most of these data are made available in near-real time on the different project websites (Table 4).

Initiated in fall 2004, the international ITP program over the last 12 years has seen the deployment of nearly 100 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.

Table 3. Project websites

Project	**Website Address**
Beaufort Gyre Observing System	www.whoi.edu/beaufortgyre
Beaufort Gyre Observing System dispatches	www.whoi.edu/page.do?pid=159656

Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	www.imb-crrel-dartmouth.org/imb.crrel/SeasonalIBinst.htm

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. As all of the moorings were located in open water this year, the mooring top transponder (located beneath the sphere at about 30 m) was not surveyed.

In coordination with the bridge, acoustic release commands were sent to the release instruments just above anchor, which let go of the anchor, so that the floatation on the mooring could bring the systems to the surface. Then the floatation, wire rope, and instruments were hauled back on board. Data was dumped from the scientific instruments, batteries, sensors, and other hardware are replaced as necessary, and then the systems were subsequently redeployed for another year. The moorings were redeployed anchor first, which required the use of a dual capstan winch system to safely handle the heavy loads. Typically it took between 4-6 hours to recover or deploy the 3500-3800 m long systems. Complete year-long data sets with good data were recovered from all of the BGOS primary instruments, except that some velocity profiles were missed by the MMP on mooring B0.

ITP deployment operations on the ice were conducted site according to procedures described in a WHOI Technical Report 2007-05 (Newhall et al., 2007). Due to weather and ice conditions, the helicopter was not used for ice floe reconnaissance, but instead floes were selected visually from the bridge and surveyed by lowering 2 scientists over the side of the ship in the manbasket to drill the potential site to determine thickness. After it was determined that the floe was adequate, the ship's gangway was lowered onto the ice for access by personnel and equipment was lowered using the ship's crane. The first icefloe selected for deployment of ITP101 and SIMB was 1.25 m thick, and the second for deployment of ITP108 and SIMB was 0.75 m. Ice analyses were also performed by others in the science party while the IBO deployment operations took place. A third floe was selected for ITP100, but was so thin that it began breaking up before the ice survey could be conducted, so that ITP was deployed over the side of the ship in open water using the ship's bow A-frame.


Figure 1. IBO 1 consisting of ITP101 and SIMB (left), IBO 2 consisting of ITP 108 and SIMB (center) and ITP 100 (right) shortly after deployments.

Other

Dispatches documenting all aspects of the expedition were composed by PolarTrec teacher David Jones and Andrey Proshutinsky and posted in near real time on the WHOI website at: http://www.whoi.edu/page.do?pid=159656.

4.10RAS (Remote Access sampler) recovery and deployment

P.I.: Michiyo Yamamoto-Kawai (TUMSAT)
Yuanxin Zhang (TUMSAT)

Recovery

A Remote Access Sampler (RAS), WQM and SUNA sensors were recovered at mooring station BGOS-A. Please see cruise report 2014 for equipment details and report 2016 for settings.

The RAS was installed with 48 sample bags (47 Kynar and 1 Tedler) and was set to collect 450 mL of seawater in each bag. Of 48, one bag was empty because the system was recovered before the sampling schedule for bag #48. Samples were analyzed for DIC and alkalinity onboard. Samples were also subsampled for analysis of $\delta^{18}O$, nutrients, and salinity (Table 1).

Table 1. List of RAS samples

#	DIC	TA	Sal	18O	nuts	#	DIC	TA	Sal	18O	nuts
1	○	○	×	○	○○	25	○	○	○	○	○○
2	○	○	○	○	○	26	○	○	○	○	○○
3	○	○	○	○	○	27	○	○	○	○	○○
4	○	○	○	○	○○	28	○	○	○	○	○○
5	○	○	○	○	○○	29	○	○	○	○	○○
6	○	○	○	○	○○	30	○	○	○	○	○○

7	○	○	○	○	○○	31	○	○	○	○	○○
8	○	○	○	○	○○	32	○	○	○	○	○○
9	○	○	○	○	○○	33	○	○	○	○	○○
10	○	○	○	○	○○	34	○	○	○	○	○○
11	○	○	○	○	○○	35	○	○	○	○	○○
12	○	○	○	○	○○	36	○	○	○	○	○○
13	○	○	○	○	○○	37	○	○	○	○	○○
14	○	○	○	○	○○	38	○	○	○	○	○○
15	○	○	○	○	○○	39	○	○	○	○	○○
16	○	○	○	○	○○	40	○	○	○	○	○○
17	○	○	○	○	○○	41	○	○	○	○	○○
18	○	○	○	○	○○	42	○	○	○	○	○○
19	○	○	○	○	○○	43	○	○	○	○	○
20	○	○	○	○	○○	44	○	○	○	○	○○
21	○	○	○	○	○○	45	○	○	○	○	○○
22	○	○	○	○	○○	46	○	○	○	○	○○
23	○	○	○	○	○○	47	○	○	○	○	○○
24	○	○	○	○	○	48	×	×	×	×	×

1.1.1.2. Deployment

A RAS 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. 400 µL of saturated HgCl2 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 and Na_2CO_3 to have salinity of ~38 and alkalinity of ~1700 µmol/L. This water was sampled for $\delta^{18}O$, salinity and alkalinity analysis for the correction to make after the recovery of the RAS.

Table 2. BGOS-A RAS/WQM settings.

	RAS	**WQM**
sirial No.	ML12905-01	WQM-406
sampling start date	2017/9/28 2:00:00 (UTC)	2017/9/28 1:45:00 (UTC)
sampling schedule	see table 3	every 6 hours
other information	No filter, new type of bags (made in Japan)	sampling time 10 minutes

Table 3. RAS sampling schedule (UTC)

#	**Date and Time**							
1	09/28/17	02:00:00	17	01/24/18	02:00:00	33	05/24/18	02:00:00

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

4.11 Underway and Moored pCO2 and pH Measurements

P.I.: Mike DeGrandpre (U.Montana,michael.degrandpre@umontana.edu) in collaboration with Rick Krishfield and Andrey Proshutinsky (WHOI)

Overview: U.S. National Science Foundation: An Arctic Ocean sea surface pCO_2, pH and O_2 observing network

This project is a collaboration between the University of Montana (Mike DeGrandpre) and Woods Hole Oceanographic Institution (Rick Krishfield, Andrey Proshutinsky and John Toole). The primary objective is to provide the Arctic research community with high temporal resolution time-series of the partial pressure of CO_2 (pCO_2), pH and dissolved oxygen (DO). We have been deploying CO_2, pH, DO and CTD sensors on the WHOI ice-tethered profilers since 2012 and on the BGOS moorings since 2013. Ancillary in situ measurements have also periodically included photosynthetically active radiation (PAR) and chlorophyll-a fluorescence. ITP sensors are deployed at a fixed depth around ~6 meters below the ice. Moored sensors are deployed below the subsurface float at ~35 m. We were not funded by NSF to deploy sensors on ITPs during the 2017 cruise.

Cruise Objectives

1. Recover 3 SAMI-CO_2 and 3 SAMI-pH sensors on the three BGOS moorings (BGOS-A, BGOS-B and BGOS-D).
2. Collect underway pCO_2 measurements to map the spatial distribution of pCO_2 in the Beaufort Sea, Canada Basin and surrounding margins.

3. Deploy a SAMI-CO_2/SAMI pH pair including DO and PAR on each of the three BGOS moorings.
4. Evaluate O_2 consumption in the seawater line.
5. Assist with other shipboard research activities and interact with ocean scientists from other institutions.

Figure 9. Sensors prior to deployment on BGOS mooring B. The CO_2 and pH sensors (black housings) (SAMI-CO_2 and SAMI-pH) were deployed at ~35 m depth. A Seabird Microcat (white housing) is also deployed by WHOI at ~ 1 m above the SAMI sensors. The SAMIs also include PAR and dissolved O_2 sensors.

Cruise Accomplishments

During the September 6 – October 3, 2017 JOIS/BGOS cruise a set of pCO_2, pH and DO sensors were deployed on the three WHOI BGOS moorings, A, B and D in the Beaufort Gyre. Photosynthetically active radiation (PAR) sensors were also deployed with each set of sensors. All sensors were deployed at a depth of approximately 35 meters. Sensors deployed in October 2016 were also recovered during the 2017 cruise and included measurements of chl-a fluorescence (see Table 1 for a summary of the data collected). The 2016-2017 data include approximately 13,000 pCO_2 and DO measurements and 5600 measurements of pH.

Table 1. DeGrandpre (UM) data collection summary (preliminary)**

Measurement platform and location	Instrument IDs	Duration
ship underway pCO_2 (see ship cruise track in this report)	SUPER-CO_2	09/07/17-10/1/17
BGOS Mooring B (CB-9) 43.1 m depth at time of recovery	SAMI-CO_2 (C38)	10/05/16 – 09/18/17
	SAMI-pH (P5)	10/05/16 – 07/13/17
	Aanderaa O_2	10/05/16 – 09/18/17
	PAR (Licor)	10/05/16 – 09/18/17
BGOS Mooring A (CB-4)	SAMI-CO_2 (C48)	10/08/16 – 09/20/17

39.5 m depth at time of recovery	SAMI-pH (P47)	10/08/17 – 09/20/17
	Aanderaa O_2	10/08/16 – 09/20/17
	PAR (Licor)	10/08/16 – 09/20/17
	Chl-a (Chelsea)	10/08/16 – 09/20/17
BGOS Mooring D (CB-21) 33.3 m depth at time of recovery	SAMI-CO_2 (C37)	10/14/16 – 09/25/17
	SAMI-pH (P68)	10/14/16 – 11/14/16
	Aanderaa O_2	10/14/16 – 09/25/17
	PAR (Licor)	10/14/16 – 11/14/16
	Chl-a (Chelsea)	10/14/16 – 11/14/16

**SAMI-CO_2 measures the partial pressure of CO_2; SAMI-pH records pH on the total scale; All records include in situ temperature; PAR and Chl-a are uncalibrated.

We also measured pCO_2 on the LSSL's seawater line in the TSG lab. This year we used the new SUPER-CO_2 system purchased by IOS. The data coverage for these measurements is also shown in Table 1.

Lastly, in collaboration with IOS personnel, we collected O_2 samples on the seawater loop and compared them to bottle samples at 4 different stations (Table 2). These data show that rather than the seawater line consuming O_2 as found in other studies (e.g. see Juranek et al. GRL, 2010) values are consistently higher than the bottle values at 5 m, suggesting that bubble injection plays a role in altering O_2 concentrations in the seawater loop.

Table 2: Dissolved O_2 loop study. Two replicates were obtained at each of four stations. Loop samples were consistently higher than the bottle value suggesting that bubble dissolution likely dominated any systematic alteration of O_2 concentrations in the seawater loop. Analyses were done by Kenny Scozzafava (IOS).

Station	Loop #	SST (deg C)	O2 Sample #	O2 ml/L (loop)	O2 ml/L (5 m bc	loop - bottle (ml/L)	diif (umol/kg
CB5	85	0.5	1267	8.387	8.383	0.004	0.2
			1219	8.44	8.383	0.057	2.6
CB27	96	-0.45	1244	8.748	8.689	0.059	2.7
			1260	8.749	8.689	0.06	2.7
A	113	1.52	1228	8.339	8.28	0.059	2.7
			1252	8.38	8.28	0.1	4.5
CB29	121	0.54	1224	8.613	8.445	0.168	7.6
			1241	8.618	8.445	0.173	7.8

4.12 Ice Watch Report

P.I. Kazu Tateyama (KITAMI), Jenny Hutchings (OSU),

Ice observer on board Seita Hoshino (KITAMI)

As in previous years, the ice observations recorded during the Louis S. St. Laurent 2017 cruise will provide detailed information for the interpretation of satellite imagery of the ice pack. Cores and transects were taken during the one ice station.

Observations from the Bridge: Methodology

Due to lack of ice observing staffs, I operated Ice Watch every 1hour during 7:00 – 18:00 as possible. The observations thus start and end around the time period of our traverse through the ice pack. Ice conditions were noted within 1nm about the ship, when visibility allowed, along the ships track during the observation period.

I 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.

In this year, we observed much young gray or young gray/white ice, ice thickness less than 30cm. There were least old ices than previous years. Similar to 2015 and 2016, it was tough to discriminate between second year ice (SYI) and multiyear ice (MYI) as the ice floes were thin and small (~100 m diameter), meaning we didn't observe much overturning. We noted some of the blue colours suggesting some of this ice was older (as noted in 2015). On our first ice station we noted 50cm level MY ice with very low salinities (less than 3 PPT throughout the core).

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 camera was facing towards the bow recording images every minute. The other camera was looking down over port side recording images every 10seconds.
Please note, that in 2015 the port camera was turned 90^{o}, so it is not longer looking at ice over turning but monitoring the ice moving under Kitami's crane mounted EM31/ICE 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 EM31/ICE.

The imagery was saved in real-time onto the ScienceNet server.

Ice Stations

I followed the standard JOIS protocol of

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

at each ice station. Moreover, I recorded snow pit information, and a sled mounted EM-31 to extend ice thickness measurements across the transect lines and around the ice station.

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

Ice Station 1, 15 Sep 2017, near station CBN3

Latitude	80.91302 N
Longitude	132.30046 W

coring: Zimmermann, Ramachandran, DeFrancesco, Zhang (Cooper, Gueguen)
drilling and measure ice thickness: DeGrandpre, Shibley
snow pit: Seita Hoshino
No EM sled data were collected due to problems with the EM sensor.
WHOI IBO buoys deployed: ITP101 / SIMB

Ice was accessed from gangway of starboard side.
Two 50 m transects were laid horizontal each other. Note that the transects were shortened (normally 100 m) due to lack of time and staffs.

Ice cores were collected at two sites along the transect line A (0m, 50 m). The cores were collected at a maximum of 1 meter from the transect line.

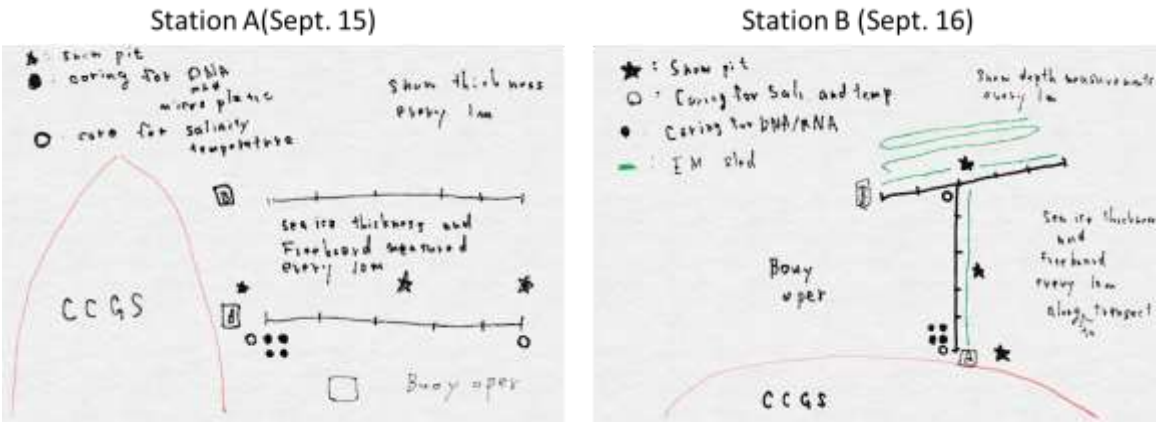
Ice Station 2, 16 Sep 2017, near station NE1.5

Latitude	80.539417	N
Longitude	140.771224	W

coring: Guguen, Defrancesco, Nicoloff, Saller, Torres
drilling and measure ice thickness: Cooper, Wietzke
snow pit and EM sled: Seita Hoshino
WHOI IBO buoys deployed: ITP108 / SIMB

Ice was accessed from gangway of starboard side.
Two 50 m transects were laid perpendicular to each other. Note that the transects were shortened (normally 100 m) due to lack of time and staffs.

Ice cores were collected at two sites along the transect line A (0m, 50 m). The cores were collected at a maximum of 3 meters from the transect line.



Schematic image of both ice-stations

Ice Cores

Ice Station	Transect/ Location	Core	Purpose	PI
1	A/50m	A	Temp/Salinity	Hutchings
1	A/0m	C	Temp/Salinity	Hutchings
1	A/0m	1	DNA/RNA	Lovejoy
1	A/0m	2	DNA/RNA	Lovejoy
1	A/0m	1	Microplastics	Ross
1	A/0m	2	Microplastics	Ross
2	A/50m	B	Temp/Salinity	Hutchings
2	A/0m	D	Temp/Salinity	Hutchings
2	A/0m	1	Microplastics	Lovejoy
2	A/0m	2	Microplastics	Lovejoy
2	A/0m	1	DNA/RNA	Ross
2	A/0m	2	DNA/RNA	Ross

Note that images of each ice core section can be found in the data repository.

The microplastic and DNA/RNA cores were not measured for temperature or divided into 10cm sections. They were instead broken up as required and placed into plastic bags for post-processing

Ice Station 1, Transect A at 0m Core C, Temperature/Salinity Core – Piece 1 (surface is at 0cm)

Ice Station 1, Transect A at 0m Core C, Temperature/Salinity Core – Piece 2 (connection to Piece1 is at 0cm).

Ice Station 1, Transect A at 50m, Core A, Temperature/Salinity Core. Surface is at 0cm.

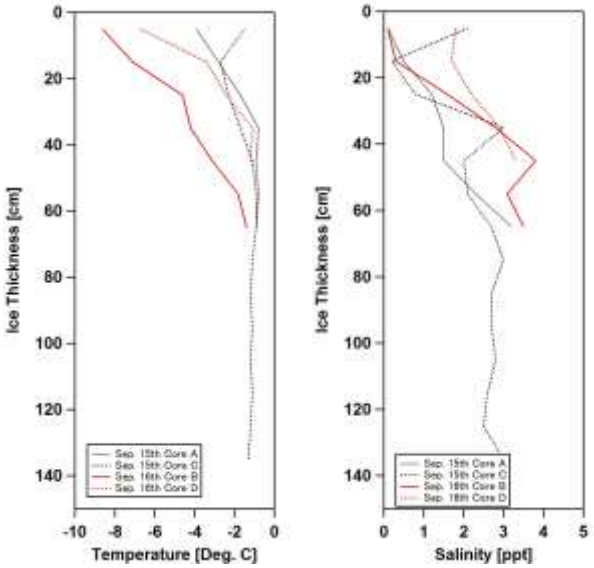
Ice Station 2, Transect A at 50m, Core B, Temperature/Salinity Core

Ice Station 2, Transect A at 0m, Core D, 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.

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 data is best used averaged across many cores. Our aim is to characterize bulk density of MY ice in the Beaufort region.



Ice core profiles from Ice Station 1 and 2.

Ice Thickness Transects

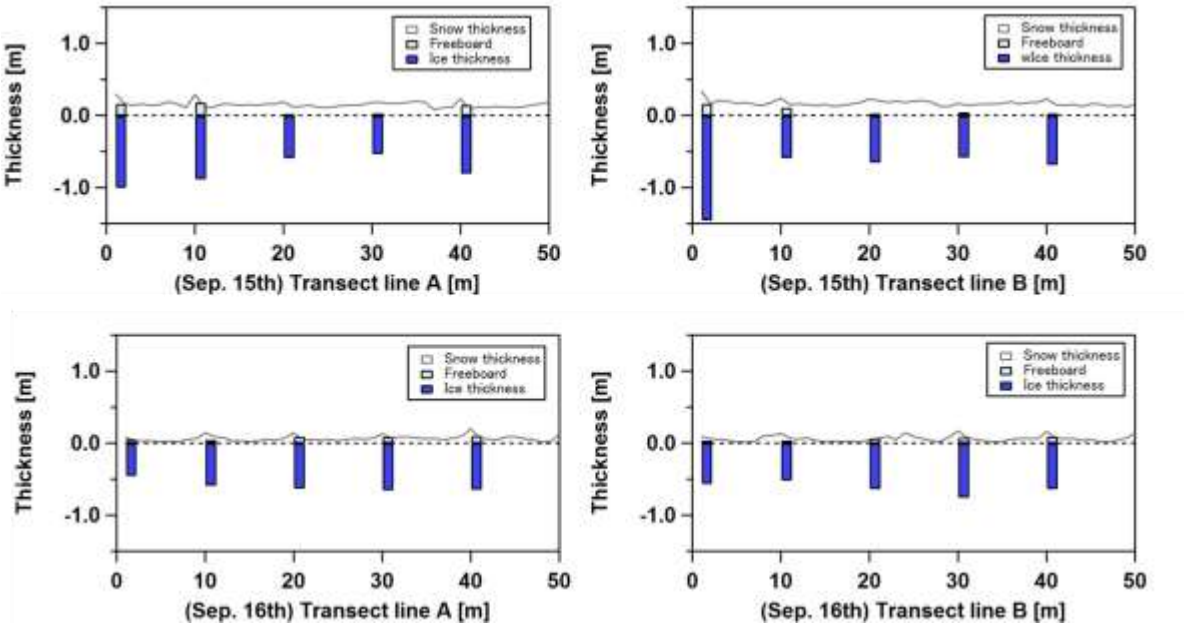
Due to lack of time and staffs, we were unable to follow the standard JOIS procedure of making 2 100m transects. We instead settled for 2 50 m transects with thickness and freeboard measurements every 10m ad snow depth every meter in each ice stations.

Snow Pits

We measured snow properties with a snow pit at the 0 m, 25m, and 50m marks of transect A for both stations. The data (e.g. snow density) is on the ScienceNet server (detailed below).

Ground truth ice thickness, freeboard (drilled) and snow depth measurements

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. Snow depth was also measured at 1-m intervals along the 50 m transects.



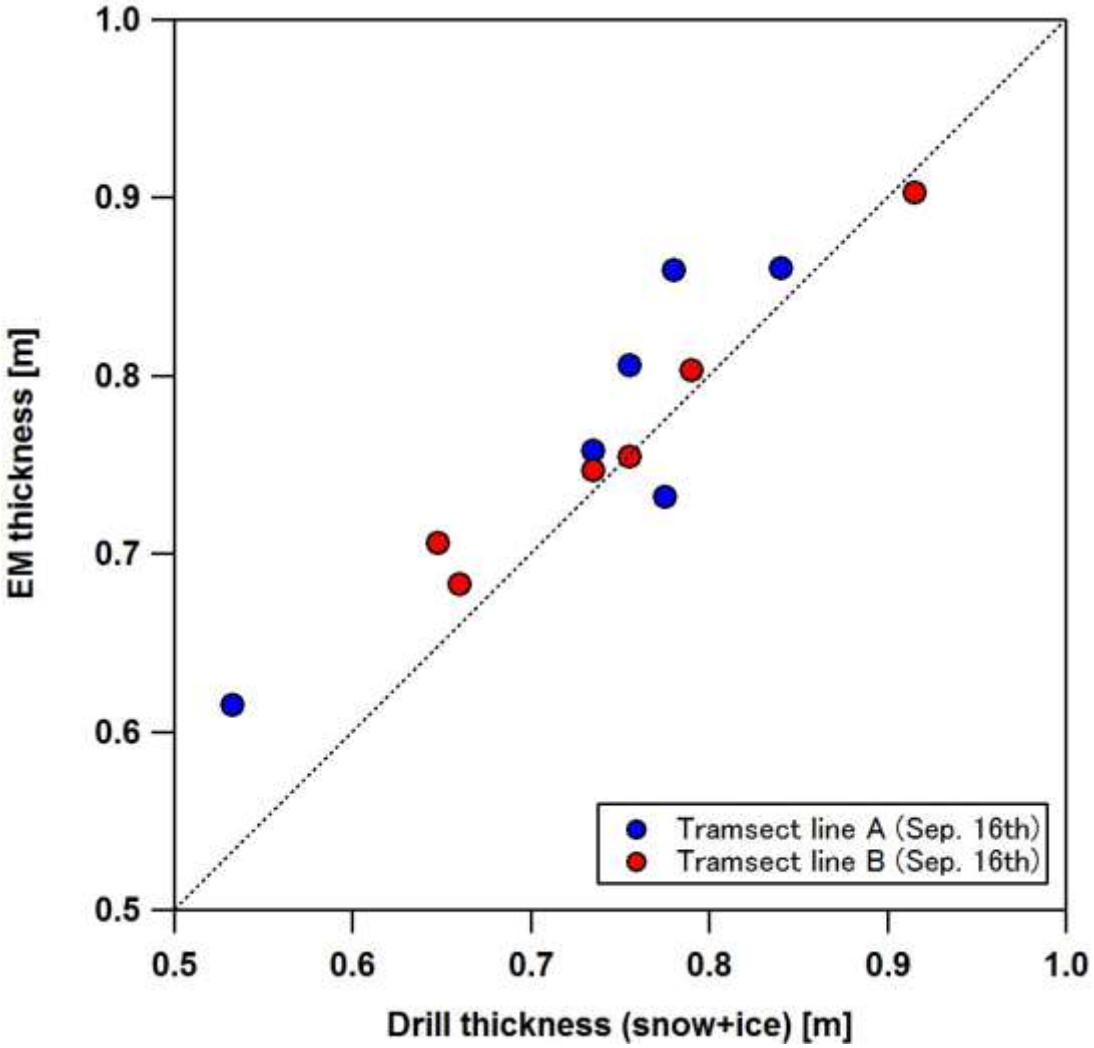
Ice thickness (blue box), freeboard (light-blue box) and snow depth (black line) for the four transects. The bottom plots the results relative to sea level. Note that the snow depth data are every meter.

There is much higher variability at ice station 1(Sep. 15th), with significant areas of thicker ice. The modal ice thickness shows 50cm at ice station 2 (Sep. 16th).

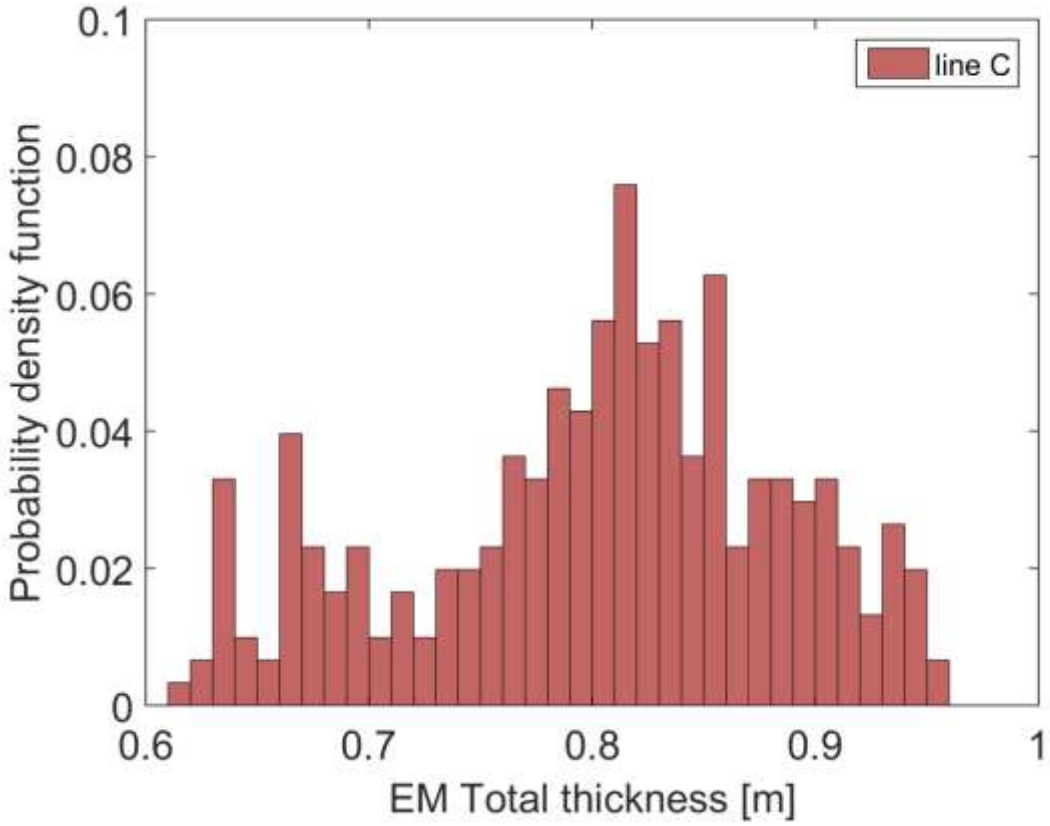
Note: ice thickness measurements at 50m do not show up in the above 4 plots although data do exist. SZ 2017-10-12

Ice Thickness from EM-31

At ice station2, 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 2 transcts and an extra transect around the buoy site. First, we measured sa-ice thickness alog 2 transect lines for validation of EM-31SH. And then, we measured areal sea-ice thickness apart from transect line B.



We can see (qualitatively) that the ice plus snow thickness is similar (mean and mode) for data collected with the drill and by the EM. Mean/mode of around 0.5 to 0.6 m. We found some thicker ice when taking the EM further from the transect lines, around the buoy deployment site (0.75 m), but never observed a thickness over 1 meter.



Histogram of ice thickness (ice plus snow thickness) collected from the EM sensor over transect 2 (Sep. 16th). First mode is 0.8m.

Summary of Ice Along the Cruise Track

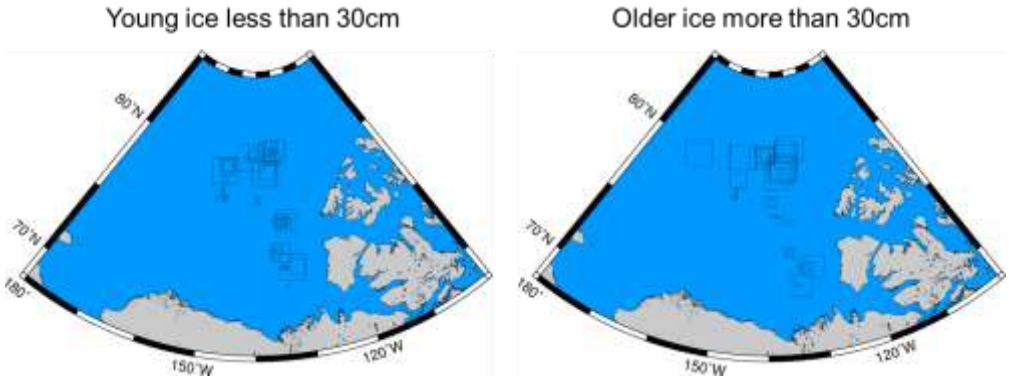
This year we travelled 'anti-clockwise' around the JOIS loop (similar to 2016), and we met sea-ice early in this cruise at September 10th. To find thick ice area enough for the buoy deployments and an ice station in the north (towards 79N) and then returning south down the 150W line before heading east.

We only spent around 10 days within the ice pack, because JOIS2017 was started earlier than previous years. We arrived in the Beaufort around the onset of freeze-up, but the freeze-up didn't appear to be occurring rapidly (confirmed by a lack of ice extent increase over our cruise time period) and the lack of much southern ice drift. We thus didn't include many observations of the open water before and after.

Images taken during Ice Watch of (left) small pancakes (right) Small floes of concerted pancake ice with ice flowers.

Young ice types were encountered throughout the cruise, and young grey/grey-white ice dominated the ice landscape. Every stage of new ice development from grease ice to young-white ice was observed. We noted nilas, grease ice, and pancakes. The pancakes varied in size throughout the cruise, mainly based on how far into the ice pack we were (large areas of small pancakes were observed as we entered the ice pack). The younger ice was interspersed with older, multiyear ice floes of varying concentration on occasion.

The ship rarely had to navigate towards leads to avoid thick ice. The only noticeable maneuvers involved s small deviations to avoid the small, thick multiyear ice floes as they entered the ship's line of sight. RADARSAT imagery wasn't used as much as on previous cruises. It was rare to see thick ice (greater than 2 m) being overturned by the ship.



Distribution of ice-concentration form visual observation. Square size means the variability of ice-concentration.

Data

\\lslnoaa\sciencenet\2017-11-JOIS\Data\Ice

- /IceStations/

Summary of IceStation2017.xlsx
/EM_sled
/IceCorePhotos

- /IceWatch/

Louis S. St. Laurent-20170906-20151005-20170907-20171005.csv
ASSISTv3_CheatSheets.xlsx - Description of data file, with header codes
/IceWatchPhotos/

- **/NetRadiometer/**

- **/EM-PMR/** -KITAMI EM-31 'sushi' and PMR(Passive Microwave Radiometer) underway cruise data

Many Thanks to the volunteers who helped at Ice Station 1 and 2.

4.13 EM ice obsersvations Cruise Report

P.I. Kazutaka Tataeyama, Associate Professor, Kitami Institute of Technology, Japan

EM/PMR/Net radiometer observations were carried out by following member

- Seita Hoshino, PhD. Student, Kitami Institute of Technology, Japan

Measurements:
Following ship underway ice observations were conducted starting from September 10th to 19th. Three instruments installed port side and bow of Louis S. St Laurent as shown in Fig.1.

1. Ice thickness measured by an electromagnetic induction device (EM), installed at crane of portside.
2. Brightness Temperature (T_B) and Infra-red Temperature measured by MMRSs (Microwave Miliwave Radiometer System) installed at portside of flight and boat deck.
3. Short wave and Long wave measured by CNR 4 (Net Radiometer) at Bow.

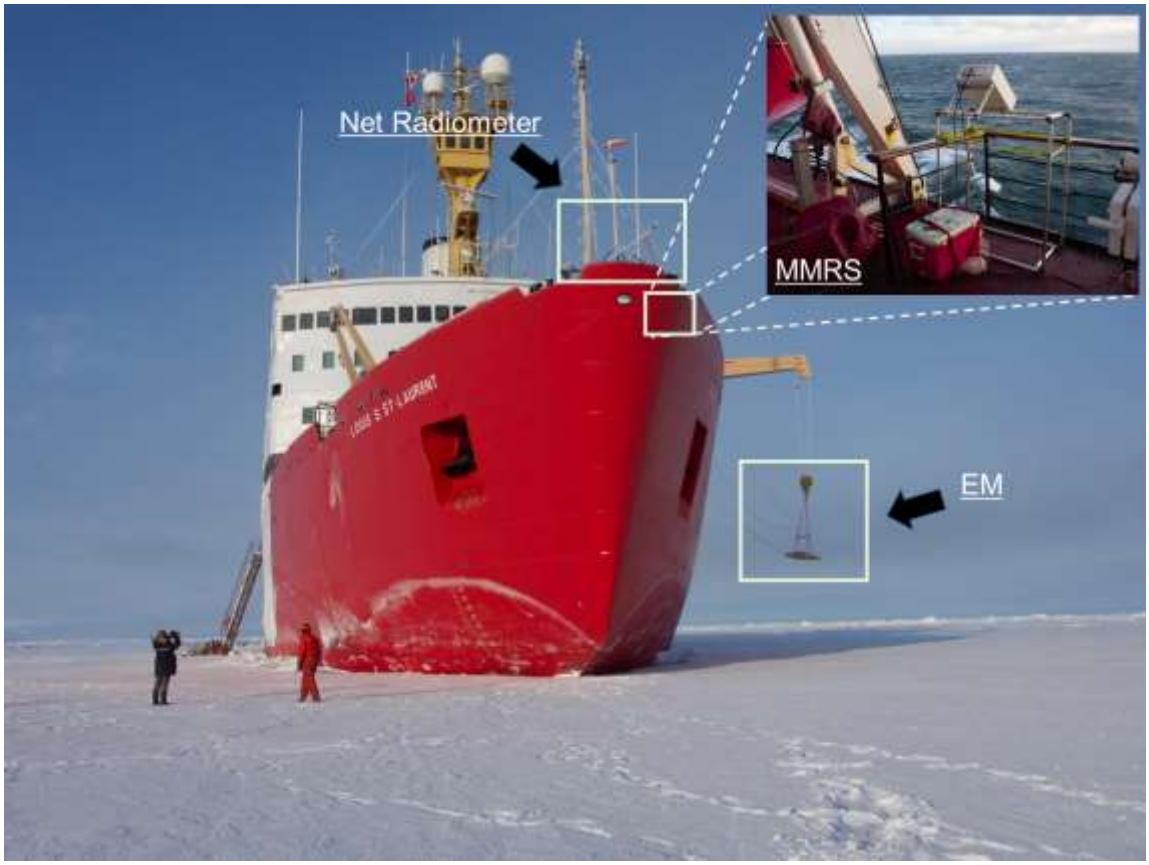


Figure 1 Positions of sensors

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) mS/m in which can be converted to a distance between the instruments and sea water at sea-ice bottom (Z_E) by using empirical equation. 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.

$$Z_{S+I} = a - \ln(\sigma_a - b)/c + Z_L$$

where a, b, and c is coefficients which derived from regression analysis.

Laser distance meter could not observe correct distance on the open water, because of mirror reflection occurs at sea-surface. Sea-ice concentration is derived from ratio of error and correct distance. Sea-ice thickness in the Canada Basin was recorded by EM system in order to research inter annual thickness change. The EM sensor covered by a yellow-orange color waterproof case was deployed from the foredeck's crane on the port side, collecting data while underway. Comparing EM thickness and AMSR2 sea-thickness (Krishfiled et al., 2014), we assess its accuracy and validity.

Observation of microwave radiation from sea-ice or sea-surface were conducted using a portable passive microwave radiometer which is developed by Mitubishi Electric Tokki Systems Co., Ltd., Japan. Two Microwave/Miliwave Radiometer Systems(MMRS) were

used for two frequencies: 18GHz with vertical polarization and 36GHz with vertical and horizontal polarizations. A radiation thermometer and a visible camera provide microwave brightness temperatures and surface temperature in Kelvin, and its visible image. EM and PMRs were collected sea-ice properties 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 [Krishfield et al., 2014].

CNR-4 recorded the radiation balance of solar and far infrared (IR). This data will be used for assuming ice albedo feedback and help interpret satellite image of sea ice. CNR-4 provides output voltage (mV) in which can be converted to short wave and long wave irradiance.

EM data are collected every 0.1 second, MMRS data are collected every 1sec, and Radiometer date are collected every 10 second.

Results:

1. EM ice thickness profiles

EM observations were carried out during September 10th to 19th (Figure 2). EM was calibrated over open water September. Empirical equation of EM thickness derived from result of calibration and PCLOOP modeled conductivity. Individual ice thickness profiles are indicated in Figure 4.

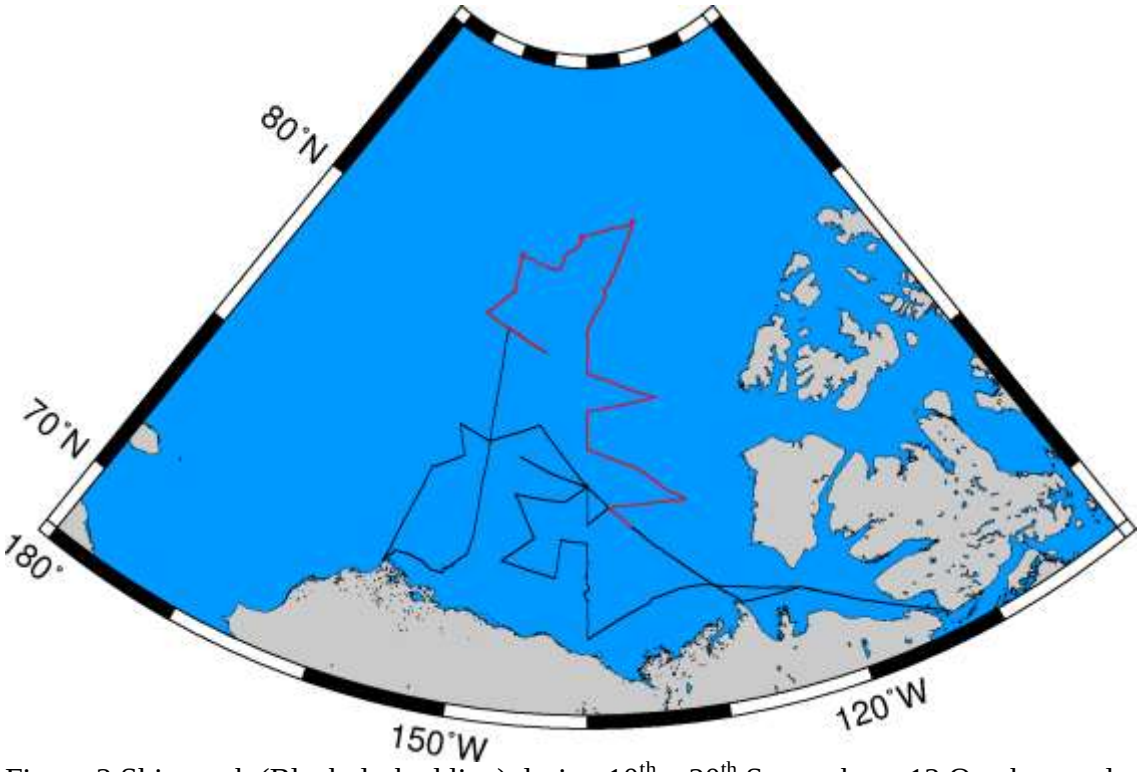


Figure 2 Ship track (Black dashed line) during 10th – 20th September - 12 October, and survey track of EM, PMR, and Net radiometer.

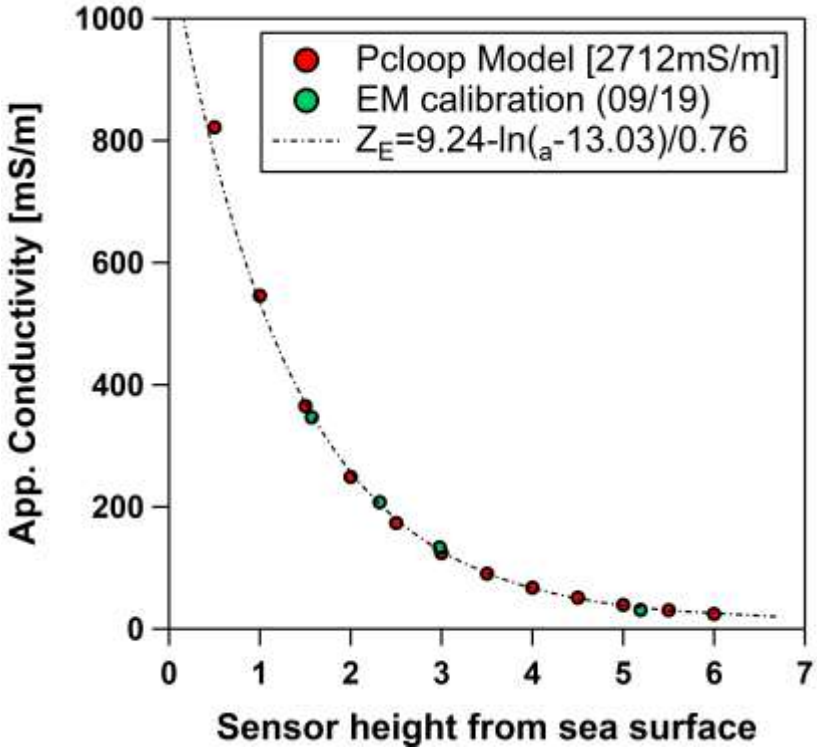


Figure 3 Result of EM calibrations open water

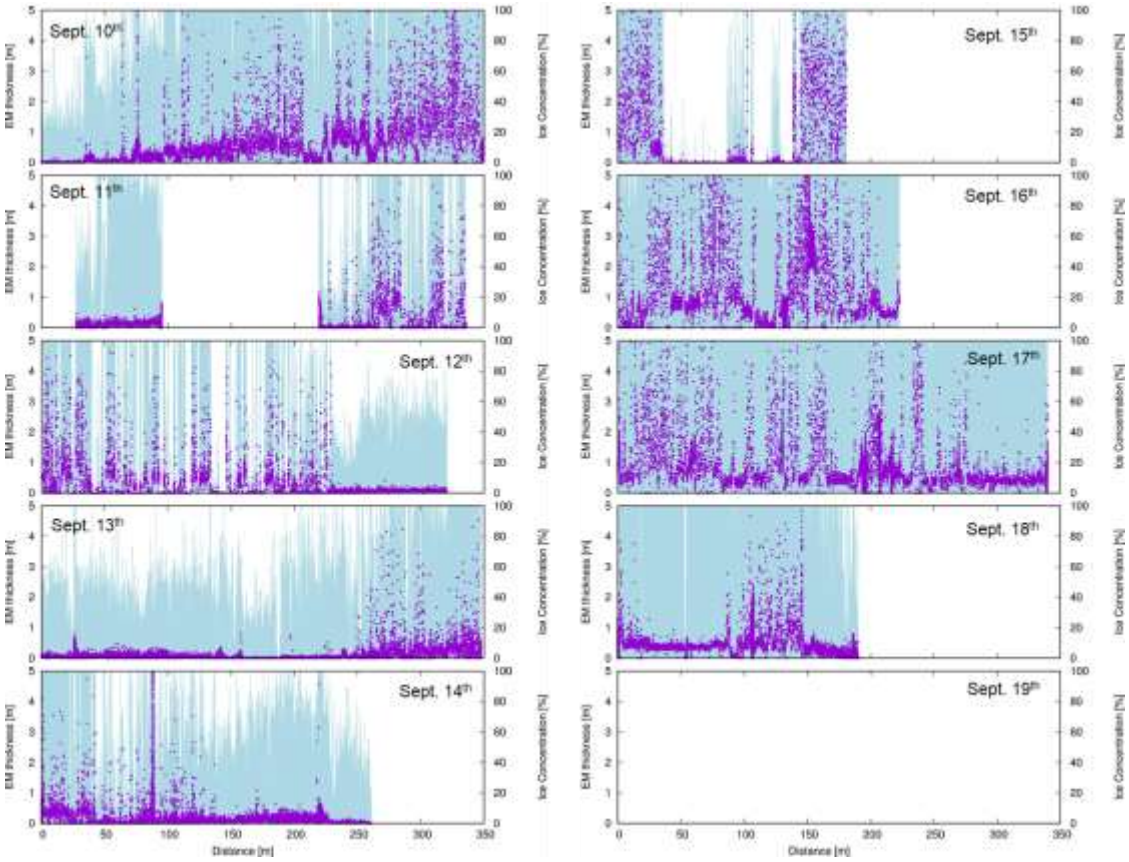


Figure 4 Profiles of EM observations.

2. Brightness Temperature (TB) and Infrared Temperature (IR) profiles

TBs (18Ghz-V, 36GHz-V, and 36GHz-H) and IR observations were carried out during September 10th to 19th (Figure 5). The total distances were xxkm. There were fewer 18GHz-V data than 36GHz-V (and H), due to sensor problems. Individual TB and IR profiles are indicated in Figure 5 and 6.

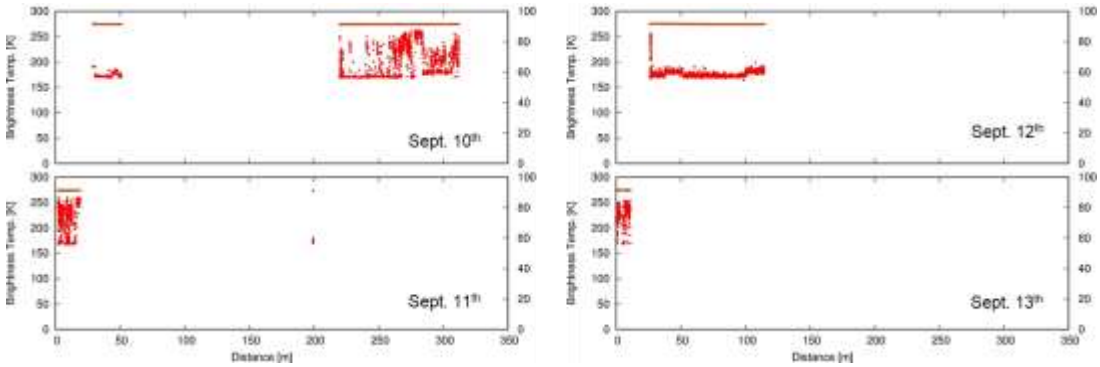


Figure 5 Profile of 18GHz-V Brightness temperature.

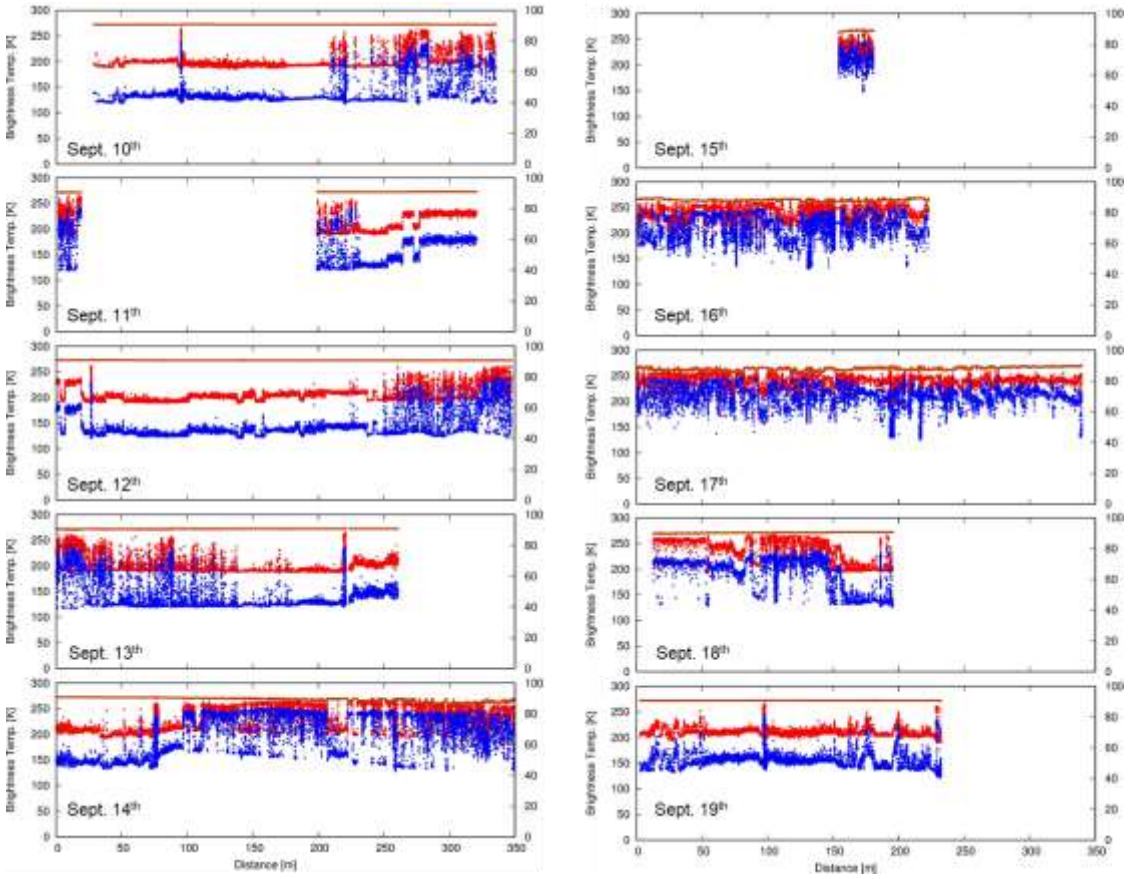


Figure 6 Profile of 36GHz-V (and H) Brightness Temperatures

3. Net Radiometer(CNR-4) Profiles

CNR-4 were carried out 11 to 19 September. Figure 7 shows the profile of shortwave, long wave and Net radiation irradiances and Albedo.

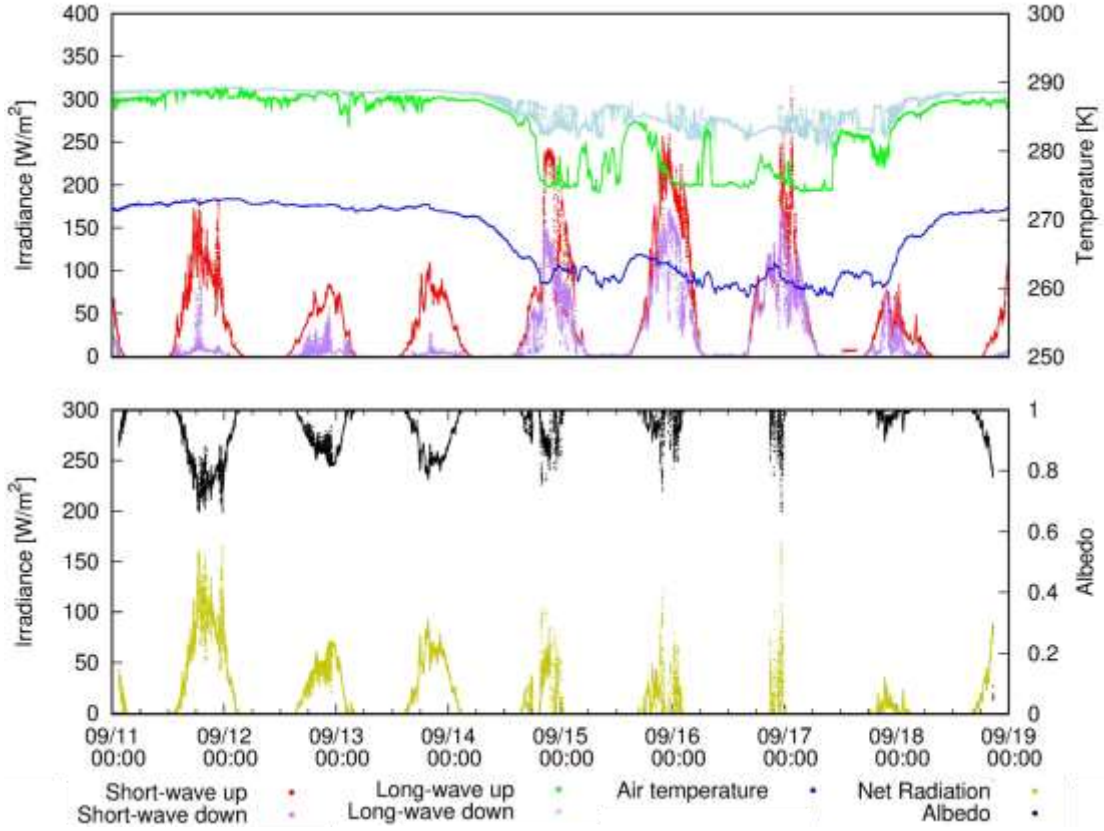


Fig.7 Profiles of Radiometer observation.

4.14 "Sponge Bobber" Surface Drifter deployments

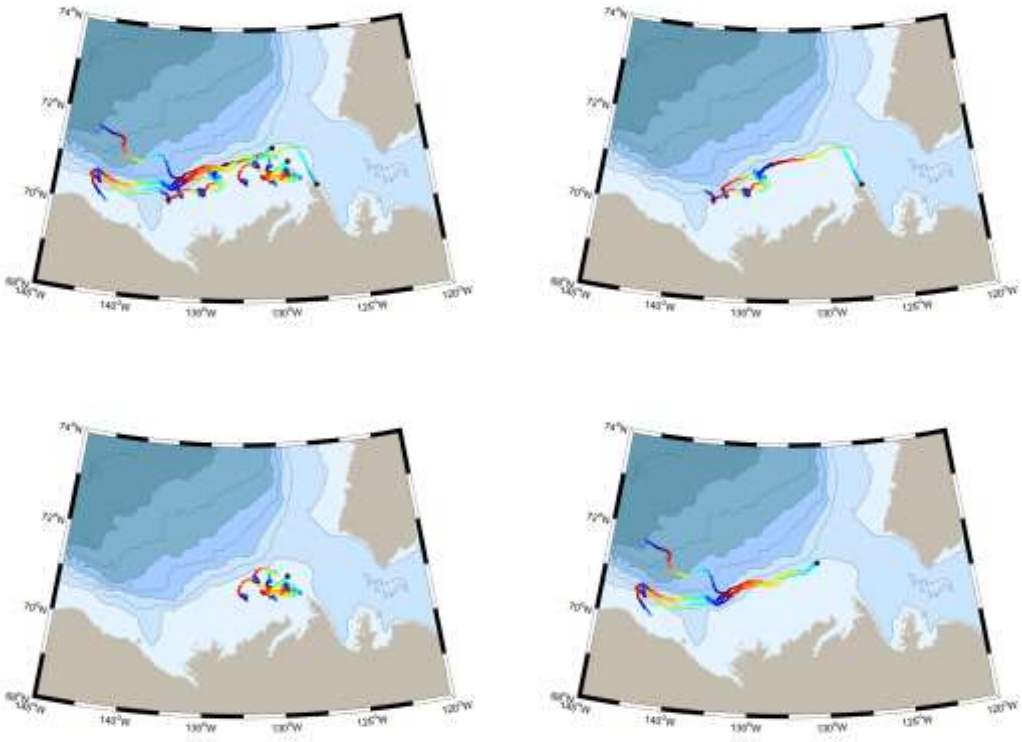
Chris Clarke (DFO-IOS)
PI Bill Williams (DFO-IOS)

'Sponge Bobber' surface drifters are designed and constructed at the Institute of Ocean Sciences and comprise of a Spot Messenger Trace, surface float and drogue (see photo above by Mengnan Zhao). Twelve Sponge Bobbers were deployed this year at the eastern end of the Canadian Beaufort Shelf, near the beginning of the expedition, to assess shelfbreak flows and upwelling flows at Cape Bathurst. The drifters were deployed in 3 groups of 4: one near Cape Bathurst, one mid-way across the shelf and one at the offshore shelfbreak. The drifters deployed at Cape Bathurst and the shelfbreak show rapid shelfbreak currents along the Canadian Beaufort Shelf from Cape Bathurst in the east, around the eastern end of the shelf and then along the shelfbreak towards Mackenzie Trough in the west. These trajectories are consistent with the strong upwelling-favourable winds (40kts) driving alongshelf flow towards the west. In contrast, the drifters deployed at the mid-shelf location show little along-shelf motion and are dominated by eddies or near inertial oscillations. The drift tracks are shown in Figures below are only for the first 11 days of deployment.

IOS SCT#	Date	UTC	Location	Latitude		Longitude	
#716	08-Sep	21:26:00	Cape Bathurst	70	33.618	127	40.982
#717	08-Sep	21:28:00	Cape Bathurst	70	33.259	127	41.587
#718	08-Sep	21:29:00	Cape Bathurst	70	33.311	127	41.712
#719	08-Sep	21:30:00	Cape Bathurst	70	33.363	127	41.897
#720	09-Sep	1:27:00	CSB Mid	71	05.979	129	33.109
#721	09-Sep	1:28:00	CSB Mid	71	06.047	129	33.289
#722	09-Sep	1:29:00	CSB Mid	71	06.106	129	33.494
#723	09-Sep	1:30:00	CSB Mid	71	16.178	129	33.769
#724	09-Sep	3:21:00	CBS Break	71	23.422	130	33.543
#725	09-Sep	3:22:00	CBS Break	71	23.452	130	33.673
#726	09-Sep	3:23:00	CBS Break	71	23.528	130	34.006
#727	09-Sep	3:24:00	CBS Break	71	23.581	130	34.225

Table xx.xx: Deployment and end time and location for the 12 'Sponge Bobber' surface drifters.

Figure: Drift tracks for the 12 sponge bobber surface drifters for the duration of the expedition (8-29 Sept 2017). The 3 drop locations are marked with black stars and the drift tracks begin coloured blue and end coloured red and change color each day. The first plot shows all 12 drifters, the following plots show each group of 4 separately.



***

5. APPENDIX

5.1 SCIENCE PARTICIPANTS 2017-11

Table 4. Onboard Science Team

Name	Affiliation	Role
Bill Williams	DFO-IOS	Chief Scientist / Surface drifters
Sarah Zimmermann	DFO-IOS	Night watchleader / data and CTD QA/QC / sample cop
Kenny Scozzafava	DFO-IOS	Dissolved Oxygen analyst
Marty Davelaar	DFO-IOS	DIC analyst (day)
Natasha Salter	DFO-IOS	DIC analyst / night watchstander
Sarah-Ann Quesnel	DFO-IOS	Nutrients analyst / Lab supervisor / Microplastics
Glenn Cooper	DFO-IOS	Day watchleader / Salinity analyst
Jasmine Wietzke	DFO-IOS	Day watchstander / Ammonium analyst
Nicole Shibley	YaleU	Day watchstander
Celine Gueguen	Trent U	Day watchstander / CDOM lead
Cassie DeFrancesco	Trent U	Night watchstander/ CDOM
Chris Clarke	DFO-IOS	Night watchleader / CTD technician / salinity analyst
Edmand Fok	DFO-IOS	Night watchstander / IT
Gina Nicoloff	Uvic	Night watchstander, zooplankton
Michiyo Yamamoto-Kawai	TUMSAT	Alkalinity analyst lead / RAS P.I.
Yuanxin Zhang	TUMSAT	Alkalinity analyst / RAS
Connie Lovejoy	Concordia U	DNA/RNA P.I.
Arthi Ramachandran	Concordia U	DNA/RNA sampling
Seita Hoshino	KIT	Ice observation + XCTD watch
David Jones	PolarTREC	Web dispatches
Mike DeGrandpre	UMontana	pCO2, SAMI
Rick Krishfield	WHOI	Moorings & ITPs & buoys / lead
Jeff O'Brien	WHOI	Moorings & ITPs & buoys
Jim Ryder	WHOI	Moorings & ITPs & buoys
Josh Mitchell	WHOI	Moorings & ITPs & buoys
Andrey Proshutinsky	WHOI	AON-BGOS program lead
Dan Torres	WHOI	LADCP
Marshall Swarts	WHOI	LADCP

Table 5. Principal Investigators Onshore for 2017-11

Name	Affiliation	Program

Motoyo Itoh	JAMSTEC	CTD/Rosette / XCTD
Shigeto Nishino	JAMSTEC	CTD/Rosette
Peter Ross	VAquarium	CTD/Rosette / Microplastics
Philippe Tortell	UBC	CTD/Rosette / CH4/N2O
John Smith	DFO-BIO	CTD/Rosette / ^{129}I / ^{134}Cs
John Nelson	DFO-IOS/Uvic	Zooplankton
Mary-Louise Timmermans	YaleU	ITP Buoys / Moorings
John Toole	WHOI	ITP Buoys
Don Perovich	CRREL	Ice Mass-Balance Buoy
Jennifer Hutchings	OSU	Ice Observations
Kazu Tateyama	KIT	Ice Observations

Table 6. Affiliation Abbreviations.

Abbreviation	Definition
APL	Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
BIO	Bedford Institute of Oceanography, DFO, Dartmouth, NS, Canada
ConcordiaU	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, Japan
KIT	Kitami Institute of Technology, Kitami, Hokkaido Prefecture, Japan
OSU	Oregon State University, Corvallis, Oregan, USA
PolarTREC	Polar Teachers and Researchers Exploring and Collaborating, Fairbanks, AK, USA
Trent U	Trent University, Ontario, Canada
TUMSAT	Tokyo University of Marine Science and Technology, Tokyo, Japan
ULaval	University of Laval, Quebec City, Quebec, Canada
UMontana	University of Montana, Missoula, Montana, USA
UOttawa	University of Ottawa, Ottawa, Ontario, Canada
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 7. Project websites

Project	Website Address

Beaufort Gyre Observing System	www.whoi.edu/beaufortgyre
Beaufort Gyre Observing System dispatches	http://www.whoi.edu/page.do?pid=159656
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	imb.erdc.dren.mil
Arctic Ocean Flux Buoy	www.oc.nps.navy.mil/~stanton/fluxbuoy
JOIS website from DFO	http://dfo-mpo.gc.ca/science/collaboration/jois-eng.html

5.2 LOCATION OF SCIENCE STATIONS for JOIS 2017-11

The scientific crew boarded the *CCGS Louis S. St-Laurent* icebreaker in Cambridge Bay, NU, on 6 September 2017 and returned to Kugluktuk, NU on 3 October 2017. 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.

5.2.1 CTD/Rosette Station List

Table 8. CTD/Rosette cast

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Cast Depth (m)	Sample number	Comments
1	CB1	2017-09-09 6:00:38 AM	71.7808	131.8780	1127	1110	1-24	Niskins 2, 9,13,20,23,and 24 did not close; altimeter was not responding, stopped at 1123m; Niskin 1: drip from spigot; Niskin 5: drip and leak from bottom of lid; Nisking 15: air vent was not closed tightly, water seems to be near surface water (1.3°C); S/N 62670 altimeter did not sense bottom.
2	CB31b	2017-09-09 14:04	72.3527	134.0060	2062	1998	25-48	Altimeter not working, stopped at ~ 15 m off of bottom; T_{max} = 667m; Niskin 11: bottom lid leaked; Niskins12 and 20 did not close.
3	CB23a	2017-09-09 21:07	72.8998	135.9912	2722	2728	49-72	Altimeter spiking all through cast. Altimeter started working close to bottom although spiking until ~50m off bottom, then good signal, no spiking, until bottom. SPAR reading 0 compared to continuous PAR sensor. Niskin 1: leaked significantly; Niskin 12: fired at 295m; Nisking 20 and 22 did not close. Niskin 12: fired at 295m,tripped at 296.8m.
4	CB22	2017-09-10 4:25	73.4468	137.9948	3085	3076	73-96	Possible problem wit chlorophyll sensor. Large values even past 500m. Niskin 6 did not close; Niskin 1: DWR for nutrients (sample #73).
5	CB50	2017-09-10 13:25	73.5038	134.2282	2858	2871	97-120	Fluorometer not working properly: readings are too high and spiky for the whole cast; Niskin 1: salt DWR collected (sample #97); Niskin 2: top vent was too tight, leaking from spigot.
6	CB51	2017-09-11 2:57	73.4975	131.0688	2532	2518	121-144	Issues with CTD pump control, took ~6 hours to fix it, hence late deployent of CTD; 0.057 VI block beam. 4.61 open beam in air. Mooring release test cancelled; Niskin 1: leaking vent, check on spigot; Niskin 6 and 13 didn't fire; Niskin 17: opened before oxygen sampled; SCM determined from the transmissometer minimum because fluorescence didn't work

7	CB40	2017-09-11 15:54	74.4950	135.4120	3243	3241	145-168	Chl-a_{max} = 76 m; tested mooring release at 3219m.
8	CB18	2017-09-12 1:02	74.9995	139.9722	3603	3613	169-192	Niskin 8: top vent is leaking; Oxygen flask 835 is cracked; Broke oxygen flask 845, used 859 instead and put it in 845's space.
9	CB17	2017-09-12 9:30	76.0005	139.9928	3676	3686	193-216	Alt = 10; FYI: Wire tension from BOT block, calm seas at CB17. 3000m: 1180# down, 1330# up. Switched winche's gear high/low at 500 m. Calm seas.
10	PP6	2017-09-12 23:13	76.2530	132.4818	3029	3024	217-240	Pump turned on at 50 m. CTD brought back to surface and re-lowered. Mooring release test at bottom; Niskin 2: vent left open; Niskin 8: either vent or spigot was open; oxygen cap 822 broken; put waterproof rosette; vast coverage of very thin ice.
11	PP7	2017-09-13 8:34	76.5387	135.4192	3548	3557	241-264	WHOI Gyro added to frame for cast; Niskin 6: replaced before cast due to broken mounting bracket, but forgot to close spigot and left vent open, so no sample; Niskin 11: endcap was mostly but not fully seated; Niskin 12: lanyard from niskin 11 caught 12 bottom lid, endcap of 12 did not seat fully and drained, no water; replaced missing 34.7 PSU (from empty niskin 12) Iodine sample with 34.4PSU (#253 duplicate).
12	CB15	2017-09-13 19:35	76.9995	139.9968	3721	3722	265-288	Data acquisition stopped at 5m, 5m to surface in 2017-11-0012-pump. Sample #265, 269, 272, 278 of Iodine were not taken because there wasn't enough water; Niskin 8: top cap had slight leak .
13	CB16	2017-09-14 3:09	78.0037	140.0503	3747	3745	289-312	Zooplankton tow (100, 500m) could not be performed due to high winds, > 25 kts.
14	CBN3	2017-09-15 8:25	80.9595	132.1842	3641	1002	313-333	DNA cast, Ice chummy on.
15	CBN3	2017-09-15 10:40	80.9505	132.1397	3639	3641	334-357	Geochemistry cast; Niskin 15: oxygen: could not open oxygen flask #847 for duplicate, used #859 instead.
16	NE1.5	2017-09-16 8:02	80.6205	141.1433	3760	3756	358-381	Geochemistry cast; Put ice chummy at bottom; Clear PCO_2 air intake, Snow falls; Niskin 1: extra water for NH_4 DWR; Niskin 2: extra water for NH4 DWR.

17	NE1.5	2017-09-16 12:06	80.6157	141.0612	3760	1005	382-405	Microplastics cast; Niskin 1,2,3,4 (bottom set) and 21,22,23,24 (5m set) tripped with stop; Niskin 1-4: white chunk of something caught in the sieve; Niskin 5-8: tripped between 404-397m, no stops; Niskin 9-12: tripped between 203-199m, no stop; Nisking 13-16: tripped between 160-156m, no stop; Niskin 17-20: tripped between 52-49m, no stop.
18	CB11b	2017-09-17 10:09	79.9957	149.9767	3808	3801	406-429	Jellyfish tentacles on the rosette; Ice chummy on; Niskin 9: fired at 361m, depth of target property (34.78) originally written as 365m, then crossed out and replaced with 349m; Niskin 18: slow drip from bottom end cap; Niskin 22: did not close; Niskin 23 and 24: yo-yo stop before closing bottles, but there was a bit of confusion so after 1m up, 2m down, the winch man brought it to the surface instead of waiting at 5m, CTD S = 27.851
19	CB11	2017-09-17 23:10	78.9863	149.9820	3811	3808	430-453	Niskin 23: CTD S = 27.682; Giant jelly fish on top of rosette.
20	CB10	2017-09-18 6:37	78.3112	153.1060	2400	2801	454-477	Niskin 1: CTD operator was too busy with sounder setting as it was not functionning properly, thought it was B-100; Speed changed to 60 m/min at ~330m; Niskin 24: USM, CTD S = 27.887
21	CB9 plastic	2017-09-18 13:29	78.0082	150.0507	3817	1003	478-501	Niskin 21,22,23,24: USM, CTD S = 27.179. All bottles tripped on the fly, except for 5 m bottles - yo-yo first, stopped and tripped.
22	CB12.5	2017-09-19 3:59	77.5123	145.0693	3801	3788	502-525	Niskin 8: leaky top vent. Niskin 10: D.O. flask (#842) lid broke Niskin 24: USM, CTD S = 27.447
23	CB9 DNA	2017-09-19 11:54	77.9995	150.0065	3827	1002	526-549	Niskin 16, 17, 18 and 22, 23, 24 -> USM
24	CB9	2017-09-19 14:01	77.9972	149.9302	3827	3812	550-573	Niskin 11: leak from bottom cap, lanyard caught cap of Niskin 12, Niskin 18: slow leak from bottom end cap.
25	CB8	2017-09-20 4:30	77.0087	149.9868	3828	3815	574-597	Down at 60 m/min at 366m; Niskin 5: sample for SUNA (nitrate sensor) calibration; Niskin 9: took NH_4 samples for test (6x40ml); Niskin 14: sample for SUNA (nitrate sensor) calibration; Niskin 20: depth decided to capture second peak in chlorophyll + temperature; Niskin 24: sample for SUNA (nitrate sensor) calibration.

26	CB7	2017-09-20 11:26	75.9995	149.9893	3831	3819	598-621	Niskin 4: lost bacteria sample, spilled sample while adding paraformaldehyde; Niskin 8: drip from spigot; Niskin14: no water for DOM; Niskin 19: drip from bottom end cap.
27	CB3	2017-09-21 3:23	74.0095	150.0160	3827	3814	622-645	Niskin 22: D.O. re-draw.
28	CB2	2017-09-21 10:27	73.0007	150.0030	3747	3737	646-669	Niskin 7: NH_4 18 stds+blanks collected; Niskin 18: slow drip from bottom end cap after D.O. sample collected; Niskin 24: Chl-*a(b)* -> DOM -> Chl-*a(a)*. *No longer taking bacteria from all Niskins.
29	BL8	2017-09-21 17:30	71.9522	150.2950	2977	2953	670-693	Niskin 2: Slow leak from bottom cap; Niskin 7: 18 NH_4 std + blanks collected.
30	BL6	2017-09-21 21:31	71.6802	151.1440	2086	2073	694-717	Niskin 2: D.O. sample messed up; Niskin 3: didn't close; Niskin 18: bottle was replaced; Niskin 22: take microplankton sample for Arthi (ConcordiaU); Niskin 24: take sample for Arthi (ConcordiaU).
31	BL5	2017-09-22 0:58	71.6125	151.3710	1736	1787		CTD only, no biogeochemistry smaples.
32	BL4	2017-09-22 4:11	71.5218	151.5817	1125	1152	718-741	Altimeter reading didn't come in, so stopped the CTD at 1151m; Niskin 3: took 2 x18 tubes for NH_4 (backup for Stds for BL-2)
33	BL3	2017-09-22 6:59	71.4650	151.8255	492	474	742-760	Transmissometer readaings were spiky, checked connectors. Greenish blue waters. Large Jellyfish in ocean surface; Seas have been picking up.
34	BL2	2017-09-22 10:22	71.3945	151.9522	165	162	761-773	Bottom: Alt -6; No USM as seas were too rough for stopping at 5 meter. So stopped at 10, waited then came straight and out of water; Coordinates are from the Bridge logs; Niskin 1,2,3: missed NH_4 samples.
35	BL1	2017-09-22 12:58	71.3618	152.0835	84	74	774-786	Coordinates from the Bridge logs; Niskin 1: slow drip from bottom end cap; Niskin 8: slow drip from bottom end cap. Seas were too rough for stopping at 5 m to collect surface niskin water, tripped on the fly. Rosette was stopped at 10 m, paused and waited for good opportunity to pull rosette straight up and out without swinging.
36	BLW	2017-09-23 4:13	72.4113	156.2482	1320	1289	787-810	Niskin 9: leaking bottom cap.

37	CBSW	2017-09-23 12:58	73.9978	155.0160	3857	3838	811-834	Altimeter reading doesn't show until 40m off bottom, may need to change frequency to 5 Hz.; Niskin 9, 10: leaking bottom end cap.
38	CBW2	2017-09-23 19:17	74.5022	152.2633	3845	3834	835-858	Niskin 9,10: leaking bottom end cap, #9 had a chip at top so niskin was replaced, #10 looked fine so just replaced O-rings.
39	CB5	2017-09-24 2:03	75.2977	153.2782	3848	3832	859-882	Niskin 5: bottom cap leaking. Niskin 20: niskin 19's lanyard wrapped around niskin 20.
40	CB4 plastic	2017-09-24 8:43	75.0007	150.0003	3829	1002	883-906	Niskin 18: tripped but did not close.
41	CB4	2017-09-24 10:53	75.0008	149.9945	3829	3817	907-930	Niskin 9: not sampled for CDOM because depth was changed; Niskin 10: change bacteria sample from Niskin 9 to 10 because depth has changed.
42	CB4 DNA	2017-09-24 14:51	75.0007	150.0027	3829	1004	931-954	Niskin 16, 17, 18 and 22, 23, 24: yo-yo
43	CBC2	2017-09-25 5:34	75.5678	145.0125	3783	3770	955-978	
44	CB27	2017-09-26 2:21	73.0038	140.0007	3230	3205	979-1002	Niskin 13: bottom cap leaking.
45	CB22 repeat	2017-09-26 7:45	73.4515	138.0200	3139	3113	1003-1026	Niskin 5: top vent left open.
46	CB21 Plastic	2017-09-26 14:04	73.9985	139.9972	3513	1003	1027-1050	Niskin 1: slow drip; Niskin 8: slow drip; Niskin 9-12-20: stopped 30 sec but no USM; Niskin 21-24: USM.
47	CB6	2017-09-27 4:20	74.6947	146.6612	3778	3769	1051-1074	
48	CB19	2017-09-27 11:10	74.3020	143.3093	3699	3689	1075-1098	Stop @ 300 meter for cups. Receive cups @ 324 meters; Niskin 1: DWR for salinity; Niskin 9: fast leak; Niskin 13: steady leak from end cap.
49	CB21 DNA	2017-09-27 23:18	73.9980	139.9927	3510	1003		Ignore bottle file as cast was redone. Samples collected on cast 50. Forgot prep the rosette before launching.
50	CB21 DNA	2017-09-28 0:48	74.0005	139.9968	3514	1003	1099-1122	Niskin 16-18 and 22-24: USM.
51	CB21	2017-09-28 3:10	73.9973	139.9850	3508	3498	1123-1146	Niskin 24: USM

52	STN A	2017-09-28 21:09	72.6013	144.6958	3435	3421	1147-1170	For Iodine sampling -> Niskin 5,8,14: used new 500 mL bottle, no rinse. Niskin 24: used 1L bottle from Chl & Nutrient labs (brown nalgone bottle) -rinsed, USM
53	CB29	2017-09-29 20:26	72.0087	139.9810	2696	2670	1171-1194	Niskin 1: bottom cap had slow leak; Niskin 8: top cap leaked significantly; Niskin 23: move D.O. duplicate from sample #1194 to #1193
54	MK6	2017-09-30 0:32	71.6057	140.0395	2525	2505	1195-1218	Niskin 8: 2 standard sample set needed for NH_4 (14 in one, 18 in other) from 450 m to 500 m water; Niskin 24: USM.
55	CB28b	2017-09-30 9:32	71.0007	139.9945	2083	2072	1219-1242	Niskin 6: 28 X NH_4 stds tubes collected from 500m; Niskin 13: slow drip from spigot; Niskin 23-24: USM.
56	MK3	2017-09-30 14:01	70.5790	139.9852	840	809	1243-1266	Nisikin 8: leak from spigot; Niksin 19: leak from spigot (vent was closed, top cap might of not seated properly)
57	cb28aa	2017-09-30 17:53	69.9965	139.9777	61	54	1267-1279	Pump wasn't on, brought up to surface and deployed again at 18:04; Niskin 12-13: USM.
58	AG5 DNA	2017-10-01 19:05	70.5467	122.9077	647	626	1280-1303	Niskin 1,2,3: no USM out of caution. Niskin 1: Slow leak from bottom end cap. Niskin 4,5,6: not really T_{max}, asymptote (??); Niskin 4-24: USM
59	AG5	2017-10-01 21:29	70.5437	122.8932	631	610	1304-1323	

5.2.2 XCTD

Table 9. XCTD cast deployment locations

Event Number	Filename	Date	Latitude (N)	Longitude (W)	Max depth (m)	Comments
16	C5_00019	2017-09-08 15:23	70.5507	122.1143	654	S/N 16016704, 15 kt
17	C3_00020	2017-09-09 10:44	72.0961	133.0308	1100	S/N 16017050
18	C3_00021	2017-09-09 18:24	72.6286	134.9910	1100	S/N 16017051
19	C3_00022	2017-09-10 2:44	73.1974	137.0248	1100	S/N 6017054
20	C5_00023	2017-09-10 10:00	73.4719	136.1341	1000	S/N 16016707
21	C3_00024	2017-09-10 19:06	73.4951	132.5175	1100	S/N 16017053
22	C3_00025	2017-09-11 12:09	74.1654	133.9138	1100	S/N 160117049
23	C3_00027	2017-09-11 22:47	74.7525	137.7137	1100	S/N 16017057
24	C3_00028	2017-09-12 7:13	75.5050	139.9998	1100	S/N 16017052
25	C3_00029	2017-09-12 13:58	76.0656	138.1514	1100	S/N 16017055
26	C3_00030	2017-09-12 16:00	76.1229	136.3876	1042	S/N 16017056
27	C3_00031	2017-09-12 19:29	76.1898	134.4781	1034	S/N 16017060
28	C3_00032	2017-09-13 4:54	76.3977	133.9708	1100	S/N 16017059
29	C3_00033	2017-09-13 14:39	76.7562	137.2670	1034	S/N 16017058
30	C5_00034	2017-09-14 0:27	77.4884	139.9713	1000	S/N 16016710; too fast
31	C3_00035	2017-09-14 9:49	78.5116	139.0390	103	S/N 16017010.
32	C4_00036	2017-09-14 10:00	78.5302	138.9929	1478	S/N 15115707; 2 kt
33	C4_00037	2017-09-14 13:19	78.9906	137.7639	1809	S/N 15115710
34	C4_00038	2017-09-14 17:24	79.3759	136.6232	1850	S/N 15115711; ship speed 0 kt.
35	C4_00039	2017-09-14 21:47	79.8716	135.3738	1850	S/N 15115712; ship stopped
36	C3_00040	2017-09-15 1:53	80.3200	134.1027	1044	S/N 16017006

37	C4_00041	2017-09-15 6:04	80.7755	132.7072	1734	S/N 15116022
38	C4_00042	2017-09-16 0:40	80.8093	135.4338	1829	S/N 15116019; ship moving very slowly
39	C4_00043	2017-09-16 4:16	80.6892	138.6056	1850	S/N 15116013; ship stopped, dropped probe in a hole in the ice.
40	C4_00044	2017-09-17 0:02	80.1560	143.0372	1836	S/N 15116014; ship speed 3 kt
41	C4_00045	2017-09-17 3:59	79.6895	144.1838	1850	S/N 15116017; ship stopped
42	C4_00046	2017-09-17 7:11	79.8379	147.8459	1850	S/N 15116020; ship stopped
43	C4_00047	2017-09-17 20:26	79.5607	149.9420	1820	S/N 15116018
44	C4_00048	2017-09-18 4:05	78.6476	151.6479	612	S/N 15116021; Broke early so launched another.
45	C4_00049	2017-09-18 4:12	78.6477	151.6505	1850	S/N 15116023
46	C4_00050	2017-09-18 10:57	78.1542	151.6265	1850	S/N 15116024
47	C3_00052	2017-09-19 0:58	77.7833	147.6031	1033	S/N 16017007
48	C3_00053	2017-09-20 2:20	77.4904	150.0764	1028	S/N 16017011
49	C5_00054	2017-09-20 9:19	76.9898	149.9703	754	S/N 16016780; Accidentally stopped early (mis-communication).
50	C5_00055	2017-09-20 15:52	75.5127	150.0194	1000	S/N 16016774
51	C4_00056	2017-09-20 22:57	75.0072	149.9289	1850	S/N 15116038
52	C5_00057	2017-09-21 1:12	74.5109	145.9297	1000	S/N 16016775
53	C3_00058	2017-09-21 8:10	73.4991	150.0155	1100	S/N 16017004; depth sounder not working, check with bridge
54	C3_00059	2017-09-21 14:57	72.5077	150.0083	1025	S/N 16017009
55	C3_00060	2017-09-21 20:23	71.8220	150.7779	1016	S/N 16017012
56	C3_00061	2017-09-20 8:02	72.9679	155.8251	1100	S/N 16017005; Ship apeed 10 kt in open water.
57	C3_00062	2017-09-21 10:05	73.4307	155.4124	1000	S/N 16016777; Ship speed 10 kt
58	C5_00063	2017-09-23 17:20	74.2480	153.6417	1000	S/N 16016778

59	C5_00064	2017-09-23 23:47	74.8831	152.7546	1000	S/N 16016776
60	C3_00065	2017-09-24 6:43	75.1442	151.5893	1090	S/N 16017003
61	C5_00066	2017-09-25 1:22	75.2107	148.2546	1000	S/N 16016779
62	C5_00067	2017-09-25 3:26	75.3934	146.5762	1000	S/N 16016773
63	C5_00068	2017-09-25 10:01	75.1908	143.7361	1000	S/N 16016781; Ship speed 15 kt
64	C5_00069	2017-09-25 12:03	74.7924	142.4377	1000	S/N 16016784; Ship speed 15 kt
65	C5_00070	2017-09-25 14:06	74.3867	141.1982	1000	S/N 16016783; Ship speed 15 kt
66	C5_00071	2017-09-25 23:13	73.5723	139.9853	1000	S/N 16016782
67	C5_00072	2017-09-26 6:11	73.2198	139.0483	1000	S/N 15115625
68	C5_00073	2017-09-26 11:28	73.7048	138.8992	1000	S/N 15115626
69	C5_00074	2017-09-26 19:14	74.1486	141.6330	1000	S/N 15115628
70	C5_00075	2017-09-26 23:55	74.4690	144.7230	1000	S/N 15115636
71	C5_00076	2017-09-28 8:52	73.6024	142.0507	1000	S/N 15115636; Ship speed 14 kt
72	C5_00077	2017-09-28 11:39	73.6355	144.3965	1000	S/N 15115634; Ship speed 15 kt
73	C5_00078	2017-09-28 14:16	73.7023	146.7044	1000	S/N 15115631; Ship speed 15 kt
74	C5_00079	2017-09-28 17:06	73.1254	145.6358	1000	S/N 15115632
75	C5_00080	2017-09-29 2:51	72.2520	146.0319	1000	S/N 1511629; Ship speed 15.9 kt
76	C5_00081	2017-09-29 4:54	71.9183	147.3267	1000	S/N 15115630; Ship speed 12 kt
77	C5_00082	2017-09-29 7:03	71.8018	145.7017	1000	S/N 15115627; Ship speed 15.5 kt in open water
78	C5_00083	2017-09-29 9:03	71.6902	144.1132	1000	S/N 15115633; Ship speed 15 kt
79	C5_00084	2017-09-29 10:52	71.5842	142.6655	1000	S/N 16016772; Ship speed 15 kt
80	C5_00085	2017-09-29 12:53	72.0901	142.4950	1000	S/N 16016771; Ship speed 15 kt
81	C5_00086	2017-09-29 14:49	72.5804	142.3497	1000	S/N 16016770; Ship speed 15 kt
82	C5_00087	2017-09-29 17:37	72.5139	140.1029	1000	S/N 16016767; Ship speed 15 kt
83	C5_00088	2017-09-30 12:11	70.8195	139.9856	1000	S/N 16016768; Ship speed 12.2 kt

84	C5_00089	2017-09-30 15:34	70.3926	139.9345	511	S/N 16016769
85	C5_00090	2017-09-30 16:32	70.2308	139.9951	262	S/N 16016766
85	C5_00091	2017-09-30 22:57	70.5638	135.0950	1000	S/N 16016763; Ship speed 15 kt

5.2.3 Zooplankton – Vertical Bongo Net Hauls

Table 10. Zooplankton vertical bongo net hauls.

Summary of samples taken at each station, based on net mesh size (150 or 236µm) and tow depth (100 and/or 500m). The 236 µm samples were preserved in 95% ethanol (EtOH), while the 150 µm samples were preserved in buffered formalin (Formalin).

Net Event #	CTD cast #	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Net Mesh (um)	Bottom Depth (m)	RBR depth (m)	Pres. Method	Comments
1	1	2017-09-09	6:39	71.7810	131.8957	150	1132	110.0	Formalin	
						236			EtOH	
2	2	2017-09-09	14:29	72.3512	131.0088	150	2063	95.3	Formalin	
						236			EtOH	
3	3	2017-09-09	21:35	72.8938	131.9865	150	2723	95.6	Formalin	
						236			EtOH	
4	4	2017-09-10	4:57	73.4443	131.9995	150	3087	90.2	Formalin	High winds
						236			EtOH	
5	5	2017-09-10	13:55	73.5000	131.2248	150	2854	95.5	Formalin	One small jelly.
						236			EtOH	
6	6	2017-09-11	3:21	73.4925	131.0652	150	2532	96.5	Formalin	
						236			EtOH	
7		2017-09-11	3:52	73.4912	131.0582	150	2532	496.2	Formalin	
						236			EtOH	
8	7	2017-09-11	16:23	74.4950	131.4062	150	3243	97.7	Formalin	
						236			EtOH	
9	8	2017-09-12	1:29	74.9992	131.9735	150	3603	90.4	Formalin	
						236			EtOH	
10	9	2017-09-12	10:10	76.0035	131.9843	150	3675	100.7	Formalin	

						236			EtOH	
11	10	2017-09-12	23:38	76.2532	131.4780	150	3028	100.4	Formalin	
						236			EtOH	
12	11	2017-09-13	9:03	76.5383	131.4127	150	3548	99.2	Formalin	Wood paint and metal in samples
						236			EtOH	
13	12	2017-09-13	20:15	77.0072	131.0005	150	3722.3	92.3	Formalin	One of the nets wasn't sprayed down on one side due to high winds - needed to get the nets on board
						236			EtOH	
14	15	2017-09-15	11:08	80.9492	131.1320	150	3640	n/a	Formalin	Did not record 100 cast due to frozen RBR sensor. Net had to be put back in water up to metal while new hose was found to avoid freezing.
						236			EtOH	
15	15	2017-09-15	12:08	80.9447	131.1115	150	3640	494.9	Formalin	
						236			EtOH	
16	16	2017-09-16	8:54	80.6190	131.1317	150	3766	97.5	Formalin	Meter on winch froze. Nets came back to surface from 56.6 m at 0.4m/s, then back down to 100m. Flowmeter readings were incorrect. RBR data showed this.
						236			EtOH	
17		2017-09-16	9:34	80.6190	131.1207	150	3760	503.6	Formalin	Uploaded RBR data after this
						236			EtOH	
18	18	2017-09-17	11:10	79.9932	131.9500	150	3808	96.0	Formalin	Let out extra 5m due to angle. Went down to 38.7m before counter unfroze. Then brought to surface and started 100m tow. Flow meter readings will be off.
						236			EtOH	
19		2017-09-17	11:44	79.9915	131.9333	150	3808	500.4	Formalin	
						236			EtOH	
20	19	2017-09-17	23:50	78.9862	131.9752	150	3811	102.1	Formalin	
						236			EtOH	
21		2017-09-18	0:21	78.9868	131.9732	150	3811	500.5	Formalin	

						236			EtOH	
22	20	2017-09-18	7:12	78.3134	131.1008	150	2400	99.0	Formalin	
						236			EtOH	
23	22	2017-09-19	4:34	77.5181	131.0713	150	3820	94.2	Formalin	
						236			EtOH	
24	24	2017-09-19	14:24	77.9962	131.9146	150	3827	95.8	Formalin	Large jellyfish in sample, Gina Nicoloff took photos and preserved it frozen in whirlpack. Some zooplankton may have been lost on jellyfish.
						236			EtOH	
25		2017-09-19	15:11	77.9939	131.8974	150	3827	500.5	Formalin	Jellyfish remnants probably in sample
						236			EtOH	
26	25	2017-09-19	4:58	77.0098	131.9882	150	3828	100.6	Formalin	
						236			EtOH	
27	26	2017-09-20	11:47	75.9988	131.9818	150	3831	102.9	Formalin	Let out extra 5m due to angle
						236			EtOH	
28	27	2017-09-21	3:58	74.0058	131.0176	150	3827	98.5	Formalin	
						236			EtOH	
29	28	2017-09-21	10:46	73.0004	131.0043	150	3736	100.8	Formalin	
						236			EtOH	
30	29	2017-09-21	17:50	71.9519	131.2909	150	2967	100.8	Formalin	Let out extra 5m due to angle
						236			EtOH	
31		2017-09-21	18:24	74.9535	131.2923	150	2967	512.8	Formalin	
						236			EtOH	
32	30	2017-09-21	21:54	71.6782	131.1465	150	2079	131.6	Formalin	
						236			EtOH	
33	32	2017-09-22	4:34	71.5238	131.5936	150	1125	101.1	Formalin	
						236			EtOH	
34	35	2017-09-22	12:35	71.3597	131.0708	150	83.44	33.8	Formalin	Wind ~27 kt. Label in jar reads event 24 instead of 34.

						236			EtOH	
35	37	2017-09-23	13:15	73.9982	131.0212	150	3854	98.8	Formalin	
						236			EtOH	
36	38	2017-09-23	19:34	74.5026	131.2625	150	3848	101.6	Formalin	
						236			EtOH	
37	39	2017-09-24	2:30	75.3018	131.2918	150	3848	99.8	Formalin	Had to stop at ~20m on upcast due to wire inboard of ship.
						236			EtOH	
38	41	2017-09-24	11:15	74.9996	131.8241	150	3829	95.3	Formalin	
						236			EtOH	
39		2017-09-24	11:51	74.9984	131.9747	150	3829	493.2	Formalin	Flow end may be 52193, which was the start number of the next net event.
						236			EtOH	
40	44	2017-09-26	2:42	72.9984	131.0061	150	3228	96.6	Formalin	
						236			EtOH	
41	45	2017-09-26	8:22	73.4502	131.0233	150	3135	100.8	Formalin	
						236			EtOH	
42	48	2017-09-27	11:36	74.2988	131.3045	150	3698	108.0	Formalin	Wind ~15 kt, rough seas
						236			EtOH	
43	51	2017-09-28	3:32	74.0040	131.9811	150	3508	81.8	Formalin	Was windy so couldn't fully spray down nets - had to bring nets in right away and only sprayed down bottom 2-3 feet of nets.
						236			EtOH	
44		2017-09-28	4:03	74.0044	131.9727	150	3508	499.1	Formalin	
						236			EtOH	
45	52	2017-09-28	21:37	72.6017	131.6995	150	3435	99.7	Formalin	Big swell so had to put nets down to bottom at ~0.1m/s
						236			EtOH	
46	52	2017-09-28	22:14	72.6030	131.9052	150	3435	477.8	Formalin	Noted that wood chunks in any of the samples may be from the box the nets sit in when not being used.
						236			EtOH	

47	58	2017-10-01	19:28	70.5440	131.9052	150	638.98	99.9	Formalin	AG5 RBR data shows inconsistent descent due to rough conditions
						236			EtOH	
48	58	2017-10-01	20:39	70.5403	131.8772	150	632.9	478.8	Formalin	Stopped at 30m on way up because wire was under ship. Bongos surfaced ~20m away from boat and "surfed" rest of way in.
						236			EtOH	Was windy so couldn't fully spray down nets (had to bring nets in right away and only sprayed down bottom 2-3 feet of nets)

5.2.4 Microbial Diversity Casts

Table 11. Locations of microbial diversity stations.

At each station, 1-8 depths were sampled and were defined as either: surface (~5 m), mixed layer (ML,~20-40 m), subsurface chlorophyll maximum (SCM), 32.3 psu, Pacific Winter Water (33.1, 33.1 psu), temperature maximum (T_{max}, ~450-500m), Atlantic Water (AW, ~800 m), and bottom minus 10 m (B-10). See **Figure X** for map of CTD/Rosette casts).

Station	Cast#	Date and time (UTC)	Latitude (°N)	Longitude (°W)	Samples	Depth sampled
CB-1	1	2017-09-09 6:00:38 AM	71.7808	131.8780	DNA	SCM
CB-31b[b]	2	2017-09-09 2:04:30 PM	72.3527	134.0060	DNA, ChlFCM, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-51[d]	6	2017-09-11 2:57:15 AM	73.4975	131.0688	DNA, ChlFCM, DAPI Euk, FISH Bact, Fish Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-40[a]	7	2017-09-11 3:54:05 PM	74.4950	135.4120	DNA, Live FCM, ChlFCM, DAPI Euk, FISH Bact, FISH Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-17[c]	9	2017-09-12 9:30:38 AM	76.0005	139.9928	DNA, Live FCM, ChlFCM, DAPI Euk, FISH Bact, FISH Euk	5, SCM, 33.1, T_{max}, AW, B-10
PP6[g]	10	2017-09-12 11:13:09 PM	76.2530	132.4818	DNA, Live FCM, ChlFCM, DAPI Euk, FISH Bact, FISH Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-15[f]	12	2017-09-13 7:35:49 PM	76.9995	139.9968	DNA, Live FCM, ChlFCM, DAPI Euk, FISH Bact, FISH Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-N3	14	2017-09-15 8:25:50 AM	80.9595	132.1842	DNA, Prot, Live FCM, ChlFCM, HPLC, DAPI Euk, FISH Bact, FISH Euk	5, ML, SCM, 32.3, 33.1, T_{max}, AW, B-10
CB-11b	18	2017-09-17 10:09:09 AM	79.9957	149.9767	DNA, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-11[a]	19	2017-09-17 11:10:59 PM	78.98633	149.982	DNA, Live FCM, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-9[a]	23	2017-09-19 11:54:36 AM	77.9995	150.0065	DNA, Prot, Live FCM, ChlFCM, HPLC, DAPI Euk, FISH Bact, FISH Euk	5, ML, SCM, 32.3, 33.1, T_{max}, AW, B-10
CB-7[h]	26	2017-09-20 11:26:13 AM	75.9995	149.9893	DNA, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-3[a]	27	2017-09-21 3:23:55 AM	74.0095	150.0160	DNA, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
CB-2[a]	28	2017-09-21 10:27:38 AM	73.0007	150.0030	DNA, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
BL-8[g]	29	2017-09-21 5:30:09 PM	71.9522	150.2950	DNA, DAPI Euk	5, SCM, 33.1, T_{max}, AW, B-10
BL-4[e]	32	2017-09-22 4:11:16 AM	71.5218	151.5817	DNA, DAPI Euk	5, SCM, 33.1, Tmax, 500m, B-10

BL-1[e]	35	2017-09-22 12:58:03 PM	71.3618	152.0835	DNA, Live FCM, DAPI Euk	5, SCM, 30m, 40m, 60m, B-10
CB-SW	37	2017-09-23 12:58:17 PM	73.9978	155.0160	DNA	5, SCM, 33.1, Tmax, AW, B-10
CB-4[f]	42	2017-09-24 2:51:04 PM	75.0007	150.0027	DNA, Prot, Live FCM, ChlFCM, HPLC, DAPI Euk, FISH Bact, FISH Euk	5, ML, SCM, 32.3, 33.1, Tmax, AW, B-10
CB-27[c]	44	2017-09-26 2:21:19 AM	73.0038	140.0007	DNA	5, SCM, 33.1, Tmax, AW, B-10
CB-6[i]	47	2017-09-27 4:20:46 AM	74.6947	146.6612	DNA	5, SCM, 33.1, Tmax, AW, B-10
CB-21[a]	50	2017-09-28 12:48:44 AM	74.0005	139.9968	DNA, Prot, Live FCM, ChlFCM, HPLC, DAPI Euk, FISH Euk	5, ML, SCM, 32.3, 33.1, Tmax, AW, B-10
Stn-A[a]	52	2017-09-28 9:09:07 PM	72.6013	144.6958	DNA	5, SCM, 33.1, Tmax, AW, B-10
CB-29[k]	53	2017-09-29 8:26:36 PM	72.0087	139.9810	DNA	5, SCM, 33.1, Tmax, AW, B-10
MK-6[i]	54	2017-09-30 12:32:11 AM	71.6057	140.0395	DNA	5, SCM, 33.1, Tmax, AW, B-10
CB-28b[c]	55	2017-09-30 9:32:06 AM	71.0007	139.9945	DNA	5, SCM, 33.1, Tmax, AW, B-10
MK-3[e]	56	2017-09-30 2:01:27 PM	70.5790	139.9852	DNA	5, SCM, 32.3, 33.1. 450m, B-10
CB-28aa[j]	57	2017-09-30 5:53:49 PM	69.9965	139.9777	DNA	5, SCM, 30, 40, 50, B-5
AG-5[a]	58	2017-10-01 7:05:43 PM	70.5467	122.9077	DNA, Prot, Live FCM, ChlFCM, HPLC, DAPI euk	5, ML, SCM, 32.3, 32.6, 33.1, Tmax, B-10
ICE at IBO1					DNA	Bottom 30cm of core

[a] Stations sampled 2017, 2016, 2015, 2014, 2013, 2012

[b] Stations sampled 2017, 2016, 2015, 2014, 2013

[c] Stations sampled 2017, 2016, 2015, 2014

[d] Stations sampled 2017, 2016, 2015

[e] Station sampled 2017, 2016

[f] Station sampled 2017, 2016, 2015, 2014, 2012

[g] Stations sampled 2017, 2016, 2015, 2013, 2012

[h] Stations sampled 2017, 2016, 2014

[I] Stations sampled 2017, 2013, 2012

[j] Stations sampled 2017, 2016, 2012

[k] Stations sampled 2017, 2014

5.2.5 Mooring Operations

Table 12. Location of mooring recovery and deployments.

Mooring Name	2016 Location	2017 Recovery	2017 Deployment	2017 Location	Bottom Depth (m)
BGOS-A	75° 0.0270' N 149° 59.9659' W	20-Sep 18:34 UTC	24-Sep 22:45 UTC	75° 1.10' N 150° 8.43' W	3825
BGOS-B	77° 59.8615' N 149° 57.6695' W	18-Sep 17:43 UTC	19-Sep 23:53 UTC	78° 1.07' N 149° 58.48' W	3827
BGOS-D	74° 0.0007' N 140° 0.0606' W	25-Sep 21:03 UTC	27-Sep 22:49 UTC	74° 0.26' N 139° 59.96' W	3513

Table 13. Ice-Based Observatory buoy deployment summary.

IBO: Ice-Based Observatory; ITP: Ice-tethered Profiler; SIMB: Seasonal Ice Mass Balance Buoy.

IBO	ITP / Buoy System	Date	Location
1	ITP101 / SIMB	15-Sep-17 15:00	80° 53.8' N 132° 23.0' W
2	ITP108 / SIMB	16-Sep-17 18:00	80° 32.2' N 140° 44.8' W
3	ITP100	17-Sep-17 18:00	79° 59.1' N 149° 43.5' W

Table 14. pCO2 and pH sensors summary (UMontana)

Measurement platform and location	Instrument IDs	Duration
underway *p*CO_2	SUPER-CO_2	09/07/17-10/1/17
BGOS Mooring B (CB-9) 43.1 m depth at time of recovery	SAMI-CO_2 (C38)	10/05/16 – 09/18/17
	SAMI-pH (P5)	10/05/16 – 07/13/17
	Aanderaa O_2	10/05/16 – 09/18/17
	PAR (Licor)	10/05/16 – 09/18/17
BGOS Mooring A (CB-4) 39.5 m depth at time of recovery	SAMI-CO_2 (C48)	10/08/16 – 09/20/17
	SAMI-pH (P47)	10/08/17 – 09/20/17
	Aanderaa O_2	10/08/16 – 09/20/17
	PAR (Licor)	10/08/16 – 09/20/17
	Chl-a (Chelsea)	10/08/16 – 09/20/17
BGOS Mooring D (CB-21) 33.3 m depth at time of recovery	SAMI-CO_2 (C37)	10/14/16 – 09/25/17
	SAMI-pH (P68)	10/14/16 – 11/14/16
	Aanderaa O_2	10/14/16 – 09/25/17

	PAR (Licor)	10/14/16 – 11/14/16
	Chl-a (Chelsea)	10/14/16 – 11/14/16

**SAMI-CO_2 measures the partial pressure of CO_2; SAMI-pH records pH on the total scale; All records include in situ temperature; PAR and Chl-*a* are uncalibrated.

Table 15. Surface drifters deployment summary (IOS).

IOS SCT# = Institute of Ocean Sciences Spot Messenger Trace number.
CSB = Canada Basin Shelf.

IOS SCT#	Date	Time (UTC)	Location	Latitude (°N)	Longitude (°W)
716	2017-09-08	21:26	Cape Bathurst	70.5603	127.6830
717	2017-09-08	21:28	Cape Bathurst	70.5543	127.6931
718	2017-09-08	21:29	Cape Bathurst	70.5552	127.6952
719	2017-09-08	21:30	Cape Bathurst	70.5561	127.6983
720	2017-09-09	1:27	CSB Mid	71.0997	129.5518
721	2017-09-09	1:28	CSB Mid	71.1008	129.5548
722	2017-09-09	1:29	CSB Mid	71.1018	129.5582
723	2017-09-09	1:30	CSB Mid	71.2696	129.5628
724	2017-09-09	3:21	CBS Break	71.3904	130.5591
725	2017-09-09	3:22	CBS Break	71.3909	130.5612
726	2017-09-09	3:23	CBS Break	71.3921	130.5668
727	2017-09-09	3:24	CBS Break	71.3930	130.5704

5.2.6 Ice Observations during 2017-11 (KIT, OSU)

Table 16. EM31/ICE observation log.

Profile Number	Start Time(UTC)	Start Position	End Time (UTC)	End Position	Length of profile[km]
1	2017-09-10 1:26	73.0531°N 134.2241°W	2017-09-10 4:55	73.4448°N 137.9981°W	64.45
2	2017-09-10 13:58	73.5000°N 134.2241°W	2017-09-10 22:08	73.4948°N 130.9400°W	104.17
3	2017-09-11 0:10	73.5053°N 130.907°1W	2017-09-11 16:44	74.4940°N 135.4034°W	177
4	2017-09-11 16:53	74.4933°N 135.4035°W	2017-09-12 1:05	74.9991°N 139.9685°W	145.51
5	2017-09-12 1:20	75.0000°N 139.9769°W	2017-09-12 23:16	76.2529°N 132.4826°W	250.44
6	2017-09-13 0:22	76.2530°N 132.4700°W	2017-09-13 21:13	77.0118°N 140.0013°W	212.09

7	2017-09-13 21:16	77.0116°N 140.0008°W	2017-09-15 14:17	80.9333°N 132.2106°W	468.42
8	2017-09-15 14:19	80.9334°N 132.2224°W	2017-09-16 19:39	80.5343°N 140.7252°W	159.26
9	2017-09-16 19:41	80.5342°N 140.7241°W	2017-09-17 23:24	78.9859°N 149.9800°W	252.3
10	2017-09-17 23:26	78.9860°N 149.9795°W	2017-09-18 14:55	78.0009°N 149.9913°W	109.98

Table 17. IBO EM and drill-hole measurement summary

IBO	Latitude (°N) Longitude (°W)	Transect Line	Length of profile [m]	Snow depth (m)		Freeboard (m)		Ice thickness (m)	
				Mean	s.d.	Mean	s.d.	Mean	s.d.
1	80.9130	Line-1	50	0.14	0.03	0.11	0.07	0.85	0.25
	132.3005	Line-2	50	0.16	0.03	0.07	0.06	0.84	0.39
2	80.5367	Line-1	50	0.05	0.02	0.08	0.02	0.68	0.09
	140.7467	Line-2	50	0.05	0.03	0.16	0.25	0.68	0.10

Table 18. IBO ice core summary.

Principal Investigator	Core #	Site	Location on transect (m)	Thickness (cm)	Freeboard (cm)
J. Hutchings	A	1, line-1	50	0.76	n/a
	C		0	1.41	n/a
	B	2, line-1	50	~0.75	0.12
	D		0	0.52	0.11
P. Ross	Microplastic 1	1, line-1	0	1.49	0.12
	Microplastic 2		0	1.41	0.14
	Microplastic 1	2, line-1	0	0.52	n/a
	Microplastic 2		0	0.55	n/a
C. Lovejoy	DNA/RNA 1	1, line-1	0	1.7	n/a
	DNA/RNA 2		0	1.66	n/a
	DNA/RNA 1	2, line-1	0	n/a	n/a
	DNA/RNA 2		0	n/a	n/a

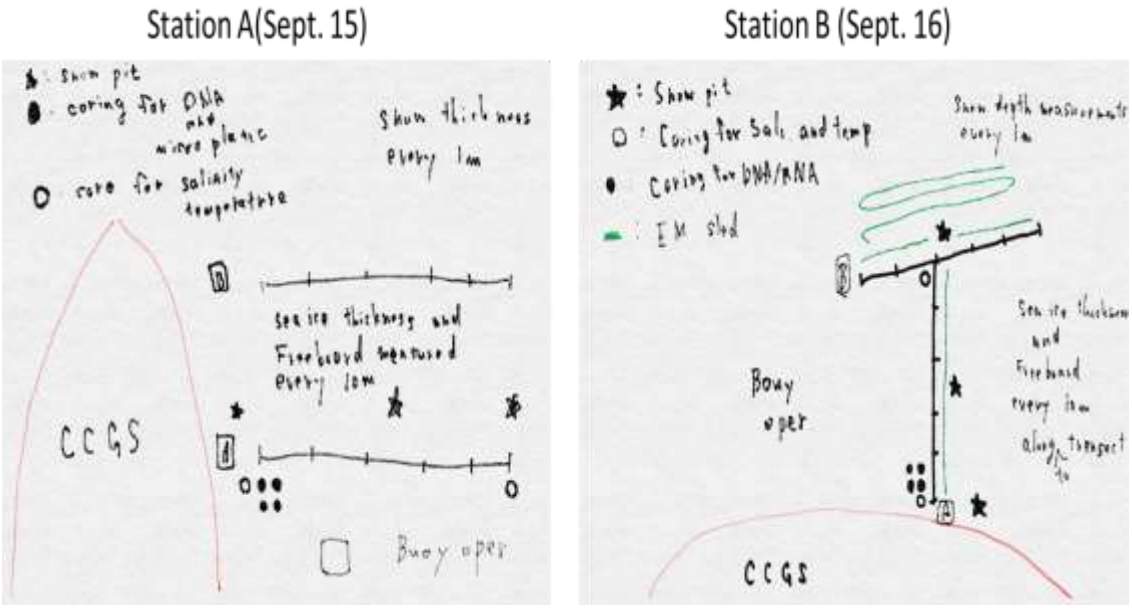


Figure 10. IBOs transects and ice core schematics.

Buoy oper = buoy operation site, CCGS = Canadian Coast Guard Ship Louis S. St-Laurent).

Table 19. Precipitation sampling summary.

Sample number	Date	Description
1	2017-09-14	Snow on deck
2	2017-09-15	Snow on sea ice at ice station (IBO1)
3	2017-09-15	Snow in funnel
4	2017-09-16	Snow on sea ice at ice station (IBO2)
5	2017-09-18	Snow in funnel + from railing
6	2017-09-19	Snow in funnel
7	2017-09-24	Snow in funnel
8	2017-10-01	Snow in funnel + railing
9	2017-10-02	Water in jar

5.2.7 Microplastics

Table 20. Microplastic depth profile sample summary.

Station Edmand Fok	Date, Time (UTC)	Latitude (°N) Longitude (°W)	Niskin	Pressure (dbar)	Sample ID	Volume (L)	NOTE
NE-1.5	2017-09-16	80.6157	1-4	1000	382-385	40.72	1000m

	12:06:02 PM	141.0612	5-8	402	386-389	40.72	T_{max}
			9-12	201	390-393	40.72	S=34.1
			13-16	158	394-397	40.72	S=33.1
			17-20	51	398-401	40.72	chl-a_{max} (SCM)
			21-24	5	402-405	40.72	5 m
CB-9Plastic	2017-09-18	78.0082	1-4	1000	478-781	40.72	1000m
	1:29:34 PM	150.0507	5-8	455	482-485	40.72	T_{max}
			9-12	251	486-489	40.72	S=34.1
			13-16	198	490-493	40.72	S=33.1
			17-20	66	494-497	40.72	chl-a_{max} (SCM)
			21-24	5	499-501	40.72	5 m
CB-4Plastic	2017-09-24	75.0007	1-4	1000	883-886	40.72	1000 m
	8:43:01 AM	150.0003	5-8	498	887-890	30.54	T_{max}; niskin 5 (sample 887) was leaking very much and so omitted from sampling
			9-12	279	891-894	40.72	S=34.1
			13-16	221	895-898	40.72	S=33.1
			17-20	79	899-902	30.54	chl-a_{max} (SCM); nikin 18 (sample 900) didn't trip
			21-24	5	903-906	40.72	5 m
CB-21Plastic	2017-09-26	73.9985	1-4	1000	1027-1030	40.72	1000 m
	2:04:27 PM	139.9972	5-8	485	1031-1034	40.72	T_{max}
			9-12	268	1035-1038	40.72	S=34.1
			13-16	214	1039-1042	40.72	S=33.1
			17-20	83	1043-1046	40.72	chl-a_{max} (SCM)
			21-24	5	1047-1050	39.72	5 m; ~1L was taken for the 1L bulk sample
			24	5	1050	1	5 m; 1L bulk sample collected

Table 21. Microplastic seawater loop sample summary.

Microplastic seawater loop samples were collected as we were either approaching or leaving the CTD/Rosette station (Station). Flow rates were calculated from timing it took to fill a graduated bucket from the seawater loop outlet used to collect the samples.

Station	Date	Sample ID	Start / End	Latitude (°N)	Longitude (°W)	Sieving time (min)	Flow rate (L/min)	Volume sieved (L)
C3O leg St-John's to Cambridge Bay	2017-08-30	loop 1	start	50.897	53.095	20.00	12	240.00
	2017-08-31	loop 2	start	57.195	54.802	20.00	12	240.00
	2017-09-01	loop 3	start	63.868	57.114	20.00	12	240.00
	2017-09-02	loop 4	start	69.220	61.404	20.00	12	240.00
	2017-09-03	loop 5	start	72.717	75.185	20.00	8	160.00

	2017-09-04	loop 6	start	74.253	88.739	20.00	8	160.00
	2017-09-05	loop 7	start	70.696	98.436	15.00	12	180.00
CB-1	2017-09-09	loop 11	start end	71.7063 71.7678	131.6288 131.8388	24.19	1.78	43.05
CB-9	2017-09-20	loop 64	start end	78.0142 77.9256	150.0015 150.0378	22.08	2.19	48.46
BL-1	2019-09-22	loop 76	start end	71.3638 71.3645	152.1026 152.4326	25.88	2.14	55.35
CB-4	2017-09-24	loop 87	start end	75.0193 75.0285	150.0781 149.7294	21.76	2.06	44.86
CB-21	2017-09-25	loop 94	start end	73.9710 73.9046	139.9620 139.9657	22.19	2.06	45.65
Stn-A	2017-09-29	loop 114	start end	72.5890 72.5368	144.6680 144.9092	21.19	2.14	45.40
CB-28aa	2017-09-30	loop 125	start end	70.1003 70.0188	139.9802 139.9799	20.23	2.16	43.70
AG-5	2017-10-01	loop 130	start end	70.5429 70.4986	122.8863 122.6532	21.77	5.12	111.59

Table 22. Microplastic ice core sample summary.

IBO	Date	Latitude (°N)	Longitude (°W)	Snow depth (m)	Freeboard (m)	Core #	core length (m)	Date melted	Volume sieved (mL)	$T°_{melted\ sample}$ (°C)
1	2017-09-16	80.9130	132.3005	0.13	0.12	1	1.49	26-09-2017	7.8	20.1
				0.13	0.11	2	1.41	28-09-2017	10.45	20.4
2	16-09-2017	80.5367	140.7467	0.03	0.05	1	0.52	19-09-2017	2.83	24.3
				0.03	0.05	2	0.55	22-09-2017	2.85	24.1

5.1 CTD/Rosette and TSG Sensor Configuration

CTD Specifications

Cast 2 Altimeter changed out as the original sensor did not pick up the bottom.
Cast 7 Fluorometer failing casts 1 to 6, replaced for cast 7.
Cast 44 Secondary temperature and conductivity swapped out with a pair that had a more recent calibration.
Two water samplers used during cruise. See table below for when they were swapped in and out.

Table 23. CTD Accuracy, Calibration and Sensor List for 2017-11

CTD

CTD#	Make	Model	Serial#	Used with Rosette?	Casts Used
Primary	SeaBird	911+	724	Yes	All

Sensor		Pre-Cruise		Post Cruise		Comment
Name	S/N	Date	Location	Date	Location	
Pressure Sensor	90559	27 May 2009	SeaBird Lab			Pre-cruise using offset of -0.69432dbar
Temperature, SBE3plus	4397	5 Nov 2015	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used
Conductivity, SBE4C	2992	5 Nov 2015	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used
Pump, SBE5T	5-3610					
Secondary Temp., SBE3plus A	4402	4 Nov 2015	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used Cast 1 to 43
Secondary Temp., SBE3plus B	4322	2 Nov 2016	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used Casts 44 to 71
Secondary Cond., SBE4C A	2984	12 Nov 2015	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used Cast 1 to 43
Secondary Cond., SBE4C B	2809	1 Nov 2016	SeaBird Lab	1 Dec 2017	SeaBird Lab	Post-cruise calibration used Casts 44 to 71
Secondary Pump, SBE5T	5-3615					

Sensor	Pre-Cruise	Post Cruise	Comment

Name	S/N	Date	Location	Date	Location	
SBE 43 Dissolved Oxygen sensor	1489	05 Nov 2015	SeaBird Lab	30 Dec 2017	SeaBird Lab	On Primary pump; Will fit to water samples
Datasonics Altimeter, Benthos	PSA-916D, 62670	28 May 2014	Benthos			2017-11 Cast 1, but did not find bottom at CB1
Datasoncis Altimeter, Benthos	PSA-916D, 1161	31 Mar 2005	Benthos			2017-11: Cast 2 to 71 (end)
Seapoint Fluorometer (Chl-a)	SCF 2979	Before 2015	Seapoint			On Secondary Pump; Not Calibrated to water samples 2017-11: Casts 1 to 6
Seapoint Fluorometer (Chl-a)	SCF 3654	Approx Jun 2014	Seapoint			On Secondary Pump; Not Calibrated to water samples 2017-11: Casts 7 to 71
Wetlabs Transmissometer	C-Star CST-1052DR	19 Aug 2017	IOS (In-house bench test)			
WETLabs ECO CDOM	4305	14 Mar 2016	WETLabs			
Satlantic Cosine Log PAR	517	25 Jun 2014	Satlantic			
Biospherical Surface PAR QSR2200	20498	4 Apr 2016	Biospherical			Logged in CTD file
Biospherical PAR QSR2150 (Continuous)	50228	21 Jun 2016	Biospherical			Continuous recording during cruise

Deck Units

Type	*make*	*model*	*serial*	*comment*
Deck Unit	Seabird	11plus	680	
Deck Unit	Seabird	11plus	649	

Rosette Pylons

Type	*make*	*model*	*serial*	*comment*
Water Sampler Carousel	Seabird	32	**452**	2017-11: Cast 1 to 3, 6 to 51
Water Sampler Carousel	Seabird	32	**498**	2017-11: Casts 4, 5, 52 to 71, using trigger from 452

TSG Seabird SBE21 sn 3297

Calibration and Accuracy Information, TSG						
Sensor		**Pre-Cruise**		**Post Cruise**		**Comment**
Name	**S/N**	**Date**	**Location**	**Date**	**Location**	
Seabird TSG SBE21	3297	18 May 2017	SeaBird Lab	13 Jan 2018	SeaBird Lab	
Seabird Temperatrue SBE-38 (Intake temperature)	0319	5 Jan 2017	SeaBird Lab	pending	SeaBird Lab	
Seapoint Chlorophyll Fluorometer	SCF3652	Jun 2014	Seapoint			Chl water samples collected
Wetlabs ECO CDOM Fluorometer	WSCD-1281	9 Jun 2011	Wetlabs			CDOM water samples collected

5.2 SCS Data Collection System. Key to what the system collects.

The SCS system on a shipboard computer called the "NOAA server" collects *RAW files. The files typically contain a day's worth of data, restarting at midnight.

The list of *.RAW files and order of variables within the data string:

Position - $GPGGA **(**GGA-RAW_*.Raw) – updated for 2017 (SS is now SS.S)
Position information
Time interval is 1 second

Description of *.RAW file string
GGA-RAW_20170930-000000.Raw
09/30/2017,00:00:17.942,$GPGGA,235814.0,7138.45271,N,14005.77463,W,2,09,0.9,30.9,M,-3.0,M,7.0,0135*47
09/30/2017,00:00:18.958,$GPGGA,235815.0,7138.44937,N,14005.77992,W,2,09,0.9,31.5,M,-3.0,M,7.0,0135*40

Comma delimited column after string name
1) Time HHMMSS.S
2) Latitude
3) Latitude N or S
4) Longitude
5) Longitude E or W
8) Horizontal dilution

Course and Speed Over Ground - $GPVTG **(**VTG-RAW_*.Raw)
Track made good
Time interval is 2 seconds

Description of *.RAW file string
VTG-RAW_20160918-000100.Raw
07/17/2016,00:02:00.478,$GPVTG,232,T,216,M,10.4,N,19.3,K,D*2E
07/17/2016,00:02:02.712,$GPVTG,232,T,217,M,10.4,N,19.3,K,D*2F

Comma delimited column after string name
1) Course made good, true north
2) T for true north
3) Course made good, magnetic north
4) M for magnetic north
5) Speed made good, Knots
6) N for knots
7) Speed made good, Km?
8) K for kilometer?

Time and Date - $ZDA **(**ZDA-RAW_*.Raw) 2017 – Time interval changed
Time and date information in UTC.
Time interval is about 11 seconds.

Description of *.RAW file string
ZDA-RAW_20170909-000000.Raw

09/09/2017,00:00:26.623,$GPZDA,235811.028,08,09,2017,00,00*55
09/09/2017,00:00:38.018,$GPZDA,235822.030,08,09,2017,00,00*5C

Comma delimited column after string name
1) Time UTC, hhmmss.sss
2) Day UTC, dd
3) Month, mm
4) Year, yyyy

Ship's Heading - $HEHDT (Ship's Gyro) **(**HDT-Gyro_*.Raw)
Time interval is 10 second

Description of *.RAW file string
HDT-Gyro_20170912-000000.Raw
09/12/2017,00:02:05.201,$HEHDT,293.52,T*10
09/12/2017,00:02:15.379,$HEHDT,293.16,T*10
09/12/2017,00:02:25.565,$HEHDT,293.42,T*11

Comma delimited column after string name
1) Ship's heading – True North

Ship's Heading - $GPHDT (POSMV) – NOT Available in 2017
Time interval is 10 seconds

Description of *.RAW file string
HDT-POSMV_20160818-000100.Raw
08/19/2016,00:01:34.336,$GPHDT,47.861,T*09
08/19/2016,00:01:45.334,$GPHDT,47.985,T*02

Comma delimited column after string name
1) Ship's heading – True North

Depth - $SDDPT (DBT-RAW_*.Raw) – String Changed in 2017
Depth is measured using either the 12 or 3.5kHz transducers r using the Knudsen CHIRP 3260 Echosounder. The system reports depth under the hull however the ship's draft may have been added to the reported value (ie 9 m may already have been added for full water depth). The sounders are always using a variable soundspeed set by the user in Knudsen software. Apply the correct soundspeed to improve accuracy. Settings for added draft and soudspeed are given in the data string.
Time interval is every second, but value updates every 5 to 7 seconds.

Description of *.RAW file string
DBT-RAW_20170919-000000.Raw
09/19/2017,00:00:07.240,$SDDBT,19092017,001259,Metres,,,,12.0kHz,3823.01,9.00,1479
09/19/2017,00:00:08.240,$SDDBT,19092017,001259,Metres,,,,12.0kHz,3823.01,9.00,1479
And for comparison:
08/27/2017,17:49:15.492,$SDDBT,27082017,172451,Metres,3.5kHz,449.19,0.00,,,,1453
08/27/2017,17:49:15.492,$SDDBT,27082017,172451,Metres,3.5kHz,449.19,0.00,,,,1453

Comma delimited column after string name
1) Date UTC: DDMMYYYY
2) Time UTC: hhmmss
3) Units

4) Sounder frequency (3.5kHz)
5) Depth (3.5kHz)
6) Applied draft (3.5kHz)
7) Sounder frequency (12kHz)
8) Depth (12kHz)
9) Applied draft (12kHz)
10) Soundspeed m/s

Meteorological data from AVOS (Automatic Voluntary Observing Ships System) - $AVRTE (AVOS-serial-AVRTE_*.RAW)
The AVOS system is mounted above the bridge and is operated and serviced annually by Environment Canada. The temperature/relative humidity sensor and The RM Young mechanical anemometer are mounted on the starboard side, about 4m above the bridge-top (approx. 25m above sea-level).
Barometer – not sure where this is mounted.
Time interval is 1 sec

Description of *.RAW file string
AVOS-serial-AVRTE_20160809-142433.RAW

08/09/2016,14:24:40.778,$AVRTE,160809,142440,00840,CGBN,32.2,338,30,,,,992.44,,7.5,92,,,,39.1,,,307.7,13.2*5A
08/09/2016,14:24:41.778,$AVRTE,160809,142441,00840,CGBN,33.3,335,27,,,,992.43,,7.5,92,,,,39.1,,,308.3,13.2*5C

Comma delimited column after string name

1) Date UTC: YYMMDD
2) Time UTC: hhmmss
3) Region?
4) Ship's Call Sign
5) Relative wind speed, knots
6) Apparent wind direction, degrees true north
7) Relative wind direction, degrees where ship's bow is "North"
8) Space for 2nd wind sensor, not installed
9) Space for 2nd wind sensor, not installed
10) Space for 2nd wind sensor, not installed
11) Barometric pressure, Mbar (same as mmhg)
12) Space for 2nd barometer, not installed
13) Air temperature, degrees C
14) Relative Humidity, %
15) Space for 2nd temperature sensor
16) Space for 2nd humidity sensor
18) Space for Sea Surface Temperature, degrees C (this is NOT the same as the sea water loop TSG intake reading – different source, slightly warmer)
19) Wind gusts, knots
20) Blank space for 2nd wind sensor gust
21) Heading ($HEHDT) direction, "Compass 1", degrees
22) AVOS fluxgate compass direction, "Compass 2", degrees
23) AVOS battery voltage

Seawater Loop (TSG) (TSG-serial-*.Raw)

Sea surface properties from sea water loop. Intake is ~9m below waterline. Please see earlier section for description of TSG sensors.
Time interval is 5 seconds.

Description of *.RAW file string
TSG-serial-_20160918-000100.Raw
09/17/2016,00:03:45.941, 1.42 1.24 27.839 24.590 0.117 0.11722 0.04029 261.003310
09/17/2016,00:03:50.944, 1.43 1.25 27.844 24.595 0.122 0.12210 0.04029 261.003368

Comma delimited column after SCS date and time stamp
1) Sea Surface Temperature in lab, Deg C
2) Sea Surface Temperature at intake, Deg C
3) Sea Surface Salinity, PSU
4) Sea Surface Conductivity in lab, mS/cm
5) Sea Surface Fluorescence (Chlorophyll-a), ug/L
6) Sea Surface Fluorescence (Chlorophyll-a) voltage, V
7) Sea Surface Wetlabs ECO CDOM Fluorometer voltage, V
8) Julian Day

Seawater Intake Temperature (SBE38) (SBE-38-serialport-*.Raw)
Sea surface temperature from sea water loop. Note this is the same temperature that appears in the TSG record. Intake is ~9m below waterline. Please see earlier section for description of TSG sensors.

Time interval is about 1 second.

Description of *.RAW file string
SBE-38-serialport-_20171002-000000.Raw
10/02/2017,00:00:06.274, 3.5106
10/02/2017,00:00:07.133, 3.5105
10/02/2017,00:00:08.010, 3.5108
10/02/2017,00:00:08.885, 3.5116

Comma delimited column after SCS date and time stamp
1) Sea Surface Temperature at intake, Deg C

Surface PAR **(**ASCII-PAR-serialport-*.Raw)

The continuous logging Biospherical Scalar PAR Sensor QSR2150A (S/N 50228, calibration date 21 June 2016), was mounted above the CTD operation area (mid-ship, starboard side, on top of the container stored above the hanger) with an unobstructed view over approximately 220deg. The blocked area is due mostly to the ship's crane and smoke stack which are approximately 50 feet inboard and forward of the sensor. The sensor logged data files independently and also reported data to the NOAA Server for logging through the SCS system (given here).

Time interval is 1 second.

Description of *.RAW file string

ASCII-PAR-serialport-_20161016-000100.Raw
10/16/2016,00:01:17.913,D|58.889
10/16/2016,00:01:18.944,D|59.04

Comma delimited column after SCS date and time stamp

1. D| - not sure what this is, ignore.
2. Surface PAR, uE/m2/sec (same as in CTD data)