Joint Ocean Ice Study (JOIS) 2018
Cruise Report

Photo by Sarah Zimmermann

Report on the oceanographic research conducted aboard the *CCGS Louis S. St-Laurent,* September 7 to October 2, 2018 IOS Cruise ID 2018-81

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1. OVERVIEW

The Joint Ocean Ice Study (JOIS) in 2018 is an important contribution from Fisheries and Oceans Canada to international Arctic climate research programs and is jointly supported by Fisheries and Oceans Canada and the National Science Foundation. It is a collaboration between Fisheries and Oceans Canada researchers (Bill Williams lead) with colleagues in the USA from Woods Hole Oceanographic Institution (WHOI) (Andrey Proshutinsky lead). 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 2018, 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, Québec City, Québec.
- 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 and inter-annual variation in the Arctic atmosphere and ocean to basin-scale changes in the Beaufort Gyre Region, 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.

Table 1. 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=162676
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	imb.erdc.dren.mil
JOIS website from DFO	http://dfo-mpo.gc.ca/science/collaboration/jois-eng.html

2. CRUISE SUMMARY

The JOIS science program onboard the *CCGS Louis S. St-Laurent* began September 7th and finished October 2nd, 2018. The research was conducted in the Canada Basin from the Beaufort Slope in the south to 79°N by a research team of 30 people of which 8 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 central and northern Beaufort Gyre 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. 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.

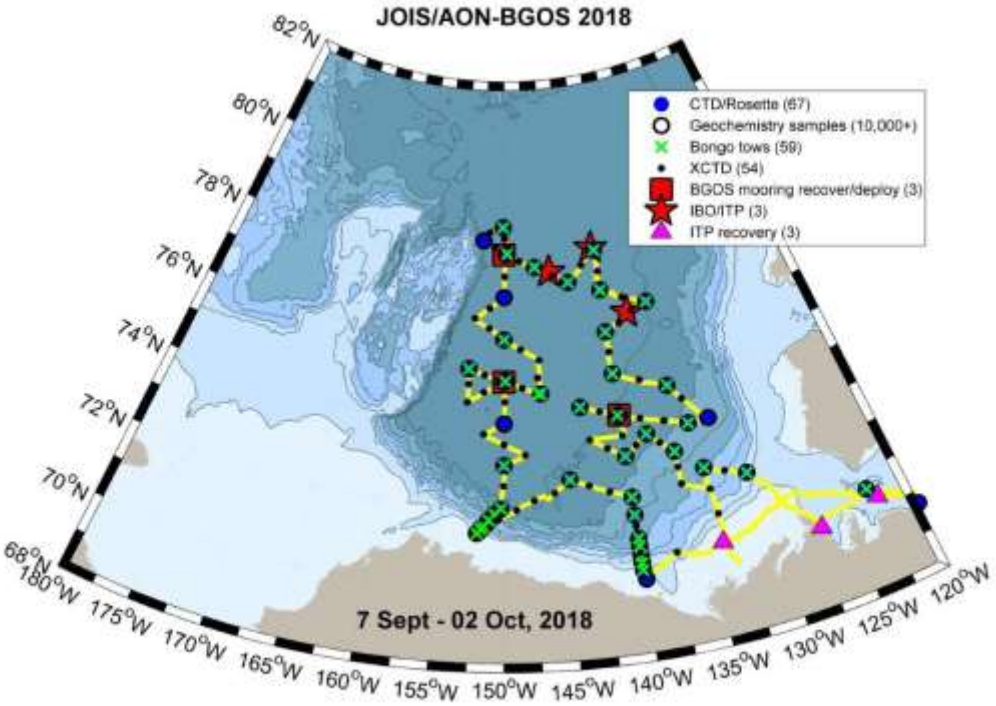

Figure 1.The JOIS-2018 cruise track showing the location of science stations.

Prior to the JOIS program, opportunistic sampling was conducted during two legs. On the first, between, Aug 9 to 20th, the Canadian Hydrographic Service conducted 14 XCTD cast for the Institute of Ocean Sciences. On the second, from Aug 24th to Sep 6th, between Iqaluit and Kugluktuk through the Canadian Arctic Archipelago, 2 science

members from the Institute of Ocean Sciences conducted 14 CTD/Rosette casts with water samples as well as underway measurements of surface seawater. These XCTD and CTD casts will be listed in the appendix but are not included in the JOIS report below.

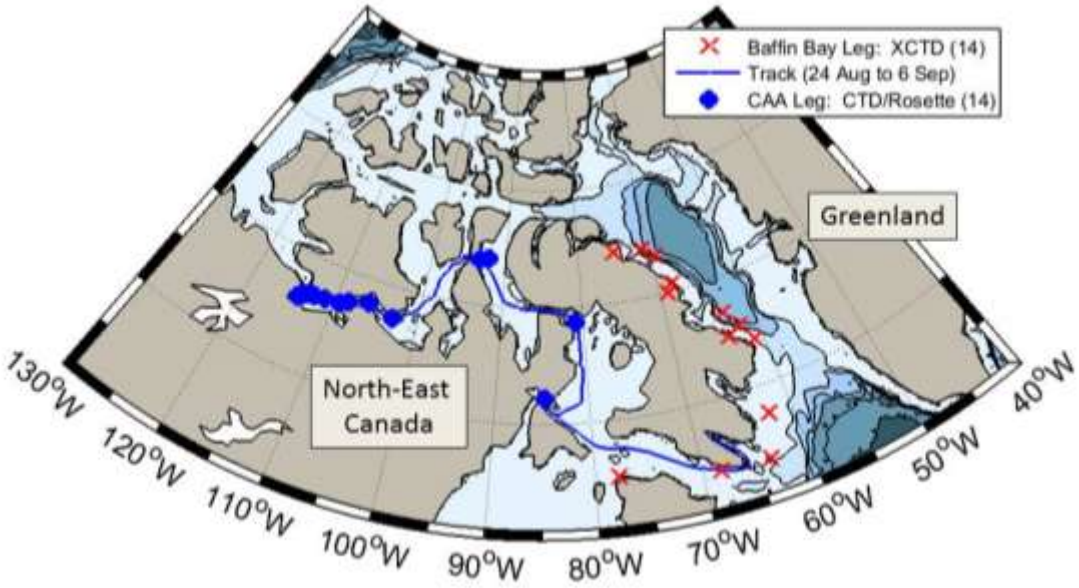

Figure 2. Opportunistic sampling performed prior to the JOIS program. Sampling not described in report but locations of stations are given in appendix.

1.1 Program Components

Measurements:

- At CTD/Rosette Stations:
  - 53 CTD/Rosette Casts at 45 Stations (DFO) with 1154 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, Triple Oxygen Isotope (TOI), ^{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). Additionally, a Microrider MR6000 was installed to measure

turbulence using 2 shear probes, 2 fast thermistors and a conductivity sensor (WHOI).
    - 59 Vertical Net Casts at 38 select CTD/Rosette stations with one cast to 100m and if possible additional deeper casts up to 500m per station. The two nets per cast have a mesh size of 150 µm and 236 µm. (DFO)

- 54 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 (ITP107, WHOI)
        1 Seasonal Ice Mass Balance Buoy (SIMBB, CRREL)
    - 1 Ice-Station with:
        1 Ice-Tethered Profiler (ITP110, WHOI)
    - 1 Ice-Station with:
        1 Ice-Tethered Profiler (ITP109, WHOI)
    - 3 Ice-Tethered Profiler Recoveries (ITP108, ITP101, ITP100, WHOI)

- Ice Observations (KIT/OSU)
  Hourly visual ice observations from bridge with more frequent 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
  -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 (160) were collected from the underway seawater loop for salinity and nutrients (DFO), DIC and Alkalinity (DFO, TUMSAT), CDOM (TrentU), microbial diversity (ULaval, Concordia), and microplastics (Vancouver Aquarium).

- Daily dispatches to the web (WHOI)

1.2 Comments on Operation

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The program's cruise-track went anti-clockwise around the Beaufort Gyre again this year. We started by steaming north along our standard eastern stations (around 140W), turning west at roughly 77N towards 150W, conducting buoy deployments in ice 1 to 1.5m thick along this northern line. We then traveled back south along 150W taking measurements at our standard western stations, mostly in open water, and back east finishing with the southern leg of stations along the 140W line, ending on 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.
- 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. Figures are from the Canadian Ice Service showing Western Region Ice Concentration and Stage (source: https://iceweb2.beta.cmc.ec.gc.ca/Archive/page1.xhtml) and the National Snow and Ice Data Center showing Arctic-wide sea-ice extent (source: http://nsidc.org/arcticseaicenews/2018/09/)

At the start of the trip, we were able to recover an ice-buoy deployed in 2017 that had drifted into Amundsen Gulf, very near our first CTD/Rosette station. A ship requiring escort through the ice was in position at the same location and was brought along until we reached Franklin Bay where we finished the escort and went to recover a second drifting ice-buoy. We initially planned to recover a third buoy the next day, very close CTD/Rosette station CB1 however the drift between location broadcasts was too great and we were unable to find the buoy. We had another opportunity at the end of the cruise and this time we were able to complete a smooth night-time recovery.

New this year we had two ice specialists from the Canadian Ice Service on board. Their daily briefings of weather, sea-state and ice-conditions showing current conditions and forecasting what to expect helped us decide how to budget program time, order of operations, and find the appropriate ice for the buoy placement.

Typical for September and early October weather, there were several storms in the Beaufort Sea during the expedition. Fortunately for us they occurred in the west when we were in the east and then in the east while we were in the west. We had frequent days of clear cold weather during our trip. We took the window of good weather at the start of

the trip to perform the Mooring-D turnaround where typically it is done at the end. This was a good choice as the weather was poor at this site at the end of the cruise. This shift in mooring scheduling was only possible with the flexibility and good organization of the WHOI team.

A large amount of multiyear ice moved south in the eastern Beaufort during the program due to an anomalous cyclonic wind pattern over the Canadian Arctic Archipelago. This made travel in the east slower than in previous years. One of the farthest east stations was repositioned to the west and another was skipped to save travel time.
These were not the high priority core-stations for the program. This multiyear ice continued to be carried and blown south, reaching the shoreline east of Tuktoyaktuk and making travel difficult for the ship, using all 5 engines, on its return. Other ships both on the east and west were seeking escort through this ice, which speaks to the severity of the ice and the need for strong icebreakers. Some of these ships would not have been able to make it even with an escort (ie the supply barges to Paulatuk and Kugluktuk) and transit was cancelled and others waited for the *CCGS Louis S. St-Laurent* to return after offloading science and crew change.

The Coast Guard delay while making the decision to postpone escort operations until after crew-change resulted in a number of travel re-arrangements for half the science party. Due to full hotels and flights at the choke point of Yellowknife this had cascading effects on travel delays for the science party. We are very thankful to the extra effort made by the ship to reach Kugluktuk in time for as many science team flights as possible once the decision to head south was made, to allow the remaining scientist to stay on until the scheduled crew change day and also for adding four scientists onto their crew change flight.

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.

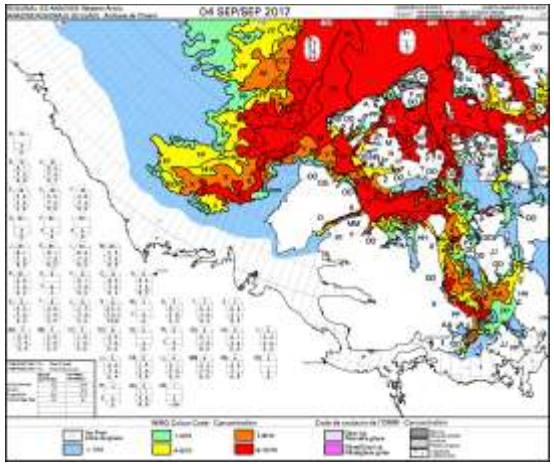

Figure 3. Sep 3, 2017 Ice Concentration

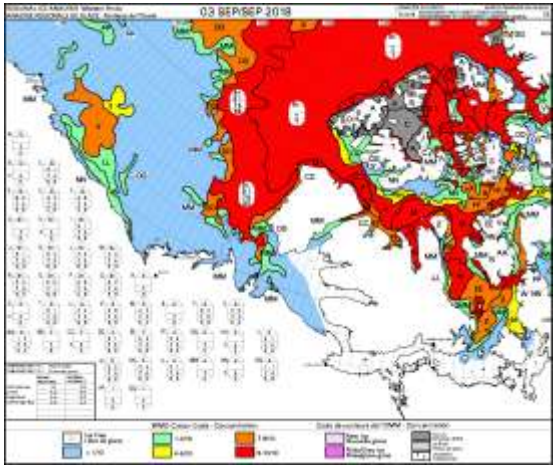

Figure 5. Sep 3, 2018 Ice Concentration

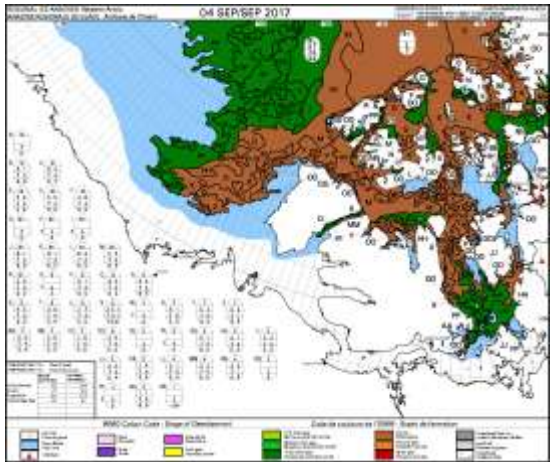

Figure 4. Sep 3, 2017 Ice Stage

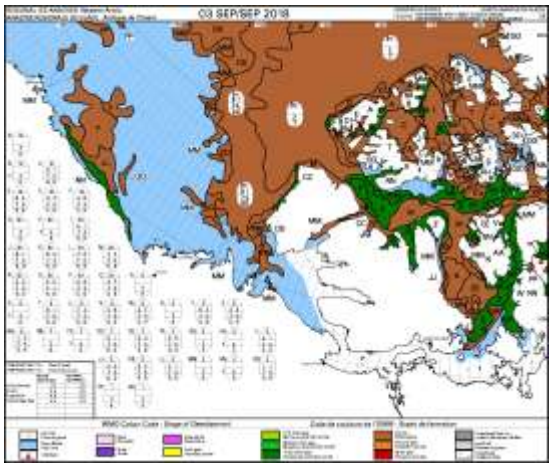

Figure 6. Sep 3, 2018 Ice Stage

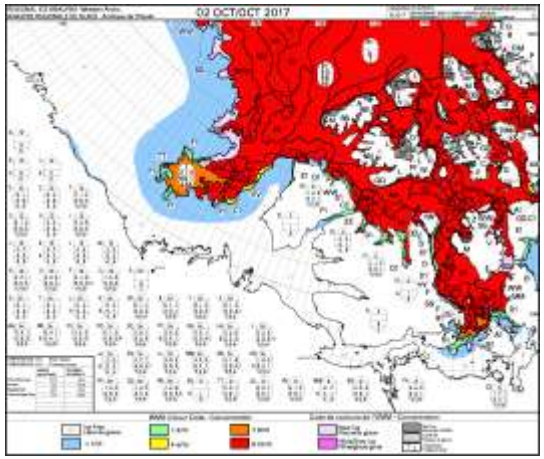

Figure 7. Oct 2, 2017 Ice Concentration

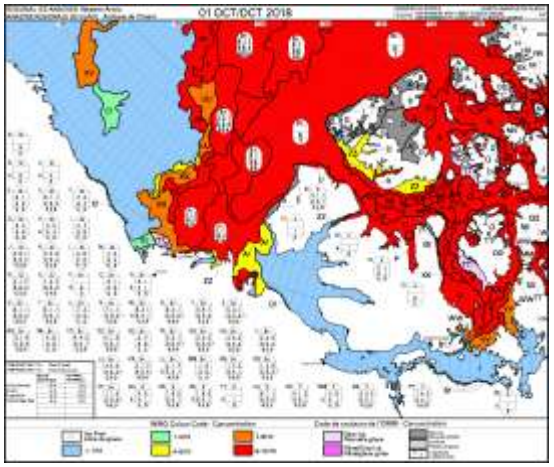

Figure 9. Oct 1, 2018 Ice Concentration

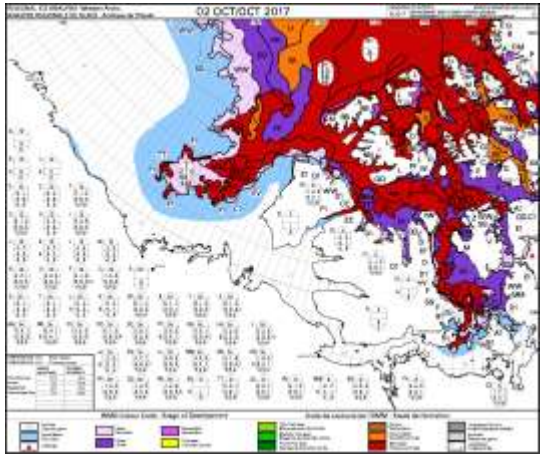

Figure 8. Oct 2, 2017 Ice Stage

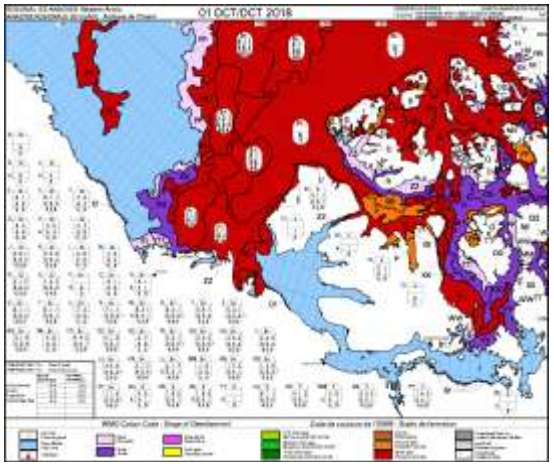

Figure 10. Oct 1, 2018 Ice Stage

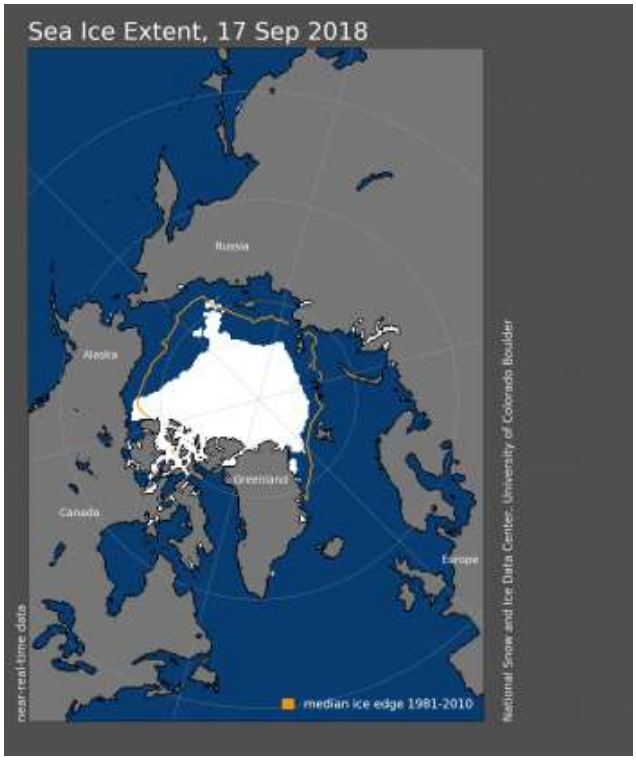

Figure 11. Sea Ice Extent mid-way through the cruise, from National Snow and Ice Data Center

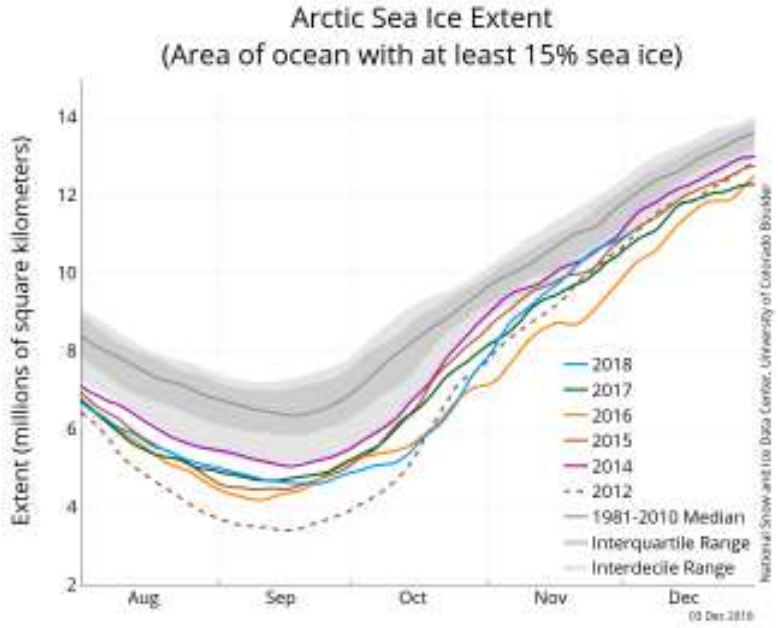

Figure 12. Sea Ice Extent from National Snow and Ice Data Center

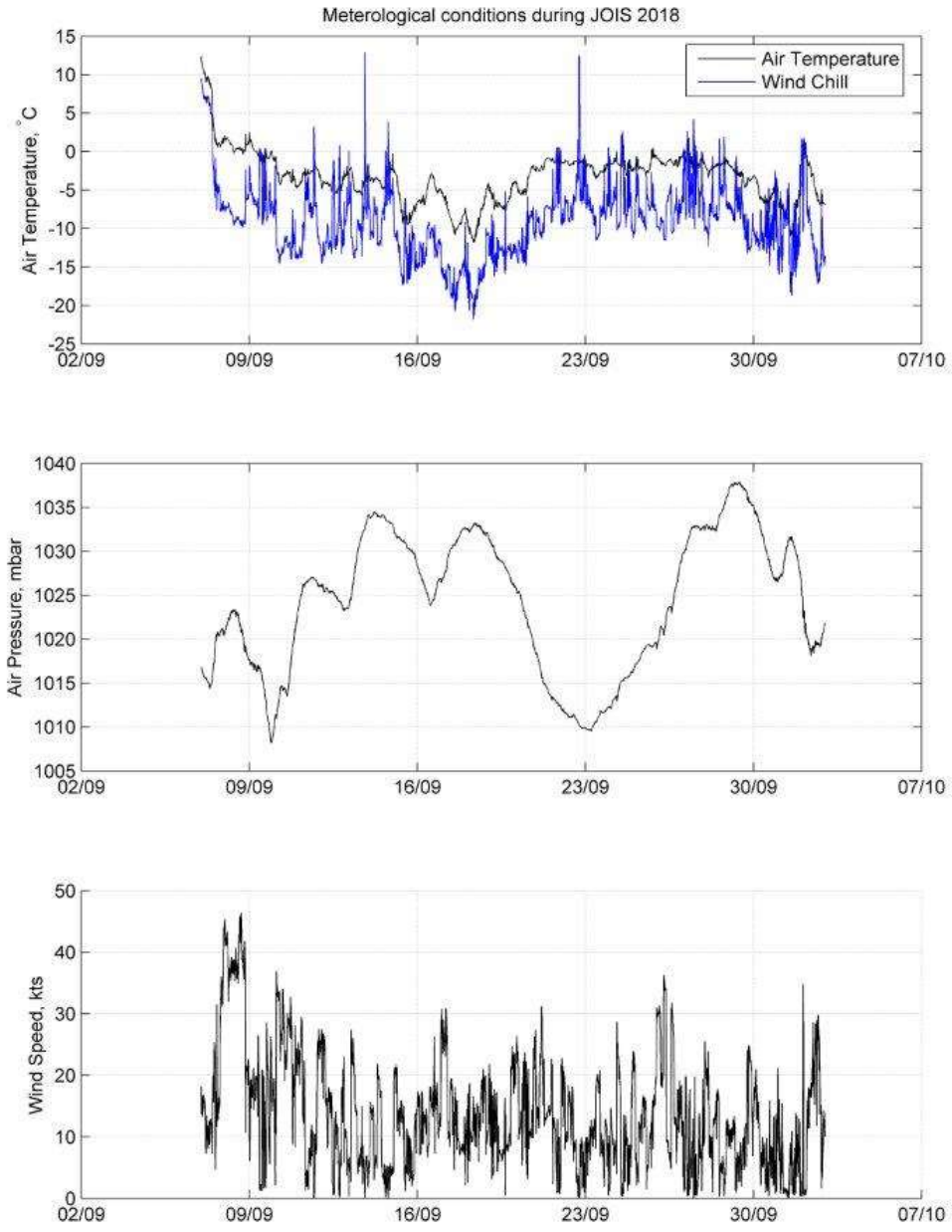

Figure 13. Temperature, air pressure and wind speed for the duration of the expedition from the AVOS weather station above the bridge of the CCGS Louis S. St-Laurent.

Completion of planned activities:

Our primary goals were met during this successful program due to efficient use of time by science and the ship, and the unflagging support from the officers and crew. We lost time for a medical evacuation of one of the science team, however the ship was able to help keep the lost time to a minimum and return us to station within 24 hours. Due to the slow travel time in ice during the first part of the cruise, we repositioned one of the easternmost stations (CB51) and dropped another (PP6), both low priority areas. Further into the cruise we repositioned a station (CB11) and dropped another (CB2a) partly to accommodate daytime mooring operations but also to give us time to add XCTD stations outside the most direct cruise-track, gaining more information in the area of the Beaufort Gyre's maximum fresh-water storage, a key component of the program.

3. ACKNOWLEDGMENTS

The science team would like to thank Captains Wayne Duffett and Jim Chmiel 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. Autumn in the Beaufort Gyre has short days, cold temperatures and high winds. Work in these conditions is difficult in comparison to the summer and we appreciate the hard work of the crew to complete our goals. New this year we had two ice specialists from the Canadian Ice Service. Their daily briefings were much appreciated. It was a pleasure to work with the helicopter pilot and mechanic and we would like to thank them for their support, particularly the extra effort made to meet our commercial flights at the end of the program. We would also like to thank the nurse and medical trained crew on board for their assistance with the emergency response, care and evacuation of one of the science team members.

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 16th annual expedition and the exciting and valuable results are a direct result of working with such experienced, well trained and professional crews.


Joint Ocean Ice Studies & Beaufort
Gyre Observational System 2018
CCGS Louis S. St-Laurent | 06/09/2018 - 02/10/2018

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)

4.1.1.1 ***Overview***

A Seabird SBE9 s/n 756 was used for the entire cruise with s/n 724 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. Last 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.

Our rosette frame was substantially changed last year to accommodate extra instrumentation that has been added again this year by Woods Hole Oceanographic Institute (WHOI). The added instrumentation were an upward facing RDI WHS300 LADCP and a downward facing RDI WHS150 LADCPs, a fiber-optic gyro (FOG), an RSL Microrider microstructure sensor, and a DSPL Sea Battery.

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 CTD 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, one or more zooplankton vertical net hauls would occur from the foredeck. On several occasions, repeat CTD casts were carried out to 1000m or less for specialty large volume water sampling (microbial diversity, microplastics, Cs isotope and a DIC sample storage study). Repeat casts were also done at some BGOS mooring sites for calibration of the SAMI and WQM instruments installed on the moorings.

Prior to JOIS cruise 2018, the SBE3plus temperature, SBE4c conductivity and SBE43 oxygen sensors on the primary SBE 9 were returned for re-calibration by the factories in November 2017. The altimeter and CDOM fluorometer were both new units in 2016. In addition, other sensors were checked for functionality and the plumbing tubing renewed and checked for functionality. See appendix for full configuration and calibration details.

Figure 14. The rosette showing the addition of LADCPs and orange battery back. The CTD, FOG logger and Mircro-rider are hidden by the Niskin bottles.

4.1.1.2 ***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 noted that the WHOI instrumentation, specifically the gyro and microrider, is tied into some of the SBE9 CTD connections. The gyro is tied into our secondary SBE3plus temperature and SBE4c conductivity sensors via y-cables in order to receive this data. The microrider uses a Y-cable to acquire 16VDC from the CTD. Initially this

Y-cable was on connector JT5 and shared power with the CDOM sensor. On Cast 46 this was switched to JT7 with the PAR sensor. We do not believe this affected the functionality or performance of any of our sensors.

4.1.1.3 *Performance notes*

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Winch

The 75hp Hawboldt model SRO 75 is the standard winch used for CTD operations. Originally 7000 m of 0.322" 3 conductor UNOLS wire was installed in 2014 and ~6500m remained on the drum in 2018. It had been re-terminated very near the ned of JOIS 2017 so was not re-terminated in June 2018 since CHS was using the wire for their sound velocity probe in Baffin Bay in August.

Minor problems were encountered with the winch. The spooling messed up at 3195 m during Cast 22. It was not noticed until there were 3 bad cross overs. An attempt was made to complete the upcast, but the spooling was too bad and the wire payed out again to re-adjust the spooling and bring back in. There were no other problems encountered with spooling during the trip.

During Cast 19, it was noted that the winch seemed slow in high gear. It was observed and seen to be slightly slow in both high and low gear. The hydraulic filter was changed. The other potential areas for contamination reducing flow were the main spool and the high/low valve. These valves were cycled repeatedly and tapped to free any junk. The speed of the winch appeared to be OK and no other problems encountered.

There appears to be a very small hydraulic leak on the motor side of the drum. It doesn't appear to be from any hoses in the area, so it is possible that it could be the main motor seal. All seals should be inspected and changed if necessary during the servicing and wire lubricating at IOS over the winter. The leak did not progress further during the cruise and leaked oil contained. Before the cruise the winch was serviced and hydraulic brake system repaired. The winch worked well during the cruise.

Wire (Conducting Cable)

During the upcast on Cast 34 there was an interruption in telemetry of the CTD with the deck unit. A communication error message appeared in Seasave. The deck unit displayed 0110 which indicated that there was still communication with the CTD, and the pylon was talking, but the pumps were off. Initially treated as a computer port issue, it became apparent that the sea cable fuse had blown. It was changed and a new data file opened (……cast034b.hex) and the cast completed without additional problems. Prior to Cast 35, the sea cable was cut back 10m and re-terminated.

Instrumented Sheave (BOT Block)

Prior to Cast 30 the outer rollers on the inboard and outboard trailing arms of the BOT block sheave were replaced.

Rosette Frame

The CDOM, altimeter and transmissometer sensors were mounted in the same positions as 2017 to allow space for LADCP and Microrider installation.

WHOI additions LADCP, Microrider and Gyro

The LADCP, Sea Battery and Fibre Optic Gyro (FOG) were installed from Cast 17 (first cast in the Canada Basin) until the end.

The Microrider was installed for Cast 18, had a small leak. Reinstalled for Cast 24, unfortunately the leak persisted and was removed after cast 25. It was re-installed for Cast 45 until the end of the cruise. Prior to Cast 46 the Microrider power source was changed from the CTD's JT5 connecter shared with CDOM to the CTD's JT7 connector shared with the PAR sensor.

In summary

The LADCP (and Gyro FOG Logger?) was run Cast 17 onwards except for Casts with mooring acoustic release tests due to noise interference, or shallow repeat casts (Casts 21, 23, 29, 33, 37, 38, 54)

The Microrider collected data on Cast 24, 25 (leaked), and Casts 45 to 67.

See the LADCP/ Microrider report below for more details.

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 Niskins' lanyards than usual.

On Cast 21, Niskin 6's top cap jammed and the trigger appeared not to fire. Niskin 6 is located very close to an aluminium flat-bar support and the cap can be jammed against if not aligned correctly.

Prior to Cast 29 minor bottle issues were cleaned up. Monofilament loops were added to the metal springs in Niskins 8, 11, 23 and 24. Niskin 19's spigot was replaced.

Prior to Cast 36 Niskin 19 was replaced as intermittent light leaking from the spigot (X check) had been noticed for a couple of cast. It was found to have a small crack around the centre mounting block.

On Cast 46, two Niskins hung up. Niskin 13 bottom cap was hung up on the downward looking LADCP and the bottom cap of Niskin 19 was hung on the lanyard of Niskin 18.

Prior to Cast 48, Niskin 13 was modified so that the bottom end cap had more clearance by opening outward. It had repeatedly had bottle flushing issues based on analysed water samples.

On Cast 61, lanyards for Niskins 11 and 12 became entangled.

Water Sampler

Generally the system performed well. A new 24 position pylon (s/n1231) was installed and performed near flawlessly. The only issue with the pylon was that a substantial amount of wire lubricant grease was squeezed out of the wire during recovery and the trigger needed to be inspected and cleaned often.

CTD

Cast 55 original cast data lost due to operator error overwriting data file just after recovery. The cast was performed again, keeping the filename and all sample bottle labels the same.

Cast 60 had bottom contact due to a failed altimeter. Lowering rate was fairly slow at 20 to 30m/min and the bottom was soft sediment. No damage to the seacable, bottles, sensors or CTD was observed on recovery however there were still traces of sticky soft mud on the frame.

Altimeter

Cast 60 had an altimeter failure during cast resulting in minor mudding of the rosette. The RMG-6-FS connector had been damaged by pulling and the altimeter pins were obviously wet. Oxygen/Altimeter Y cable and the Benthos altimeter 62670 was removed and replaced with 72144 prior to Cast 61.

CDOM sensors

Cast 8 onward, CDOM sensor (Wetlabs FLCDTR) s/n 4305 started having period of offset/spikey data in the upper 300m. Cast 21 was quite bad.. The connectors were inspected and cleaned. The issue persisted and the Microrider/CDOM Y cable was removed for Cast 23. This Y cable is wired to provide power to the Microrider with an MCILS-6-MP wired like an SBE9 external input connector for the CDOM sensor. This unfortunately did not clear the problem.

Prior to Cast 24 the CDOM sensor s/n 4305 was removed and replaced with s/n1076.

Cast 24 and 25 had the Microrider on, sharing power off this CTD connector. It was removed after Cast 25.

Prior to Cast 45 the Microrider was re-installed. The CDOM values shifted this cast, with a positive offset.

Prior to Cast 46 the Microrider was moved to the JT7 connector shared with the PAR sensor. The Y-cable was removed and the CDOM was alone on its own cable. There was still an offset in the CDOM data.

Prior to Cast 48, CDOM s/n1076 was removed and s/n4305 was swapped in after a thorough cleaning. The CDOM signal was very noisy, much worse than dealing with a good but offset value seen with s/n 1076.

Prior to Cast 49, the CDOM sensor was changed back to sn1076 and the cable was replaced.

In summary:

Casts 1 to 23	s/n 4305	Bad data in parts of Casts 8 to 23
Casts 24 to 47	s/n 1076	CDOM data offset Cast 45 to 47
Casts 48	s/n 4305	Bad data Casts 48
Casts 49 to 67	s/n 1076	CDOM data with offset.

Transmissometer

Cast 48 data were noisy on downcast between 300 and 1700m.

Prior to Cast 49 All transmissometer connectors were opened and cleaned (bulkhead, VMG adaptor and CTD bulkhead).

Prior to Cast 50, the fluorometer/transmissometer Y cable was changed.

Fluorometer

Prior to Cast 50, the fluorometer/transmissometer Y cable was changed.

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

See appendix for CTD sensor configuration and calibration information.

4.2 LADCP, FOGLogger, Microrider Report

P.I. Daniel J. Torres for LADCP and FOGLogger (WHOI)
P.I. Sylvia Cole, John Toole and Dan Torres. For Micro-rider (WHOI)
Marshall Swartz (at –sea lead), Jasmine (Jian) Zhu (WHOI)

Note – text is from the 2017 JOIS cruise report though setup and operation is very similar for 2018. The section on samples taken has been updated for 2018.

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

LADCP/FOGLogger System

On JOIS 2018, 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. 2017 photos, though similar for 2018. 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.

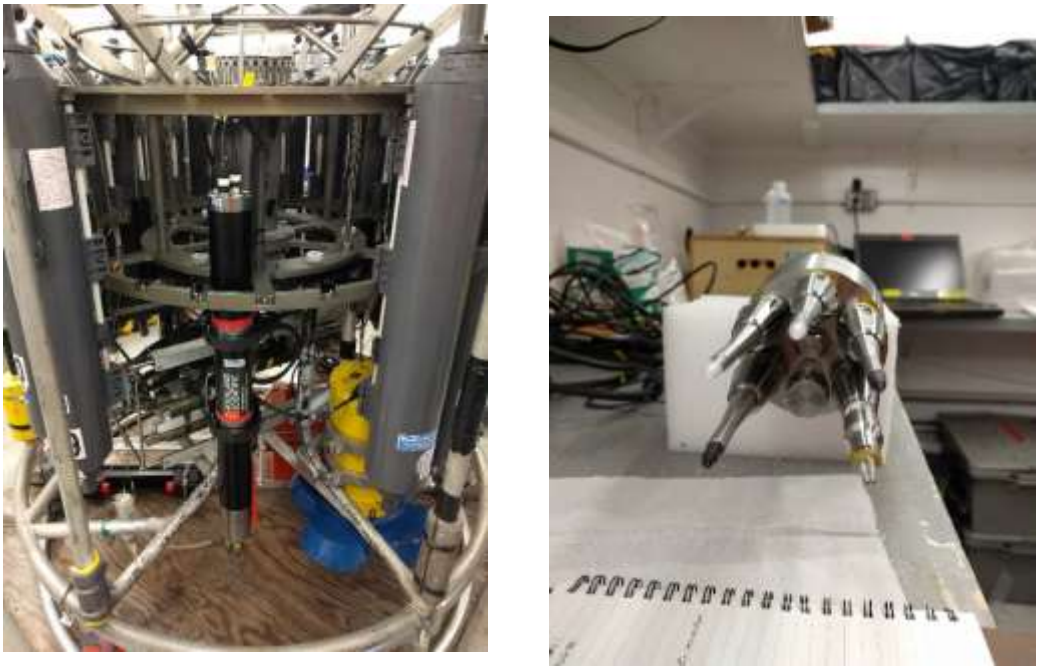

Figure 3. Rockland Scientific Microrider Photos from 2017 are similar for 2018.

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

The LADCP and Gyro FOG Logger were run starting with the third CTD cast on the cruise (Cast 17) onwards except for casts with mooring acoustic release tests due to noise interference, or shallow repeat casts (Casts 21, 23, 29, 33, 37, 38, 54)

The Microrider collected data on Cast 24, 25 (leaked), and Casts 45 to 67. The Microrider had a ~0.5cm long hair-width wire caught in one of the o-ring seals not typically opened and was not discovered and removed until after Cast 25. After further pressure casing tests the instrument was reassembled and used on Casts 45 onward. Up to Cast 46, the power was provided by the CTD using a Y-cable from the JT5 bulkhead connector shared with the CDOM sensor. Cast 46 onwards the power came from the JT7 bulkhead connector shared with the PAR sensor.

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 2. Water Sample Summary for Main CTD/Rosette

Parameter	Canada Basin Casts	Depths (m)	Analyzed	Investigator
Dissolved Oxygen	All	Full depth	Onboard	Bill Williams (IOS)

Triple Oxygen Isotope	Surface bottle from most stations. StnA, 6 depths in top 500m	Surface	Shore Lab	Rachel Stanley (Wellesley)
N_2O / CH_4	Stations near shelf (BL and MK lines, AG5)	Full depth/select	Shore lab	Philippe Tortell (UBC)
DIC, alkalinity	All Additional storage study at CB9	Full depth on 140W and moorings, else 300m	Onboard	Bill Williams (IOS) Storage Study by Lisa Miller (IOS)
CDOM	All	9 samples over the Full depth	Onboard and Shore lab	Celine Gueguen (UTrent)
DOM	Select (CB9, CB11, CB8, CB7, CB4)	4 samples over the Full depth	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)/ David Walsh (Concordia)
Nutrients	All	Full depth	Onboard	Bill Williams (IOS)
Ammonium	Stations near shelf	Top 300m	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 200m	Shore lab/may not analyse	Bill Williams (IOS)
DNA/RNA and Microdiversity	Select	Select, Some Full depth.	Shore lab	Connie Lovejoy (Ulaval)
^{134} Cs	BL4	Surface, summer and winter	Shore lab	John Smith (DFO-BIO)

		Pacific Waters (50, 140m)		
^{129}I	Select (CB8, CB10, CB12, CB15, PP7, BL1, BL4, STN-A)	Select from full depth	Shore lab	John Smith (DFO-BIO)
Microplastics	CB21	Surface, summer and winter Pacific Waters, Atlantic Water and 1000m.	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 O2/Ar & Triple Oxygen Isotopes

Sampling by CTD Watch
P.I.: Rachel Stanley (WHOI)

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

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

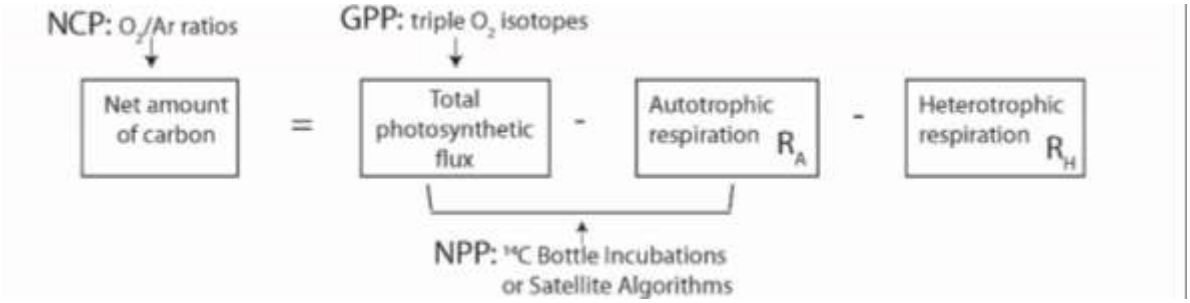

Figure 15. Schematic illustrating the different types of biological production: Net Community Production (NCP), Gross Primary Production (GPP), and Net Primary Production (NPP).

Sampling 2018:

Surface samples were taken at most stations with a short profile of 6 depths at Stn-A to 500m. Samples were collected into vacuum sealed bottles, preloaded with a preservative of mercuric chloride. Samples were stored at room temperature and shipped by air from Kugluktuk for analysis at WHOI (Zoe Sandwith).

4.3.2 Methane and Nitrous Oxide in the Arctic

Sampled by CTD Watch
PI: 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 methanogenesis 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.

Sampling 2018:

Samples were collected in duplicate in ~80ml glass vials, preserved with mercuric chloride and capped with a plug followed with a crimped metal top. The samples were

stored upside down and kept at 4C while onboard. Samples were sent by air from Kugluktuk to University of British Columbia for analysis immediately after the cruise.

Samples were collected at shelf and slope stations along the BL and MK line in addition to AG5 in Amundsen Gulf. Samples were collected from select depths over the station's full depth.

4.3.3 Iodine-129, Cesium-134

Sampling by CTD Watch
P.I.: John Smith (DFO-BIO)

Sampling was performed for two radionuclides ^{129}I and ^{134}Cs in the Arctic Ocean.

Measurements of ^{129}I along the northern edge of the program area provide information about the spread of Atlantic-origin water labeled by discharges from European reprocessing plants.

Measurements for ^{134}Cs in the upper water column of one station near the entry of Pacific derived waters to the Canada Basin will indicate if any water from near the Fukashima nuclear reactor spill of 2011 has entered the Arctic.

Samples for ^{129}I were collected into 1L Nalgene bottles with lids taped shut to prevent leaks. Samples for ^{134}Cs were taken at 3 depths, 50 to 60L per sample and collected into 20L plastic bottles. Sample bottles were stored between 4C and room temperature until analysis on shore at Bedford Institute of Oceanography (DFO).

4.3.4 Dissolved Organic Matter Sampling

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

4.3.4.1 ***Summary***

Chromophoric Dissolved Organic Matter (CDOM) samples were collected for Celine Guéguen (TrentU), following the protocol given below. A total of 453 samples were collected at 58 stations and 41 from the underway seawater loop system between August 30th and October 1st, 2018 on board the CCGS Louis S. St-Laurent during the Canadian Arctic Archipelago transit and the Joint Ocean Ice Study –Beaufort Gyre Observational System 2018.

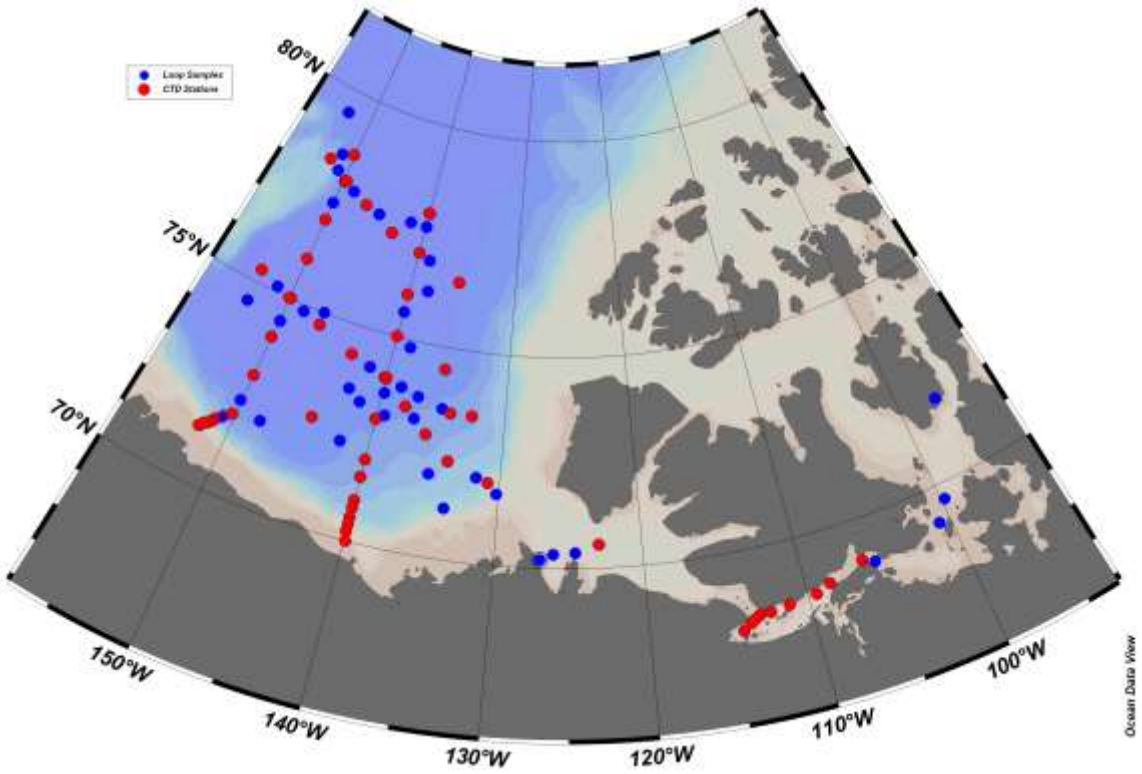

Figure 1: Map of the Arctic Ocean representing the sampling sties of the CTD stations (red) and the loop samples (blue).

4.3.4.2 ***Rosette Casts Samples***

4.3.4.2.1 Samples > 200m

The bottom spigot of Niskin was opened to allow stream of seawater to flush the 40 mL amber glass vial used for CDOM sampling. The vials and caps were rinsed 3X with sample water before collecting the actual sample.

1L water samples were collected for DOM analysis at 4 depths (T-max, 1000-m, 2000-m and Bottom-100m) at CB7, CB8, CB9 and CB11. The samples were solid phase extracted immediately after collection.

4.3.4.2.2 Samples <200m

Samples from depth shallower than 200 m were filtered in line through a pre-combusted GF/F, 47 mm, 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.

4.3.4.3 *Underway Samples*

Forty one 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 flush the 40 mL amber glass vial used for CDOM sampling. Vials and caps were rinsed 3X with sample before collecting the actual sample. Upon collection of each sample from the underway system, CDOM sensor reading (volts), latitude, longitude, UTC time, sample ID etc. was noted.

4.3.4.4 *Storage and Analysis*

After collection, CDOM samples were immediately transported to the 4°C walk-in walk-in fridge where they were stored in the dark in a tote until analysis. The CAA samples from Casts 2 to 14 were analysed on the Aqualog spectrofluorometer on September 07-09, 2018. The Canada Basin samples were analysed onboard within 12h of collection. The 5-m and chlorophyll maximum samples at the BL and MK stations were also analysed on a portable fluorometer. The results will be compared to those obtained using the Aqualog spectrofluorometer.

The DOM extracts were stored in the -20°C freezer and transferred to Trent University for analysis.

4.3.5 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.

Oxygen Isotopes Samples were collected into 30 ml glass vials. Once at room temperature, the caps were retightened and the vials inverted for storage. Samples will be analyzed at Oregon State University, at the College of Oceanic and Atmospheric Sciences (COAS) Stable Isotope Lab, by Jennifer McKay. Samples will be analyzed

using a DeltaPlusXL Isotope Ratio Mass Spectrometer connected to a H_2O-CO_2 equilibration unit.

4.3.6 Dissoved Inorganic Carbon

Marty Davelaar, Cassandra Konecny (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)

Samples for DIC and Alkalinity analysis were collected into 250 mL glass bottles. Since most of the samples on this cruise were analyzed within 2 days, mercuric chloride (HgCl2) and grease were not used to help preserve the samples. Instead a Teflon stopper was used to seal the bottle. Samples were stored at 4°C until analysis. DIC, then alkalinity were measured from the same sample.

DIC samples were analyzed at sea shortly after sampling using a VINDTA 3D - analysis system (S/N 84) to determine DIC. The VINDTA uses a Windows based PC and LabView software along with a coulometric detector (UIC Coulometrics, model 5011). The VINDTA dispenses and acidifies a known volume of seawater, strips the resultant CO2 from solution, dries it and delivers it to the coulometric detector.

4.3.7 Alkalinity

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

4.3.7.1 ***Sampling***

During the 2018 JOIS cruise, seawater samples were collected for DIC/alkalinity analysis from 0-350m of the water column at most of CTD/R stations into 250 ml glass bottles. At selected stations, deeper samples (0-bottom) were also taken. Since all of the samples on this cruise were analyzed within two days, mercuric chloride was not used to help preserve the samples; instead a Teflon stopper was used to seal the bottle. A total 733 samples were collected from Niskin bottles. Of these, 51 samples were taken in duplicate.

4.3.7.2 ***Analysis***

Samples were analyzed for DIC first, and then seawater left in the bottle was analyzed for alkalinity on board. Samples were put in water bath (28 °C) at least 20 minutes before being analyzed. The total alkalinity was determined by potentiometric titration using 0.1N HCl/0.6N NaCl, using an open cell system named ATT-05 (Kimoto electric co. ltd.). Alkalinity values are reported in units of μmol/kg.

At the start of each batch, seawater was run through the system to condition the instruments. Once the system appeared to be working well, certified reference material (CRM) was run to confirm proper operation. The concentration of acid was chosen to give the assigned alkalinity values for CRM. 70mL of seawater was transferred from the

sample bottle to a glass beaker by using a glass syringe equipped with a stopper to take a same volume of sample water every time. An initial amount (ranged from 1.4 to 1.8 mL) of the HCl/NaCl was added to the seawater and then 0.05 ml aliquots of acid were added to the seawater until a pH of below 3.6 was obtained. The sample was then stirred for 600 seconds to degas CO_2, the reading of pH (EMF) and addition of 0.05 mL of acid were repeated until a final pH of below 2.995 was reached.

A plot of total alkalinity measurements vs. CTD-salinity or CTD-depth was made simultaneously during analysis, and samples that seemed unusual in the plot were re-analyzed. Drift throughout the day was monitored by checking the values of replicate analysis of seawater and/or CRM.

4.3.7.3 *Precision and Standards*

Table 3. Water Sample Precision

Chemistry Sample	Precision (s_p)	Units	Number of Replicates (n)	Minimum Range	Maximum Range
Alkalinity (from DIC sample)	2.67	µmol/kg	51	1850.82	2308.94

The accuracy of the alkalinity analysis was assured by daily analysis of certified reference material (batch 173, concentration of S=33.414psu, alkalinity=2210.77 µmol/kg; DOE 1994; Dickson 2001; Dickson et al. 2003) supplied by Andrew Dickson (Scripps Institute of Oceanography, San Diego, USA). Precision is given by the pooled standard deviation (s_p) of sample duplicates and was 2.67 µmol/kg, where n = 51 pairs.

4.3.7.4 *References*

Dickson, A. 2001. Reference materials for oceanic measurements. Oceanography. 14(4):21-22.

Dickson, A.G., Afghan, J.D., Anderson, G.C. 2003. Reference for oceanic CO_2analysis: a method for the certification of total alkalinity. Mar. Chem.80(2-3):185-197.

DOE. 1994. In: Dickson, A.G. and Goyet, C. (Eds.). Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water, Version 2. ORNL/CDIAC-74.

4.3.8 Nutrients

Sarah Ann Quesnel (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)
Nutrient samples (nitrate plus nitrite, silicate and orthophosphate) were collected into 15 mL polystyrene test tubes. One set of samples were analyzed onboard, while the other complete set was frozen at -20°C for checks on shore. Ideally, the first set was analyzed within 12-24 hours from collection. Casts 1 to 14 were collected before the analyst was on board so were frozen for a week before analysis. Samples were analyzed on board using three channel Auto-Analyzer 3 (Seal Analytical, AA3), following the methods described by the manufacturer.

4.3.9 Dissolved Oxygen

Tamara Fraser (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)
Oxygen samples were collected in ~140 mL calibrated ground glass stoppered iodine flasks. Samples were analyzed on board within 48 hours using an automated Scripps Institution of Oceanography (SIO) Winkler-based UV titration system, consisting of: laptop with LVO2 software, 2 Brinkmann 665 Dosimats, a pencil UV lamp, a UV100BQ photodiode detector, a mini stirrer with a water bath sample holder mounted on top, 2 Platinum Resistance Thermometers (PRT) to monitor solution temperatures, and an analogue to digital converter to convert voltages from the detector and the 2 PRTs, to a digital signal. The methodology followed was as described in the SIO Oxygen Titration Manual Version 10-Apr-2003.

4.3.10 Salinity

Mike Dempsey, Chris Clarke, Peter van Buren (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)
Salinity samples were collected in 200 mL type II glass bottles with screw caps and disposable plastic inserts. Samples were transferred to the temperature-controlled lab for storage until they were analysed on board within one week of collection. Samples were analyzed in a temperature-controlled lab on a Guildline AutoSalinometer Model 8400B (SN: 69086), which was standardized with IAPSO standard seawater.

4.3.11 Ammonium

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

Ammonium samples of 40.5 (± 0.5) mL of seawater were collected into 50 mL acid washed glass test tube, and analyzed onboard following the Holmes et al. (1999) fluorometric protocol. After adding working reagent to samples, they were kept in the dark for 6 to 8 hours at room temperature then measured using a TD-700 fluorometer (Turner Designs) with 25mm sample holder, which allowed direct measurement in the sampling tubes rather than sub-sampling into cuvettes. The fluorometer was operated in simple mode with sensitivity calibrated depending on the expected range of sample concentration, having a midrange from 0.5 μM standard (s2) – 1.0 μM standard (s4), reading sensitivity levels of 25-29. Samples with concentrations falling outside of calibrated standard curves were evaluated again with the instrument calibrated to a higher standard (typically the 2.0 μM standard (s5) reading a sensitivity level of 22-23.

Holmes, R.M., Aminot, A., Kérouel, R., Hooker, B.A. and Peterson, B.J. (1999). A simple and
precise method for measuring ammonium in marine and freshwater ecosystems. Can. J. Fish.
Aquat. Sci., 56: 1801-1808.

4.3.12 Chlorophyll-a

Sampled by CTD Watch
P.I.: Bill Williams (DFO-IOS)
Total Chlorophyll-a (>0.7um) samples were collected into brown 1-L polyethylene bottles. Samples were filtered onto 25 mm glass fiber filters (Advantec GF7525MM) under low vacuum filtration. If the sample could not be filtered immediately, it was kept cool until filtered and the time taken until filtered was noted. Filters were then folded in half in another GF/F filter (90mm), wrapped in aluminum foil and stored at -80°C for analysis on shore at IOS. For analysis, samples will be extracted in glass scintillation vials with 10.14 mL of 90% Acetone/10% double deionised water for 24 hours in the dark, in the -20°C freezer. One hour before sample reading, they will be removed from the freezer and placed in the dark to equilibrate to room temperature. Samples will be analyzed on a Turner 10AU fluorometer, SN:5152FRXX, calibrated with commercially pure chlorophyll a standard (Sigma). Fluorescence readings taken before and after acidification will be used to calculate chlorophyll and phaeopigment concentrations (Holm-Hansen et al 1965).

Holm-Hansen, O., Lorenzen, C.J., Holmes, R.W., and Strickland J.D.H. 1965. Fluorometric
Determination of Chlorophyll. J.du Cons. Intl. Pour l'Epl. De la Mer. 30:3-15.

4.3.13 Bacteria

Céline Guéguen (TrentU), Cassie DeFrancesco (TrentU)

P.I. : Connie Lovejoy (ULaval) and David Walsh (Concordia)

Bacteria samples were collected at every station and depth between 9 September and 30 September, 2018. Flow cytometry (FCM) samples for bacteria, pico- and nanoeukaryotes were collected for Connie Lovejoy (ULaval), who took over for Bill Li (DFO-BIO). Samples were collected and processed alternately by Céline Guéguen (TrentU) and Cassie DeFrancesco (TrentU).

Samples were initially collected into 10mL scintillation vials . From these 1.8mL was subsampled into a 2mL cryovial with the addition of 0.2 mL Paraformaldehyde (PFA, 10%) added for preservation. Samples were stored at -80C until analysis on shore.

4.4 Moorings and Buoys

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

4.4.1 Summary

As part of the Beaufort Gyre Observing System (BGOS), three bottom-tethered moorings deployed in 2017 were recovered, data was retrieved from the instruments, refurbished, and redeployed at the same locations in September 2018 from the *CCGS Louis S. St. Laurent* during the JOIS 2018-81 Expedition. Furthermore, three Ice-Tethered Profiler (ITP) buoys were deployed on ice floes: one with a Seasonal Ice Mass Balance Buoy (SIMB), and three ITPs were recovered. A summary of moorings and buoys recovered, serviced and deployed are listed in Tables 1, 2 and 3.

Table 4. Mooring recovery and deployment summary.

Mooring Name	2017 Location	2018 Recovery	2018 Deployment	2018 Location	Bottom Depth (m)
BGOS-A	75° 1.0420' N 150° 8.6919' W	24-Sep 16:14 UTC	25-Sep 22:41 UTC	75° 0.0072' N 150° 0.0075' W	3827
BGOS-B	78° 1.0488' N 149° 58.7219' W	21-Sep 15:24 UTC	23-Sep 1:08 UTC	78° 0.352' N 149° 57.066' W	3827
BGOS-D	74° 0.2476' N 140° 0.3005' W	13-Sep 17:52 UTC	14-Sep 23:52 UTC	74° 0.1940' N 140° 0.0073' W	3512

Table 5. Ice-Based Observatory buoy deployment summary.

IBO	ITP / Buoy System	Date	Location
1	ITP107 / SIMB	17-Sep 21:00	76° 22.9' N 137° 37.3' W
2	ITP110	19-Sep 20:00	78° 1.4' N 140° 15.0' W
3	ITP109	20-Sep 18:42	77° 34.0' N 145° 7.8' W

Table 3. Buoy recovery summary.

Recovery	Buoy	Date	Location
1	ITP108	9-Sep 16:30	70° 17.6' N 122° 23.4' W
2	ITP101	10-Sep 02:38	70° 6.5' N 126° 54.9' W
3	ITP100	30-Sep 07:34	70° 29.5' N 133° 58.3' W

4.4.2 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.

Fifteen 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 2003-2017 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 from 2015 through 2017, suggesting that the historic cyclical nature of freshwater accumulation and release in the BG may no longer pertain.

4.4.3 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 three ITPs and one US Army CRREL SIMB, and recovered two ITP surface packages and one profiler. 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 13 years has seen the deployment of over 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 6. 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=162676
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	www.imb-crrel-dartmouth.org/imb.crrel/SeasonalIBinst.htm

4.4.4 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. The ship's small boat was used to hook the top surface flotation package to a leader. Then the flotation, 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 with sufficient resources for data collection up to 2 years since a recovery cruise has not yet been funded. The moorings were redeployed anchor first, which required the use of a dual capstan winch system to safely handle the heavy loads. This year, recoveries took between 4.5 and 5.5 hours after release, and deployments took 6-6.5 hours for 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 the battery of the shallow MMP on mooring A expired in late August.

Figure 1. Recovery of top floatation package (left), MMP (center) and backup floatation cluster (right) of mooring D.

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 ITP107 and SIMB was 0.8 m thick, the second for deployment of ITP110 was 0.8 m, and the third for deployment of ITP 109 was 0.75 m. Ice analyses were also performed by others in the science party while the IBO deployment operations took place.

Figure 2. IBO consisting of ITP107 and SIMB (left), ITP 110 (center) and ITP 109 (right) shortly after deployments.

All three ITPs deployed in 2017 were recovered during the expedition. All were recovered in open water in depths more shallow than the mooring tether, and one still included the profiler which was dragging on the bottom. The small boat was used to hook ITP 108 surface package which was located in Amundsen Gulf and fed to the starboard A-frame and the complete system including profiler was hauled on board. ITP 101 surface package was recovered in Franklin Bay just east of Cape Bathurst on the small boat and transported to ship where it was craned onboard. ITP 100 was recovered at night using the manbasket to hook the package and hoisted on deck.

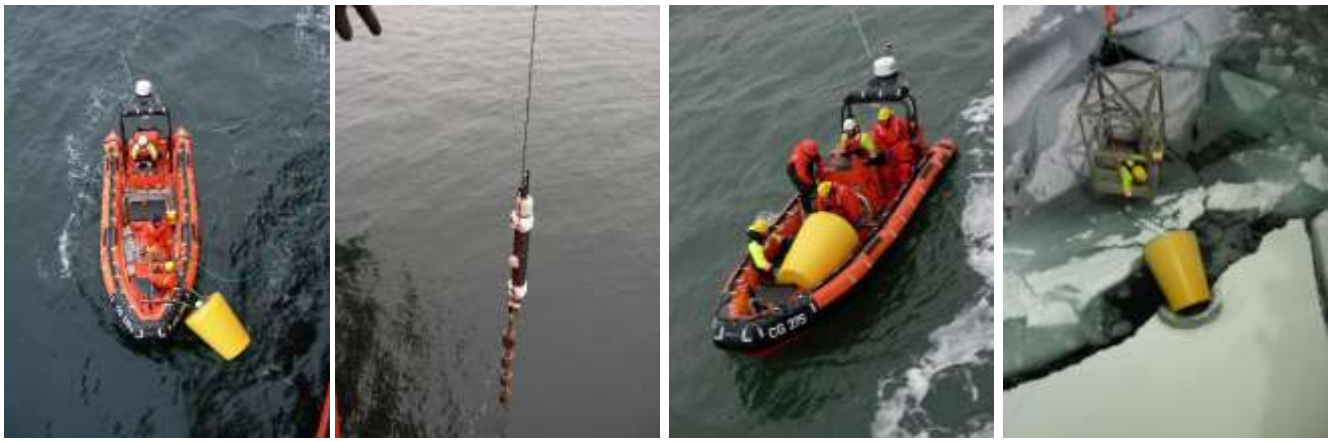

Figure 3. Recovery of ITP 108 surface package (left) and profiler (center left), ITP 101 (center right), and ITP 100 (right).

4.4.5 Outreach

Dispatches documenting all aspects of the expedition were composed by Hugo (RJ) Sindelar from Ocean Media Institute in Montana and posted in near real time on the WHOI website at: http://www.whoi.edu/page.do?pid=162676.

4.5 Underway and Moored pCO2 and pH Measurements

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

4.5.1 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, temperature and dissolved oxygen (DO).
The pCO_2 and DO sensors were deployed on the WHOI ice-tethered profiler (ITP), placed on the ITP cable just under the ice. The sensors will send their data via satellite using the WHOI ITP interface. On each of the 3 BGOS moorings, a SAMI-CO2/SAMI-pH pair equipped with DO, photosynthetically active radiation (PAR) and temperature sensors will be deployed at a depth of approximately 35 meters.

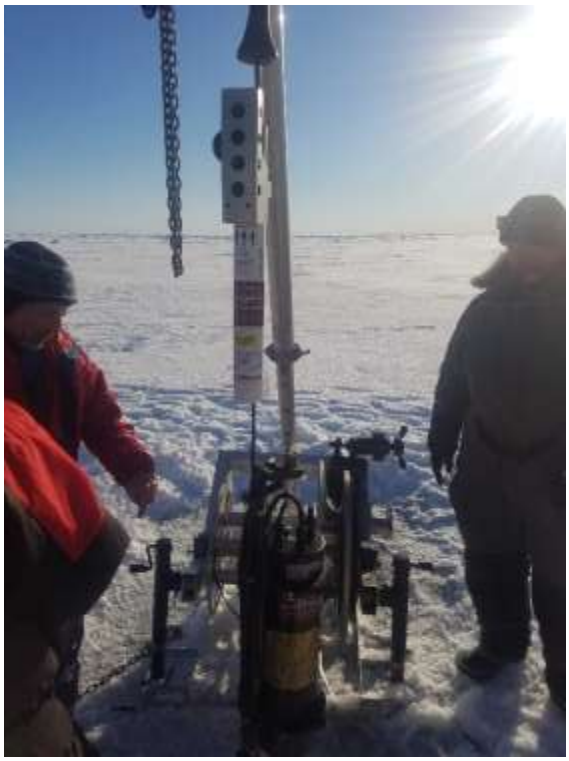

Figure 16. SAMI-CO_2 and Seabird Microcat w/ dissolved Oxygen deployed on ITP 110 during the first ITP deployment.

4.5.2 Cruise Objectives

1. Deploy 1 SAMI-CO_2's & 1 Microcat ODO on 2 of the WHOI ITPs (ITP107 & ITP110).
2. Conduct underway pCO_2 measurements to provide data quality assurance for the ITP-based sensors and to map the spatial distribution of pCO_2 in the Beaufort Sea and surrounding margins.
3. Deploy 1 SAMI-CO2/SAMI pH pair on each of the three BGOS moorings (BGOS-A, BGOS-B and BGOS-D).
4. Assist with other shipboard research activities and to interact with ocean scientists from other institutions.

4.5.3 Cruise Accomplishments

We deployed a SAMI-CO_2 as well as a Seabird Microcat equipped with a dissolved Oxygen sensor on 2 of the ITPs (ITP107 & ITP110). We collected underway

pCO_2 data using an infrared equilibrator-based system (SUPER-CO2, Sunburst Sensors). The instrument was connected to the Louis seawater line manifold located in the main lab. We also deployed a SAMI-CO2/SAMI-pH pair on the BGOS-A, BGOS-B and BGOS-D moorings. The sensor data collection is summarized in Table 1 below.

Table 7. pCO_2 and pH sensor data collection summary

Measurement system	Instrument IDs	Location	Duration
Underway infrared-equilibrator pCO_2	SUPER (Sunburst Sensors)	Entire cruise track (see IOS report in this document)	9/7/2018 - 10/1/2018
ITP SAMI-CO_2 and Seabird Microcat w/ DO sensor	WHOI ITP 107, SAMI-CO2 (C180)	First ITP deployment, CO2 ~ 4.5 m depth, Microcat ~ 4 m depth (see WHOI cruise report in this document)	9/17/2018 - present
ITP SAMI-CO_2 and Seabird Microcat w/ DO sensor	WHOI ITP 110, SAMI-CO2 (C181)	Second ITP deployment, CO2 ~ 4.5 m depth, Microcat ~ 4 m depth (see WHOI cruise report in this document)	9/19/2018 - present
SAMI-CO_2 / SAMI-pH	CO2 : C48u pH : P68u	BGOS-A mooring	9/25/2018 – present
SAMI-CO_2 / SAMI-pH	CO2 : C38 pH : P47u	BGOS-B mooring	9/23/2018 - present
SAMI-CO_2 / SAMI-pH	CO2 : C37 pH : P5	BGOS-D mooring	9/14/2018 - present

4.6 RAS (Remote Access sampler) recovery and deployment

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4.6.1 Recovery

A Remote Access Sampler (RAS), WQM sensors were recovered at mooring station BGOS-A. Please see cruise report 2014 for equipment details and report 2015 for settings.

The RAS was installed with 48 sample bags (new bags from Japan) and was set to collect 450 mL of seawater in each bag. 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	○	○	○	X	X	48	○	○	○	○	○○

4.6.2 Deployment

No deployment this year.

4.7 XCTD Profiles

Operators: Kazu Tateyama, Kazutoshi Sato, Hayato Okuda(KITAMI)
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 54 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.

4.8 Vertical Net Tows

Matt Miller *(UVic), Chris Clarke, Mike Dempsey, Peter Van Buren, Francesca Loro (DFO-IOS), Cassie DeFrancesco (Trent University)*
P.I.: John Nelson (DFO-IOS)

4.8.1.1 ***Sampling***

Zooplankton sampling and preservation were conducted on board by Matt Miller (University of Victoria), Chris Clarke (DFO-IOS), Francesca Loro (DFO-IOS), and

Cassie DeFrancesco (Trent University) of the day watch, and Mike Dempsey (DFO-IOS) and Peter Van Buren (DFO-IOS) of the night watch. A standard Bongo net system was used with a fitted 150μm net on one side and a fitted 236μm 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 17. Matt Miller and Chris Clarke rinsing the bongo nets after a cast during JOIS 2018.

A total of 59 bongo vertical net hauls were completed at 38 stations (see Appendix). The sampling strategy was to perform net hauls whenever time and weather permitted, provided they did not interfere with the rosette operation or require additional ship time. At each station where net hauls were performed, the sampling plan was to start with a 100m depth cast, and if time permitted, additional deeper casts were performed. The first cast was preserved for John Nelson (DFO-IOS), and the additional casts were for Matt Miller (UVic) to pick pteropods from for his master's thesis, as well as for Michiyo Yamamoto-Kawai (TUMSAT). The depths of these additional casts varied from 100-500m, but most were 300m. Additional casts were completed at 18 out of 38 stations. No 1000m casts were possible as time was limited, 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 an electrically heated 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. The hose was removed after every station, coiled, and carried down to the cargo hold to keep warm.

Samples collected from the 236μm mesh nets were preserved in 95% ethanol, and those collected from the 150μm were preserved using formalin with a final sample concentration of 3.7% formaldehyde. The formalin samples will be examined for species identification and the ethanol samples for DNA sequence analysis. Pteropods (*Limacina helicina*) were picked by Matt from the additional cast samples, which were then either air dried or preserved in 95% ethanol and will be analyzed for shell condition. The rest of the sample was preserved using the same methods as the 100m tows, since it was not altered in any other way and seemed pointless to dump the sample overboard. The size (adult or juvenile) and approximate number of pteropods picked from these additional samples were recorded in the plankton log.

4.8.1.2 ***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, resulting in wood chips getting into the samples.

The mesh on one of the cod ends separated from the PVC, and was not repairable in the field. It was very useful to have a third set of cod ends packed, and it is recommended to continue doing so.

Sending a spare garden sprayer that could stay on the ship would be a good idea, since it is such an integral part of processing zooplankton samples, and has many plastic parts that could easily break.

Only one set of plastic sieves was sent on this trip. It wasn't an issue since they didn't break, but it would be good to send a spare set of sieves.

The bag of spare mesh should be updated; many of the meshes are irrelevant sizes for the current sampling plan, and are not well-marked with their mesh size.

The 'date' field on the paper labels and in the plankton log book should be updated to specify UTC date format. The digital log spreadsheet asks for UTC date, but the paper log and labels don't specify, yet ask for both local and UTC time. This caused confusion, and the result was local time being entered in most cases which then had to be converted when entering the data on the digital log.

One of the small bolts on the crossbar of the TSK flowmeters backed off, resulting in the nut falling into the plankton net (fig. 2). The nut was discovered in the cod end after the net haul. After carefully inspecting the flowmeters, the bolt was noticed to be missing its nut. The nut was screwed back on and tightened, but it started to back

off again towards the end of the trip. This is a ‘finger-tighten’ nut and bolt, and it should be monitored during future cruises to make sure they are tight.

Figure 2. TSK flowmeter crossbar nut and bolt which came loose during the 2018 JOIS cruise.

4.9 Diversity, Biogeography and Functional Roles of Arctic Microbial Communities

Adam Monier (University of Exeter), Deo Florence Onda, (University of the Philippines), Thomas Grevesse (Concordia University)
P.I.: Connie Lovejoy (Laval University), David Walsh (Concordia University)

4.9.1 Introduction and objectives

The changing conditions in the Arctic Ocean are expected to affect microbial communities by limiting nutrient supply, changing salinities and even increasing ocean acidification (e.g. Coupel et al., 2012; Riebesell et al., 2013; Thoisen et al., 2015). Loss of ice for example has been implicated to the shift in size of the dominant autotrophs in the Arctic (Li et al., 2009), which would have implications on both carbon and energy transfers to the higher trophic levels. Ice loss in 2007 has also been implicated in the decreased diversity and functional groups in the Arctic across the three domains of life namely Archaea, Bacteria and Eukarya.

Recent 16S and 18S rRNA gene surveys have highlighted the ubiquity and revealed potential novel microbial species in the region with few sequences matching morphologically defined or cultivated species (e.g. Lovejoy et al. 2006, 2014; Brown et al. 2009; Bachy et al., 2012). Past JOIS expeditions have provided opportunities to investigate eukaryotic microbial community structures in the unstudied northern sector of the Canada Basin. Samples collected on ice-free (2012) and ice-covered (2013) years provided

contrasting views, which can be used to predict how microbial communities might change in response to the various ice scenarios. The use of high throughput sequencing (HTS) technology coupled with bioinformatics analysis and conventional microscopic provided insights on species diversity, composition, activity and community structure. Acquired data suggest that the water masses serve as distinct environments, which then select for different microbial communities (Monier et al. 2013 & 2015). Further, network analyses demonstrated varying types of community interactions at each water mass (Deo Onda's Frontiers), with the parasites playing important roles in the potential regeneration of nutrients and elements. Phylogeny-based studies also revealed undescribed/unidentified diversity of microbes in the Arctic region, specifically in the Canada Basin.
In line with these, our objective for this year is to collect samples on the same sites visited in the past years to continue our long-term monitoring work. In addition, we collected more samples from the deeper Canada Basin, whose microbial communities have not been studied thoroughly. Additional work was also done to look at parasites by infection experiments to possibly isolate chytrid fungi and parasitic alveolates.

4.9.2 Methodology

Samples were collected at stations that were mostly visited in 2012 and 2013 but targeting at most 8 depths per station, including the surface (5 m), bottom of the upper mixed layer (20 m), deep chlorophyll maxima (DCM), Pacific summer water at salinity of 32.3 (PSW), core of the Pacific Winter water at 33.1 salinity, temperature maximum (T-max), Atlantic halocline at 1000/1500 m, and the bottom waters. Additional samples from ice cores water underneath the sea ice were also collected for other possible investigations.

Sampled depths were selected based on water column characteristics profiled by the downcast of the CTD of the main deck rosette. Samples for DNA/RNA, DAPI, FISH, FCM and metagenomes were collected at all depths while HPLC samples were only from surface and DCM. Additional samples using 10-20 L of water samples were collected in 5 stations with dedicated casts.

4.9.3 DNA and RNA

DNA/RNA samples from large (>3 µm) and small (0.22 -3 µm) fractions were collected by filtering 6L of seawater at room temperature, first through a 3.0 µm polycarbonate filter, then through a 0.22 µm Sterivex unit (Millipore). Large fraction samples were placed in 2-mL microfuge tubes. In addition, seawater samples were also collected from the underway loop (surface waters, 10 meters) and filtered through a 50 µm mesh then through a 0.4 µm polycarbonate filter. All filter samples were immersed in RNAlater solution (Ambio) and left for at least 15 minutes at room temperature before being stored at -80°C.

4.9.4 Proteomics – Thomas Grevesse

Protein samples from large (>3 µm) and small (0.22 -3 µm) fractions were collected by filtering 12 L of seawater at room temperature. Water was sequentially filtered through a 3 µm pores flat polycarbonate filter (45 mm diameter) and a 0.22 µm pores Serivex filter unit. The large fraction collected on the flat filter was placed in a 2 mL cryovial tube and stored in 1.6 mL of RNAlater. 2 mL of RNAlater were added to the sterivex. All filters were kept at least 15 min at room temperature before being stored at -80°C.

4.9.5 Fractionated Pigments for HPLC

Samples were collected to look at pigment profiles of the photosynthetic community using high pressure liquid chromatography (HPLC). Samples were fractionated into total and small fractions. Total samples were obtained by filtering 2000 mL of seawater at each station and depth sampled through 0.7 µm GF/F filters (Millipore). The 0.7-3µm fraction HPLC samples were obtained by pre-filtering 2000 mL of seawater through 3 µm polycarbonate filters before finally filtering through 0.7 µm GF/F filters. All samples were wrapped in foil, labelled and stored at -80°C until further processing in the lab (ULaval).

4.9.6 Epifluorescent Microscopy

Samples for biovolume estimation, abundance and gross taxonomic classification by microscopy were collected and preserved as described by Thaler and Lovejoy (2014) at each station and depth sampled. In summary, 90 mL seawater is added with 10 mL 10% glutaraldehyde (final concentration) to fix the cells, 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 were stored in opaque boxes and kept frozen until analysis in ULaval.

4.9.7 Fluorescent in situ Hybridization (FISH)

FISH is a technique that uses fluorescent-labelled nucleic acid probes to identify specific phylogenetic group under the microscope. Samples for FISH were collected in duplicate for eukaryotes and bacteria at each station and depth sampled. Seawater was fixed with 3.7 % (final concentration) formaldehyde (Sigma-Adrich) and processed within 1-6 hours after sampling. For eukaryotic organisms, 100 mL of fixed sample was filtered onto a 0.8 µm polycarbonate filters (AMDM) and for bacteria, 25 mL was filtered onto 0.2 µm polycarbonate filters (AMDM). Filters were air-dried and stored at -80ºC until analysis in the laboratory.

4.9.8 Conventional Light Microscopy

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

4.9.9 FCM – single cell sorting

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

4.9.10 Live culture of parasites

Three Arctic representative phytoplankton cultures were brought onboard: the diatoms *Chaetoceros neogracile* (RCC2278) and *Attheya* sp. (CCMP2083), and the dinoflagellate *Polarella* sp. (CCMP2088). These cultures were used as baits for parasite cells with the aim of collecting fungal or alveolates cells. At the three ice camps (IBO1, 2 and 3), under ice seawater samples (6L) were collected after coring operations. Coastal surface seawater samples were also collected during the BL and MK transects (stations BL1 and CB28aa). Surface seawater samples were filtered first through a 50 µm mesh and then through a 10 µm mesh. The biomass accumulated on the 10 µm mesh was then resuspended in 50 mL filtrated seawater (i.e., the output of the 50/10 µm filtration). 3 mL of these resuspended biomass samples were used to inoculate 2 mL of phytoplankton cultures; 2.5 mL of inoculated cultures were transferred in 2.5 mL of phytoplankton cultures every 5 days.

4.9.11 Summary

A total of 160 samples for DNA/RNA and 40 samples for proteomics from different depths at 23 stations including the ice cores were collected during this expedition. With more depths and samples, a higher resolution investigation microbial community partitioning and diversification can be carried out.

Additional Ice Core samples were also collected during the trip. A total of 5 cores, 3 cores from Station 1 and 2 cores from station 2 were collected. Each core was divided into 3 equal parts namely top, middle and bottom, which were then slowly melted overnight and filtered.

See appendix for list of stations.

4.9.12 Issues

The microbiology team had been provided with 12-bottle rosette deployed in the foredeck dedicated to the needs of the program in the past years. However, the later date of the campaign this year as compared to previous years limited the possibility of foredeck work due to harsh conditions. Thus, as agreed with the IOS group, we were given some dedicated bottles (4) in the maindeck rosette during full-depth casts and a short cast on our own as time permits in our selected target stations. To partially resolve the issue of limited bottles during non-dedicated casts, we tried to collect excess waters on other bottles that were on the same depth as ours (i.e. surface, ML, below SCM). The volume of water however was not enough to fill in the needs of the program. For example, to perform all the protocols described above, ~9.0 l of water is needed, however, we were only able to collect 3.5 to 6L in some bottles. The volume of 6L was usually needed for the DNA/RNA application due to the low amount of genetic material available. The usability of volume less than usually required will be tested once samples are already in the laboratory.

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4.10 Microplastics sampling

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

4.10.1 Background / Summary

Plastic litter has globally been recognized as a major threat to marine ecosystems, but increasing reports of microplastics (items < 5mm) have led to heightened concerns about plastic pollution in the world's oceans. Microplastics are categorized as: (1) primary microplastics, which are deliberately manufactured, such as industrial plastic resin pellets (nurdles) or microbeads used in personal care products, and (2) secondary microplastics, which are the breakdown products from larger products, such as food and beverage containers or fibers from synthetic ropes and textiles/wastewater effluent. Approximately 80% of all plastic litter in the ocean is estimated to originate from land based sources (Andrady, 2011).

While concerns about debris and microplastic pollution have largely focused on areas close to human activities, remote regions are not immune from contamination. The two key attributes that make plastic products so desirable to consumers – durability and light weight – allow for their easy transport with ocean currents. Studies have revealed that plastic litter is found in the Arctic *(Lusher et al.*, 2015; Obbard *et al*., 2014; Trevail *et al.*, 2015) with macro-plastic ingestion in seabirds, cetaceans and Greenland shark (Trevail *et al.*, 2015). The presence of microplastic in the Arctic was recently reported in ice cores, with 34 – 234 particles per m^3 of ice was observed (Obbard *et al.*, 2014). The authors noted the potential for huge quantities to be released as a consequence of melting sea ice melting due to climate change. A second report from Svalbard (Norway) found that a majority of microplastics in water consisted of fibers, with average concentrations of 0.34 (± 0.31 SD) particles per m^3 in surface waters and 2.68 (± 2.95 SD) particles per m^3 in subsurface water (-6 m) (Lusher *et al.*, 2015). There have been no reports of ingestion of

microplastics in arctic biota and our understanding of biological risks related to microplastics remains largely confined to laboratory studies. Previous research from our laboratory revealed ingestion of microplastic particles by two zooplankton species in the NE Pacific Ocean (*Neocalanus cristatus* and the euphausiid *Euphausia pacifica)* (Desforges *et al.*, 2015). Ingestion of microplastics by zooplankton represents a potentially significant concern as this may impact the bottom of the marine food web and/or lead to trophic transfer in Arctic species that rely on zooplankton, such as Arctic Cod and Bowhead whales.

The scope of the sampling effort during this Joint Ocean Ice Study (JOIS) expedition was to define the spatial distribution of microplastics at the surface (~10 m) along the cruise track around the Beaufort Gyre and for 1 profile at station CB-21, in addition to testing 3 different sampling methodologies. Due to high contamination levels measured in previous years, we are testing 2 new sampling methods this year in an effort to reduce contamination during sample collection. These 2 methods are a candle filter apparatus and an in-line filtration system.

In total, 11 sieved samples from 11 stations (4 in the Coronation Gulf, 7 during JOIS) , 15 in-line filtration samples at 5 stations, 7 candle filter samples at 6 stations, 4 depth profile samples from 1 station, 7 air blanks and 13 procedural blanks, which all will be described below. This year, no ice core samples were collected. The sample locations are given in the appendix.

4.10.2 Sampling

4.10.2.1 ***Equipment:***

- Sieving system: stainless steel (SS) 316 #230 mesh sieve, with SS 316 lid (pore diameter = 62.5 μm, Hogentogler & Co Inc.) was utilised for sieved samples.

- In-line filtration system: in-line 45 mm polypropylene filter holders X 3, SS 316 wire mesh 45 mm discs (60, 230 and 400 mesh size, baked at 450°C to remove all debris from manufacturing, SS316 tube and swage locks for connecting the filter holders together, peroxide-cured silicone tubing connecting seawater loop system to in-line filtration system.

- Candle filter system: iSpring WSP-50, reuseable spin down sediment water filter. Consisting of 50um stainless steel mesh held in a white plastic cylinder inserted into a clear plastic housing that screws onto a brass fixture connecting inlet and outlet water supply..

- Ultrapure water (18.2 mΩ.cm) produced by a Millipore Milli-Q Reference water purification system.

- A 500 mL squirt bottles filled with ultrapure water, for rinsing the sieve and collecting the material from the sieve

- 20mL glass vials with plastic lined cap for sieved material collection.

- Tyvek suits and nitrile gloves for samplers to wear while collecting all samples.

4.10.2.2 ***Method***

Three systems were used from the seawater loop, sampling the surface waters from the ship's intake at 10m while the ship is underway. These methods are the sieving system, the in-line filtration and the candle filter. Only one method was used for sampling a Niskin bottles using the rosette. Air blanks and procedural blanks were collected as well. All sample were stored at 4C and brought back for onshore analysis by Peter Ross' lab at the Vancouver Aquarium. See appendix for sample location summary.

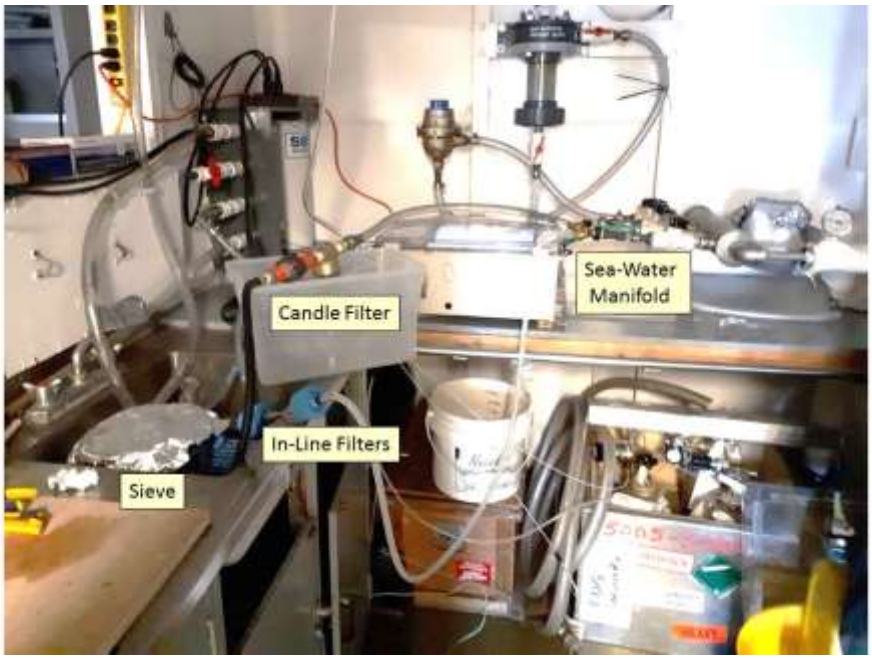


Figure 18. Surface seawater being measured simultaneously by all three methods (Sieve, In-line filters and Candle filter)..

4.10.2.2.1 Sieving system (seawater loop)

For seawater loop samples seawater from the CDOM sensor line was sieved onto #230 mesh sieve with lid, for ~20 to 75 minutes leaving the stations of interest, giving a total sieved volume of ~67-220 L per sample, depending on the flow rate and sieving time. The particulate matter collected on the sieve's mesh was transferred to 20 mL scintillation vials by washing out the mesh with ultrapure water and decanting the particulates into the vial with the aid of a glass funnel. Flow rate of the CDOM sensor line outflow was measured after each sample collection using a graduated 10 L bucket and a stopwatch. Once the in-line filtration system was put together, sieved samples were collected at the same time as the in-line filtration and candle filter samples for comparison purposes.

4.10.2.2.2 In-line filtration system

A brass y-connector was installed on one of the seawater loop manifold outlet to feed simultaneously the in-line filtration and the candle filter systems. The in-line filtration system was connected to the y-connector by a 1 meter piece of Masterflex peroxide-cured silicone tubing. For in-line filtration samples, the filter holders were set without the filter disc, and first rinsed with sample water at the same time as the candle filter system was rinsed. Then the water flow was turned off so the filter discs could be placed in each filter holders. The 60 mesh size filter disc was placed in the first filter holder at the water inlet of the system, then the 230 mesh size, followed by the 400 mesh size as the end filter disc. The water flow was turned and left on until the candle filter's flow meter read ~1000L. After the water flow was stopped, the filter holder with the 60 mesh filter disc was unscrewed, the frit of top part of the filter holders was rinsed down into the scintillation vial (to collect any of the particles that might of stock to it) and the filter disc was carefully transferred to that scintillation vial with metal forceps. The scintillation vials were then filled to the neck with Milli-Q water. Idem was done for the 230 and 400 mesh size filter discs. After all 3 filter discs were removed, the in-line filtration system was rinsed out with Milli-Q water and stored in the set-up configuration to reduce airborn contamination.

4.10.2.2.3 Candle filter system

The candle filter system was connected to the same y-connector the in-line filtration system was on, so it could be sampled simultaneously. The nominal pore size of the candle filter is 50 µM. For candle filter samples, the assembly, without the mesh filter, was flushed with sample seawater (very low concentration of microplastics) for a few minutes. The mesh filter was then rinsed with Milli-Q water and installed into the filter assembly. Seawater was then run through at 7.5 to 15.5 L/min to 1000L, which was measured by a Gardena flow meter. The flow was turned off and the bottom valve of the filter assembly opened to collect the sample water in the Milli-Q rinsed mason jar (500mL or 1L size). Then, the filter assembly was opened and mesh filter dropped into

the mason jar. Milli-Q water was added to reach ~1/2 up the mesh assembly before closing the mason jar to shake for 20 to 30 seconds to release material from the mesh filter. The mason jar was then re-opened, the mesh filter removed and rinsed with Milli-Q water while collecting the rinsed water into the mason jar. As a trial, for some of the samples the mesh filter was left in the mason jar, reducing possible contamination from the final step. The mason jar was stored at 4°C until returned to the Vancouver Aquarium.

Figure 19. Candle filter system set-up.

For all 3 methods, the start and end time, and latitude/ longitude positions were noted, as well as marked in the corresponding TSG file.

4.10.2.2.4 Depth profile (station CB-21)

For depth profile samples, 4 niskin bottles from the CTD/Rosette, fired at the same depth, were collected together through the brass 230 mesh. To confirm at which depth the bottles were tripped, a salinity sample was collected from every niskin prior to microplastic sampling, which took roughly 300 mL of sample water from each niskin. The sieve was then washed with Milli-Q water and the particulate matter collected decanted into a 20 mL scintillation vial with the help of a glass funnel, giving a total sieved volume of 40.72 L per sample. The average volume ± standard deviation of the niskin bottles minus the salinity sample volume was estimated to be 10.18 ± 0.14 L, by filling 4 of them with water, a pseudo salinity sample pseudo collected from each, and then measuring the remaining volume from each with a graduated cylinder. The samples were stored at 4°C until returned to the Vancouver Aquarium laboratory.

4.10.2.2.5 Blanks

During the cruise a set of blanks were collected from the seawater loop. These consisted of :

a) 6 air blank samples were collected by laying out a filter paper in the area where sample was being collected from sieve and/or candle filter system for the duration of the collection operation. The filter was folded and wrapped back in its aluminium foil packet, labelled and stored with the sieved samples.
b) 13 procedural blanks (4 for sieved samples and 9 for in-line filtration samples) were collected immediately after the actual samples were collected. The sieved and in-line filtration procedural blanks were collected simultaneously as the samples were. The sieve and cover lid, and the in-line filtration system were set-up in the same way as it was to collect samples and left in the sampling area for the same amount of them before collecting the "blank" samples. Blank sample collection was performed the same way as for the actual samples, with similar rinsing and decanting times.

4.11 Underway measurements

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

The ship's seawater loop system draws seawater from below the ship's hull at 9 m using a 3" Moyno Progressive Cavity pump. After measuring the intake seawater temperature, seawater travels through ~50m of stainless steel piping to a manifold in a wetlab. The lab is configured with Seabird SBE21 thermosalinograph, Chl-a fluorometer and CDOM fluorometer.

In summary measurements were made for:

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, Dissolved Inorganic Carbon, and Alkalinity (IOS/DFO)
    - Coloured Disolved Organic Matter (*Celine Gueguen, TrentU*)
    - Microplastics (*Peter Ross, Vancouver Aquarium*)
    - Microbes (Adam Monier and Connie Lovejoy, *Oxford University and ULaval,*)
c. Measurements of partial pressure of carbon dioxide (pCO_2) (*Mike DeGrandpre, UMontana)*

Details of the set-up, operation, instruments' make, model, sn, calibration, and performance are given in the appendix.

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.

The Shipboard Computer System (SCS) was used to log

d. GPS from the ship's Furuno GPS, using NMEA strings $GPRMC, $GPGGA, $GPVTG, and $GPZDA. Giving position, time, date and course and speed over ground.
e. AVOS weather observations of air temperature, humidity, wind speed and direction, and barometric pressure ($AVRTE)
f. Heading from the ship's Gyro ($HEHDT)
g. Sounder depth and the applied ship's draft and sound speed ($SDDBT)
h. Surface Photosynthetically Active Radiation (PAR)
i. Time-stamped 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.

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.

4.12 Ice Watch Cruise Report

P.I. Kazu Tateyama (KITAMI), Jenny Hutchings (OSU),
Ice observers on board, Kazu Tateyama, Kazutoshi Sato, Hayato Okuda (KITAMI)

As in previous years, the ice observations recorded during the Louis S. St. Laurent 2018 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.

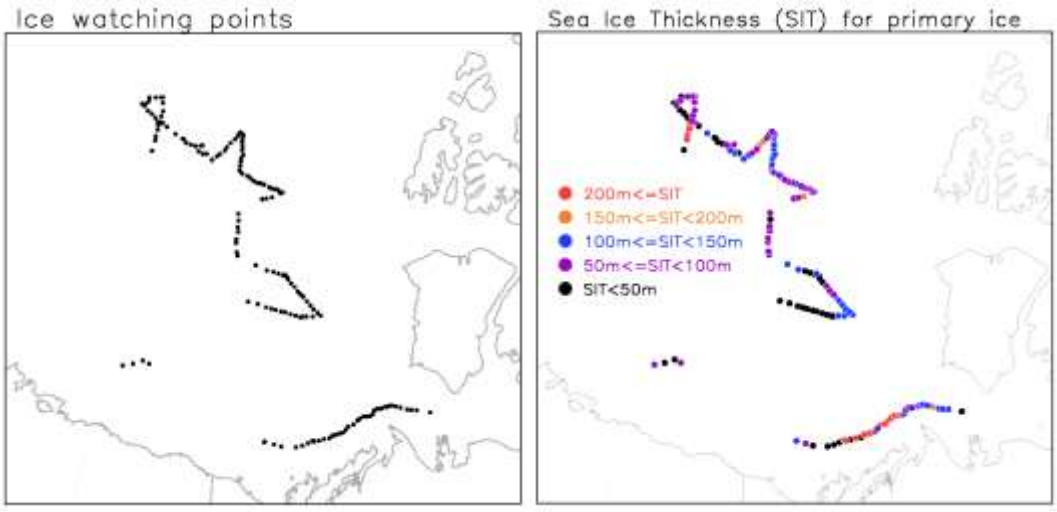
Observations from the Bridge: Methodology

We operated Ice Watch every 1hour for two periods (period1: from 15 to 23 September and period 2: from 28 September to 2 October). 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.

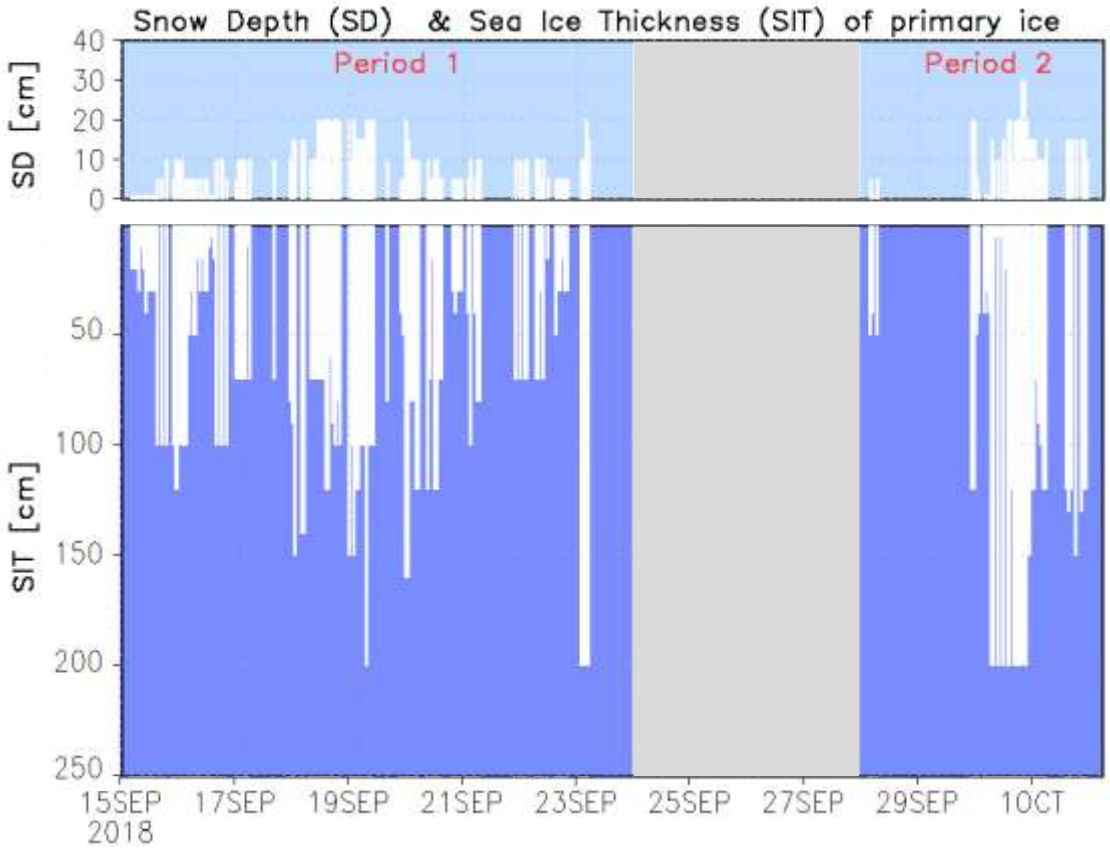
I follow the ASSIST observation protocol. ASSIST is based upon ASPECT (Worby & Alison 1999) bridge observation protocol, with additional information to characterize Arctic sea ice. Additional observables include melt pond characteristics, sediment on ice and an additional ice type – second year ice.

During period 1, the young white/gray ices less than 50cm were observed before 17 September. After 18 September, we observed much young white ice, ice thickness thicker than 50cm. During 18 and 21 September, we encountered relatively thicker young ices exceeding 150m. The multiyear ices thicker exceeding 200m were observed on 23 September. During period2, there were thicker ices than period 1. The multiyear ices exceeding 200m were also observed. During ice watching period, Sea Ice concentration almost exceeded 80 %.

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.



Ice watching observation points (left) and Ice thickness for primary ice (right)



Snow depth and Sea Ice Thickness for primary ice

4.13 EM/PMR/Radiometer ice observation Report

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

Kazutaka Tateyama, Associate Professor, Kitami Institute of Technology, Japan
Kazutoshi Sato, Research Associate, Kitami Institute of Technology, Japan
Hayato Okuda, Associate Professor, Kitami Institute of Technology, Japan

Measurements:

Following ship underway ice observations were conducted starting from September 15 to 22. Three instruments installed port side and bow of Louis S. St Laurent as shown in Fig.1.

1. Ice thickness measured by the Electro-Magnetic induction device (EM), installed at crane of portside.
2. Brightness temperatures (TB) and Infrared temperature measured by the Passive Microwave Radiometers (PMR) installed at portside of flight and boat deck.
3. Short wave and Long wave radiations measured by the Net Radiometer at Bow.

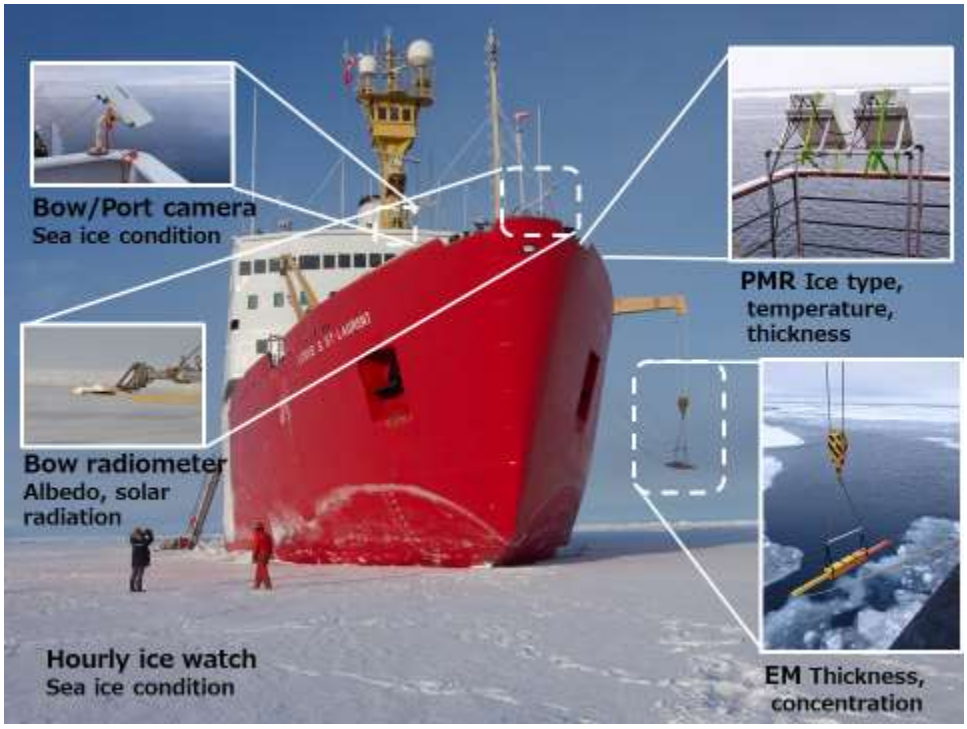


Figure 1 Positions of ship-based measurement sensors

4.14 Ice Stations Report: Cores, Ice Thickness, Snow Pits

Ice measurement were conducted by following the standard JOIS protocol at each ice station.

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

See documents ‘TransectInstructions.docx’ and ‘CoreInstructions.docx’ describing the methodology.

Ice Station 1
coring: Adam Monier, Matt Miller, Donovan Tremblay, Deo Onda
drilling and measure ice thickness: Mike Dempsey, Peter van Buren, Jessica Kenigson
snow pit: Kazu Tateyama, Kazutoshi Sato, Hayato Okuda

Ice was accessed from gangway of starboard side. 200 m transect was set. Ice cores were collected at four sites (0, 40, 100, 150 m) along the transect line. The thickest and the thinnest ice core samples were collected at the 100m site (1.06 m thick) and at the 150m site (0.73 m thick), respectively.

Ice Station 2
coring: Thomas Grevesse, Donovan Tremblay
drilling and measure ice thickness: Mike Dempsey, Peter van Buren, Yuanxin Zhang
snow pit: Kazu Tateyama, Kazutoshi Sato, Hayato Okuda

Ice was accessed from gangway of starboard side. 150 m transect was set. Ice cores were collected at four sites (0, 50, 100, 150 m) along the transect line. The thickest and the thinnest ice core samples were collected at the 100m site (1.00 m thick) and at the 150m site (0.42 m thick), respectively.

Ice Station 3
coring: Celine Gueguen, Guillaume Paradis, Cassandra Konecny, Jasmine Zhu
drilling and measure ice thickness: Jessica Kenigson, Donovan Tremblay, Peter van Buren
snow pit: Kazutoshi Sato, Hayato Okuda

Ice was accessed from gangway of starboard side. 150 m transect was set. Ice cores were collected at four sites (0, 50, 100, 150 m) along the transect line. The thickest and the thinnest ice core samples were collected at the 100m site (1.00 m thick) and at the 150m site (0.42 m thick), respectively.

Ice Thickness Transects

Due to lack of time and staffs, we were unable to follow the standard JOIS procedure of making a 200m transect. We instead settled for 2 50 m transects with thickness and freeboard measurements every 10m ad snow depth every meter in each ice stations.

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.

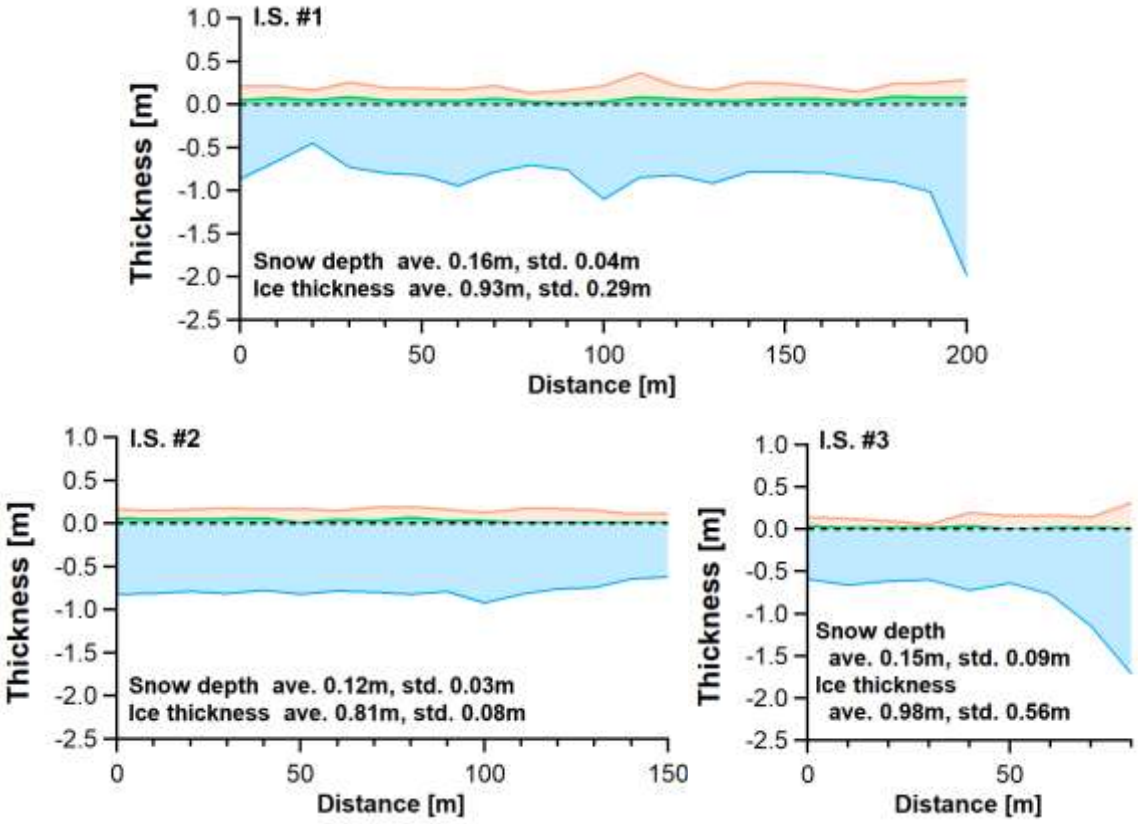


Figure 5 Ice thickness (blue box), freeboard (light-blue box) and snow depth (black line) for the four transects. The bottom plots the results relative to sea level. Note that the snow depth data are every meter.

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).

Ice Cores

Table 1 shows the summary of collected ice core samples. Images of each ice core section can be found in the data repository

Table 1 summary of collected ice core samples

Ice Station	Site	Purpose	PI
1	0m	Physics	Hutchings
		DNA	Lovejoy
	40m	Physics	Hutchings
	100m	Physics	Hutchings
	150m	Physics	Hutchings

2	0m	Physics	Hutchings
		DNA	Lovejoy
	50m	Physics	Hutchings
		DNA	Lovejoy
	100m	Physics	Hutchings
	150m	Physics	Hutchings
3	0m	Physics	Hutchings
	45m	Physics	Hutchings
	80m	Physics	Hutchings

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

Figure 1 Ice Station 1, 0m, DNA/RNA core

Figure 2 Ice Station 2, 0m, DNA/RNA core

Figure 3 Ice Station 3, 0m, physics 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 first year ice in the Beaufort region.

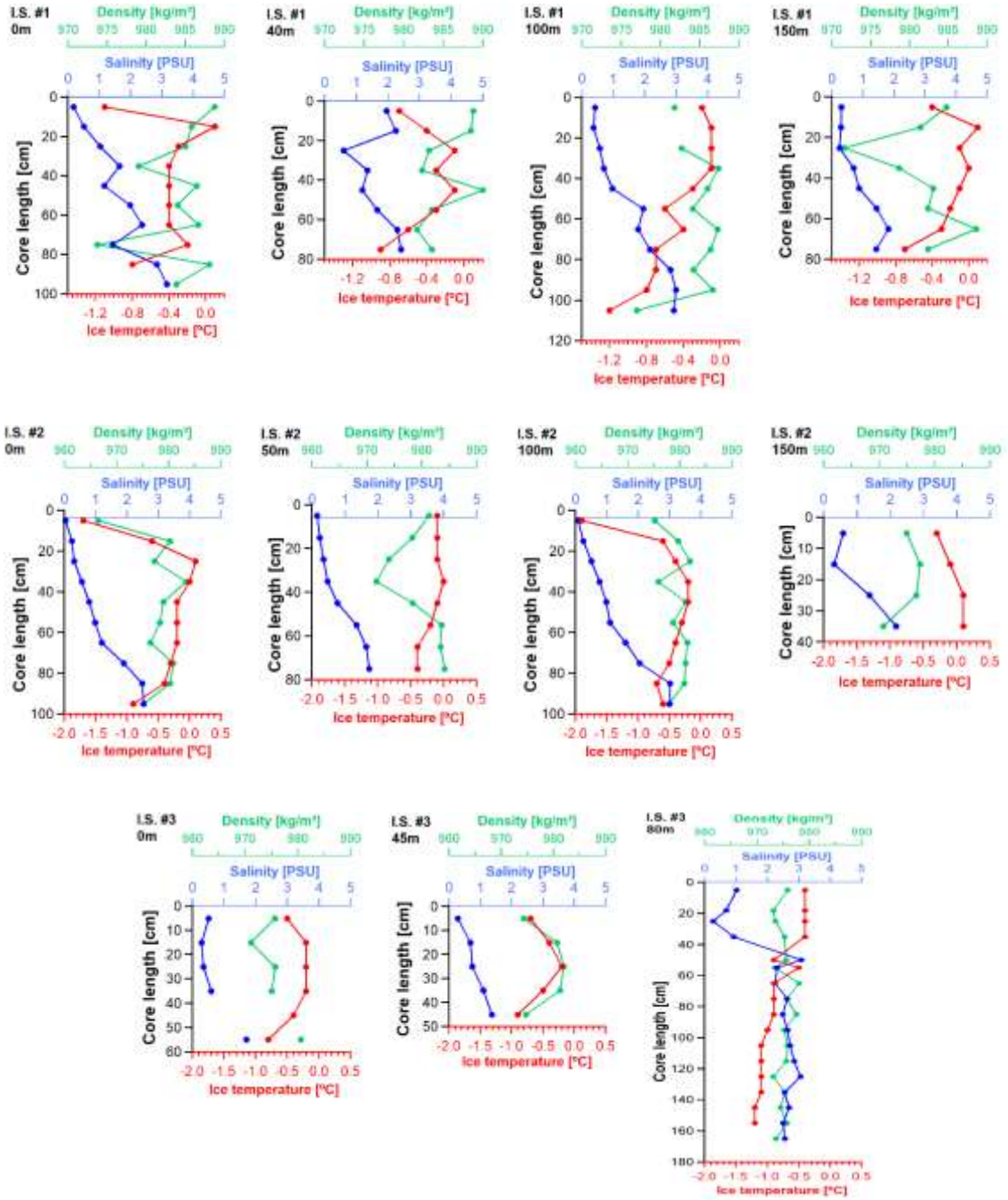


Figure 4 Ice core profiles from Ice Station 1, 2 and 3.

Snow Pit observations

We measured snow properties with snow pits at ice stations. Profiles of temperature, salinity and density of snow and structure of snow layer were collected.

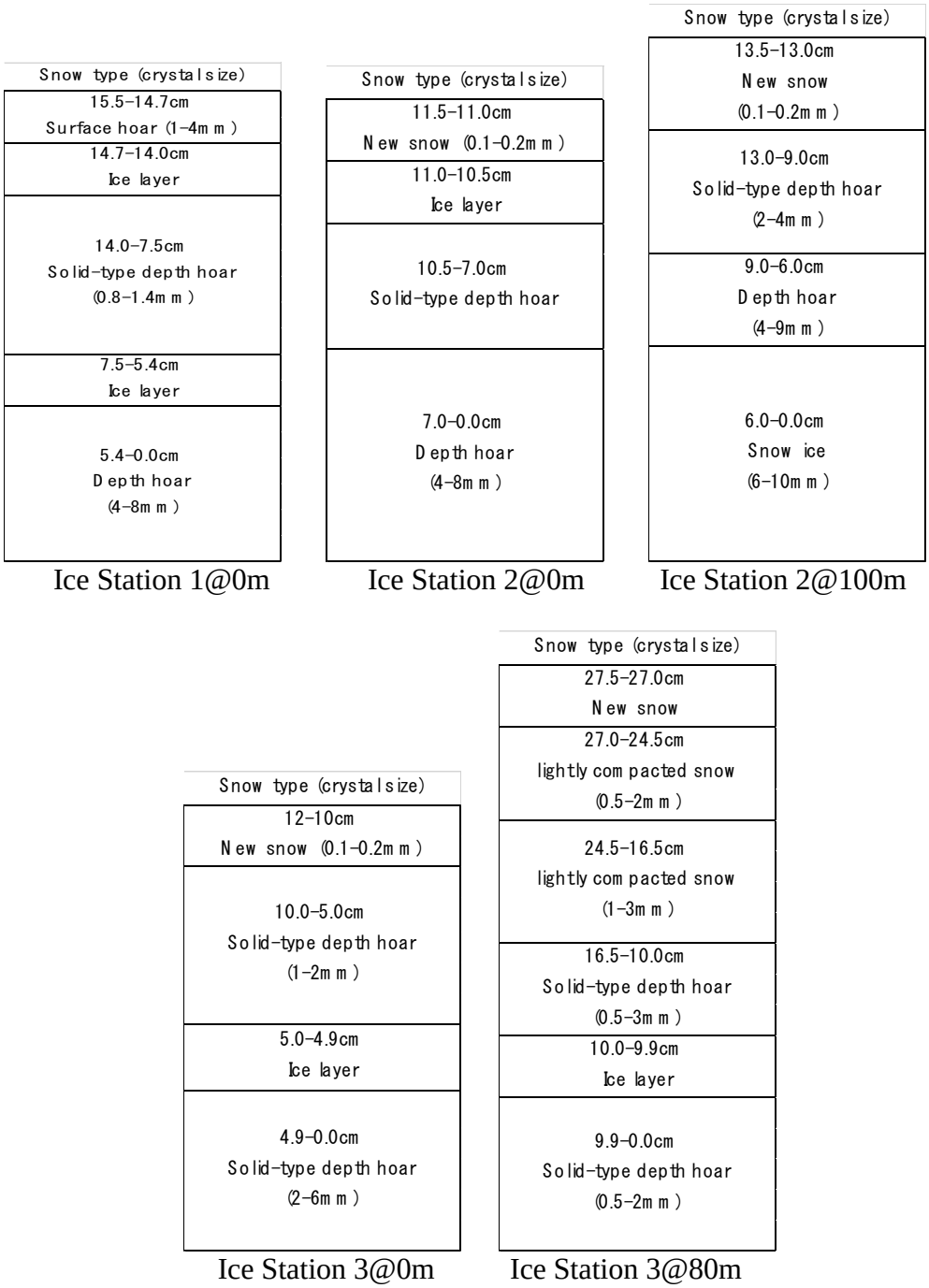


Figure 5 Results of snow structure observations

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Figure 20. Photo taken by R.J. Sindelar with help from the science team.

5. APPENDIX

5.1 SCIENCE PARTICIPANTS 2018-81

Table 8. Onboard Science Team pre-program from Aug 25th to Sep 6th.

Name	Affiliation	Role
Sarah Zimmermann	DFO-IOS	Chief Scientis t/ CTD/ XCTD / Microplastics
Edmand Fok	DFO-IOS	CTD / XCTD / Microplastics

Table 9. Onboard Science Participants for 2018-81.

Name	Affiliation	Role
Sarah Zimmermann	DFO-IOS	Chief Scientist / data and CTD QA/QC
Tamara Fraser	DFO-IOS	Dissolved Oxygen analyst
Marty Davelaar	DFO-IOS	DIC analyst (day)
Cassandra Konecny	DFO-IOS	DIC analyst (night)
Sarah-Ann Quesnel	DFO-IOS	Nutrients analyst / Lab supervisor / Microplastics
Christopher Clarke	DFO-IOS	Day watchleader / Salinity analyst / CTD technician
Edmand Fok	DFO-IOS	Day watchstander / IT / CTD operations
Franscesca Loro	DFO-IOS	Day watchstander / Ammonium analyst
Matt Miller	UVic	Day watchstander / Zooplankton
Cassie DeFrancesco	TrentU	Day watchstander / CDOM analyst
Mike Dempsey	DFO-IOS	Night watchleader / Salinity analyst / CTD technician
Peter van Buren	Dfo-IOS	Night watchstander / zooplankton
Jessica Kenigson	YaleU	Night watchleader / CTD operations / chl-*a*
Celine Gueguen	TrentU	Night watchstander / CDOM analyst
Yuanxin Zhang	TUMSAT	Alkalinity analyst (night) / RAS recovery
Sayaka Kumakawa	TUMSAT	Alkalinity analyst (day) / RAS recovery
Thomas Grevesse	ConcordiaU	DNA/RNA
Deo Onda	ULaval	DNA/RNA (University of the Philippines collaborator)
Adam Monier	ULaval	DNA/RNA (University of Exeter collaborator)
Kazu Tateyama	KIT	Ice observations / E/M ice thickness
Kazutoshi Sato	KIT	Ice observations / polar meteorology
Hayato Okuda	KIT	Ice observations / E/M ice thickness
Hugo Richard Sindelar IV	OMI	Web dispatches / Documentary filming
Cory Beatty	UMontana	pCO2, SAMI
Rick Krishfield	WHOI	Moorings & ITPs & buoys / lead
Jeff O'Brien	WHOI	Moorings & ITPs & buoys

Jim Ryder	WHOI	Moorings & ITPs & buoys
Nico Llanos	WHOI	Moorings & ITPs & buoys
Marshall Swartz	WHOI	LADCP / Microrider
Jasmine (Jian) Zhu	WHOI	LADCP

Table 10. Principal Investigators Onshore for 2018-81

Name	Affiliation	Program
Bill Williams	DFO-IOS	Program lead / CTD/Rosette
Motoyo Itoh	JAMSTEC	CTD/Rosette / XCTD
Shigeto Nishino	JAMSTEC	CTD/Rosette
Peter Ross	VAquarium	CTD/Rosette / Microplastics
Philippe Tortell	UBC	CTD/Rosette / CH4/N2O
Michiyo Yamamoto-Kawai	TUMSAT	CTD / Rosette / Alkalinity
Connie Lovejoy	ULaval	CTD/Rosette / Microbial Diversity
David Walsh	ConcordiaU	CTD/Rosette / Microbial Diversity
Rachel Stanley	WCollege	CTD/Rosette / TOI
John Smith	DFO-BIO	CTD / Rosette / ^{129}I / ^{134}Cs
Svein Vagle	DFO-IOS	Underway system
Mike DeGrandpre	Umontana	Underway system
John Nelson	DFO-IOS/UVic	Zooplankton
Andrey Proshutinsky	WHOI	Moorings and ITP program lead / CTD/Rosette / XCTD
Mary-Louise Timmermans	YaleU	Moorings / ITP buoys
John Toole	WHOI	ITP Buoys
Don Perovich	CRREL	Ice Mass-Balance Buoy
Dan Torres	WHOI	LADCP / FOG logger / Microrider
Jennifer Hutchings	OSU	Ice Observations

Table 11. Affiliation Abbreviations.

Abbreviation	Definition
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
OMI	Ocean Media Institute, Bozeman, Montana, USA
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
UBC	University of British-Columbia, Vancouver, BC, Canada
ULaval	University of Laval, Quebec City, Quebec, Canada
UMontana	University of Montana, Missoula, Montana, USA
UVic	University of Victoria, Victoria, British Columbia, Canada
VAquarium	Vancouver Aquarium, Vancouver, British-Columbia, Canada
WCollege	Wellesley College, Wellesley, Massashussetts, USA
WHOI	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
YaleU	Yale University, New Haven, Connecticut, USA

Table 12. 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=162676
Ice-Tethered Profiler buoys	www.whoi.edu/itp
Ice Mass Balance buoys	imb.erdc.dren.mil
JOIS website from DFO	http://dfo-mpo.gc.ca/science/collaboration/jois-eng.html

5.2 LOCATION OF SCIENCE STATIONS

The scientific crew boarded the *CCGS Louis S. St-Laurent* icebreaker in Kugluktuk, NU, on 6 September 2018 and returned to Kugluktuk, NU on 2 October 2018. 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

Table 13. CTD/Rosette cast locations for 2018-81.

Cast #	Station	CAST START DATE and Time (UTC)	Latitude (°N)	Longitute (°W)	Water Depth (m)	Cast Depth (m)	Sample Numbers	Comments
1	RB-1	2018-08-28 18:40	66.09217	84.7615	140	118	1-24	
2	FBN1-18	2018-08-30 01:55	69.36933	80.9080	110	98	25-30	Sample #29 -> drip from bottom valve.
3	BE6-18	2018-09-01 02:41	71.92167	93.6547	121	110	31-39	Skipped sample #38 (Niskin 8).
4	BE6.6-18	2018-09-01 04:57	71.999	92.4162	222	208	40-50	Oxygen bottle # 829 was dirty , used #889 instead.
5	QN-18	2018-09-04 18:20	68.66633	103.0217	125	108	51-57	
6	CG1-18	2018-09-05 00:31	68.999	106.1433	125	132	58-64	Low transmisometer reading. Sample #64: duplicates on all properties except CDOM. Unusual oxygen profile -> CTD oxygen low at surface and higher from 50m to bottom.
7	CG2-18	2018-09-05 04:50	68.70517	108.5022	127	114	65-71	
8	CG3-18	2018-09-05 12:29	68.54433	109.4767	189	179	72-81	Redrawn oxygen on sample #75.
9	CG6-18	2018-09-05 15:54	68.45733	111.2693	228	205	82-91	All top vents were open.
10	CG7-18	2018-09-05 18:27	68.3927	112.4898	197	182	92-101	
11	CG8-18	2018-09-05 19:55	68.3862	113.1283	197	156	102-111	No oxygen samples collected.
12	CG9-18	2018-09-05 21:09	68.3047	113.4888	116	84	112-118	Used same filter for CDOM as for cast 11. No oxygen samples collected.
13	CG10-18	2018-09-05 22:11	68.2295	113.7903	155	146	119-127	No oxygen samples collected.
14	CG11-18	2018-09-05 23:44	68.0753	114.3175	197	186	128-137	
15	AG5-DNA	2018-09-08 20:45	70.5573	122.9175	650	639	108-161	DNA/RNA cast: Bottle stops are "up-stop" on the upcast with 30 seconds delay before closing.
16	AG5	2018-09-08 22:38	70.5570	122.9178	659	638	162-181	Geochemistry casts: SCM is at 20m.

17	CB1-E	2018-09-10 20:04	71.9600	130.8602	790	768	182-205	Sample #190 -> top valve wasn't tightened; sample #205 -> yo-yo bottle USM for up/stop/mix; no Barium sample collected; at 500m on upcast a washing machine was on, with outflow close to CTD/Rosette point of entry in the water.
18	CB31b	2018-09-11 05:08	72.3515	133.9995	2600	2057	207-230	No sample #206; T_{max} at 476m.
19	CB23a	2018-09-12 11:09	72.8977	135.9940	2730	2735	231-254	
20	CB22	2018-09-12 16:40	73.4430	137.9752	3102	3115	255-278	Sample #262 target depth adjusted from 500m to 550m to account for proximoity to T_{max}.; added WHOI acoustic releases.
21	CB27	2018-09-12 23:08	72.9977	140.0003	3211	3209	279-302	Redrawn oxygen on sample #279 -> bubble when adding fixing chemicals; sample #284 did not fire, samples #297 and #298 fired without stopping and spiggots were dripping; sample #300 -> top cap stuck open (bottom closed but top didn't), sample #302 -> redrawn oxygen as a bubble was added when addding the fixing chemicals; added WHOI accoustic release; LADCP was not turned on prior to deployment.
22	CB21	2018-09-13 12:03	73.9932	140.1318	3506	3505	303-326	Major winch trouble-> first 5 bottles all compromised as had to re-lower the rosetted from 1700m to 3400m; chummy added on upcast. Niskin 22 -> depth changed from 40m to 37m to match mooring PCO_2 sensor depth; CDOM -> very low values recorded at 350m and 500m.
23	CB21-DNA	2018-09-13 23:10	73.9812	140.0330	3507	1002	327-350	DNA/RNA cast: Duplicate DIC for mooring PCO_2 comparison; yo-yo each depth -> even at 37m -> 30 sec , up 1m , down 2m , up 1m, 30 sec.

24	CB19	2018-09-14 04:44	74.3003	143.3007	3493	3688	351-374	Collected bottom water for nutrient analysis' deep water reference; sample #360 fired at 484m instead of 488m. Bottle 15 and16 (samples #365 and #366 had spiggots pushed in but still contained water; LADCP and microrider operational.
25	CB21-Plastic	2018-09-14 12:08	74.0042	140.0243	3512	3511	375-399	Microplastic cast: sample #377 -> oxygen sample got 1 extra drop of NaOH; bottle stops with multiple bottles are yo-yo'ed (up/stop/mix); sample #383 was skipped; LADCP and Microrider operational.
26	CB50	2018-09-15 11:16	73.4860	134.3508	2908	2888	400-423	redrawn oxygen sample #403 and #422. Microrider removed.
27	CB51W	2018-09-15 18:47	73.4872	132.6037	2813	2712	424-447	Station CB51 moved to XCTD site between CB50 and original CB51 location to save time through ice -> re-named CB51W
28	CB40	2018-09-16 09:47	74.4775	135.3713	3150	3240	448-471	Took CTD to bottom-10m but first bottle was tripped on the up cast at bottom-100m; sample #466 had a leaky spiggot.
29	CB18	2018-09-16 20:47	75.0015	140.0100	3630	3614	472-495	Sample #490 -> leaking from spiggot when open and top valve closed; sample #492 -> redrawn oxygen because of bubble present; sample #495 -> DIC/ALK sample taken before TOI sample.
30	CB17	2018-09-17 06:06	76.0078	140.0382	3690	3687	496-519	Outside air temperature = -7.4°C, - 20°C with windchill.
31	PP7	2018-09-18 04:56	76.5362	135.5107	3570	3562	520-543	Sample #520 -> spiggot leaked when open and top vent is closed.
32	CB15	2018-09-18 20:44	77.0107	139.9382	3720	3717	544-567	Outside air temperature = -4°C; sample #554 fired at 296m instead of 269m.
33	CB16 DNA	2018-09-19 09:46	77.9587	139.9680	1000	1003	568-591	DNA/RNA cast: Extra bottle fired at 33.1 psu and 32.1 psu and DCM depths to have oxygen and salt samples collected. All stops were up-stop-mix (yo-yo'ed).

34	CB16	2018-09-19 11:54	77.9530	139.9397	3742	3739	592-598	Sample #603 (niskin 12) -> misfire due to ADCP in the way, DIC/Alk duplicate taken on sample #602 instead of sample#603 because of misfire; sample #594 ->loose cap.
34B	CB16	Continuation of upcast in second file					599-615	
35	CB13	2018-09-20 05:49	77.2797	143.1960	3772	3769	616-639	Sample #634, slight dribble on spiggot, had to wiggle top cap to stop the dripping.
36	CB12	2018-09-20 23:11	77.6950	146.6858	3802	3801	640-663	Sample #653 top vent was open; sample #658 had a leaking spiggot; empty Microrider case on rosette for watertight test by M.swartz.
37	CB9	2018-09-21 06:59	78.0053	149.7955	3816	1002	664-687	DNA/RNA cast: up-stop-mix (yo-yo stops) for all 3-bottle groups.
38	CB9-DICA	2018-09-21 08:54	78.0147	149.7420	1000	1003	688-711	DIC study A: 5 niskin (#20-24) fired at surface (5m) and each 500mL, 250mL, 125mL and beer bottles poisoned with 100 µL $HgCl_2$ and Brent bottle with 50 µL $HgCl_2$. Niskin were fired with Up stop yo-yo mix method, paused a couple seconds between each fire.
39	CB9-DICB	2018-09-21 11:03	78.0268	149.6600	3814	3812	712-735	DIC study B: each 500mL, 250mL, 125mL and beer bottles poisoned with 100 µL $HgCl_2$ and Brent bottle with 50 µL $HgCl_2$. All niskin fired with up stop yo-yo mix for each group of niskin; sample #721-726 -> winch accidentally overshot target depth, sample #731 had a dripping spiggot.
40	CB11	2018-09-22 03:54	78.6425	150.1120	3810	3810	736-759	Outside air temperature = -1℃.
41	CB10DNA	2018-09-22 11:30	78.3293	152.3160	3400	3815	760-783	Forgot to collect I^{129}, sample collection added to following cast, station CB8.

42	CB8	2018-09-23 07:47	77.0045	150.0002	3818	3816	784-807	Sample #799 ->redrawn oxygen because of bubble in samples; sample #804 -> CDOM missing at SCM (sample was added after main labels were printed); Up/Stop for niskin 1; yo-yo niskin 24; all others used Up/No stop.
43	CB7DNA	2018-09-23 18:25	76.0003	150.0098	3800	3818	808-831	DOM samples drawn but not in label file (printed after words); no TOI sampled; sample #831 top vent was open.
44	CB6	2018-09-24 04:38	74.6967	146.6967	3773	3771	832-855	
45	CB4	2018-09-24 11:35	75.0162	149.8775	3817	3817	856-879	DOM samples #860 and #862 not sampled intentially; sample #869 ->redrawn oxygen sample because of bubble in sample; DNA/RNA's Bottom-100m -> only 1 noted in imported label file; hand made labels for CDOM samples #860 and #862; niskin Bottom-100m and 5m were yo-yo'ed, all other niskins were fired Up/No stop; grease on spiggot of niskin 15 (sample #870); LADCP and microrider operational.
46	CB5	2018-09-25 01:59	75.3003	153.2940	3837	3835	880-903	Sample #895 fired at 201m instead of 206m; LADCP and microrider operational.
47	CB4DNA	2018-09-25 13:06	75.0052	150.0295	3818	1002	904-927	DNA/RNA cast: Sample #916 -> no water in niskin and sample #922 -> no water collected due to considerable leak from bottom seal, therefore samples from niskin 13 and 19 collected from niskin 14 and 20, respectively instead; samples #919 to #921 moved to match with BGOS-A PCO_2 + RAS; white plume observed 2-3 m from surface during 5m bottle closure; all niskins were yo-yo'ed; LADCP and microrider operational; *** *Notable feature in temperature , salinity and oxygen profiles around 158m. Eddy?***

48	CB3 w/DNA	2018-09-26 03:09	74.0010	150.0057	3814	3817	928-951	Deep water reference collected from niskin 1 for salt analysis; sample #928; only 2 oxygen samples drawnn instead of the intended 3. LADCP and microrider operational.
49	CB2DNA	2018-09-26 17:09	73.0013	150.0075	3800	3736	952-975	Sample #957-> filled standard and blank tubes for NH_4 (500m); data file is *0049b as *0049 corresponds to "fake" cast for filming purposes.
50	BL8	2018-09-27 01:47	71.9547	150.2595	3000	2997	976-999	Sample #981 (600m) -> 4L drawn for sapre NH_4 standards and blanks; sample #982 (500m) -> filled standard and blank tubes for NH_4; sample #982 -> top valve open; sample #991 -> a 3rd N_2O sample was drawn and DIC was drawn before N_2O; sample #993 -> N_2O duplicate had a bubble delivered by pipette; jelly fish tentacles on rosette; surface niskin (sample #998-999) were yo-yo'ed before tripping.
51	BL7	2018-09-27 05:37	71.8197	150.7630	2000	2574	CTD only	CTD cast only, no water collection.
52	BL6	2018-09-27 08:40	71.6817	151.1867	2000	2062	1000-1023	Sample #1007 (500m) -> filled standard and blank tubes for NH_4; sample #1021 -> second temperature reading for oxygen was 5.2°C; sample #1021 and #1022 depths adjusted for shallower than expected Chl-a_{max}; sample #1000 -> CDOM drawn before N_20. For the N_20 samples -> having trouble getting rubber stopper in without a bubble getting caught between leg and bottle neck on a few of these bottles. Bacteria samples drawn from samples #1009 and #1011 are not reflected in the rosette sheet but labels were printed and likely collected.
53	BL5	2018-09-27 11:53	71.5950	151.3653	1500	1571	CTD only	No water collection. CTD cast only

54	BL4CS	2018-09-27 13:44	71.5222	151.5818	1100	301	1024-1039	Cs cast: Samples bottles were collected into carboys as pairs (1+2, 3+4, 5+6, etc); damplers did not realize however that water from bottles 11 and 12 where closed at different depths. Therefore unintenauitally mixing water from 50m with water from 5m into the same carboy. All stops where Up/Stop and yo-yo'ed.
55	BL4	2018-09-27 16:17	71.5210	151.5867	1100	1118	1040-1063	Sample #1042 -> filled standard tubes X2 for NH_4; sample #1048, 1051 and 1053 -> oxygen redrawn; data file is *0055b; paper rosette sheet differs from label printed. See confirmation.
56	BL2	2018-09-27 18:56	71.3937	151.9525	150	155	1064-1076	Sample #1064 -> oxygen redrawn; sample #1072 3rd N_2O sample collected as one had suspect air bubble; sample #1075 -> extra N_2O sample collection. Lots of jelly fish on rosette.
57	BL1	2018-09-27 20:34	71.3627	152.0780	81	72	1077-1086	
58	BL3	2018-09-27 22:07	71.4655	151.8197	500	530	1087-1107	No T_{max} sample; sample #1098 top vent was open; sample #1102 ->N_2O redrawn due to air bubble. Chl-a_{max} layer between 0-18m; CTD oxygen shows mix layer between 0 and 20m.
59	STNADNA	2018-09-28 11:10	72.6007	144.7050	3428	3418	1108-1131	Sample #1125 -> top seal compromised ; sample #1131 -> DIC taken late.
60	CB29	2018-09-28 20:54	72.0003	139.9972	2698	1428	1132-1155	Sample #1132 -> 5m off bottom instead of 10m; sample #1139 -> stopcock pushed in but not leaking; sample #1144 -> oxygen minimum @ 34.1 psu depth.
61	MK6	2018-09-29 01:37	71.5683	140.0045	2500	2456	1156-1179	Sample #1163 -> filled NH_4 standard tubes; niskins 11 (sample #1166) +12 (sample #1167) bottom cap problem and lanyards caught. Sample #1166 -> already sampled for oxygen, niskin 12 had no water.

62	CB28b	2018-09-29 06:04	70.9983	139.9958	2000	2066	1180-1203	
63	MK4	2018-09-29 08:59	70.8115	140.0015	1500	1518	1204-1227	Sample #1204 -> oxygen redrawn; sample #1210 -> filled NH4 standard and blank tubes; sample #1211 -> oxygen redrawn; sample #1224 -> $\delta^{18}O$ was broken during packup.
64	MK3	2018-09-29 12:06	70.5707	140.0010	787	757	1228-1248	Sample #1228 -> oxygen redrawn; sample #1235 -> oxygen redrawn; sample #1247 -> oxygen redrawn; sample #1240 -> loose top vent; sample #1244 -> spigot dribble.
65	MK2	2018-09-29 14:21	70.4030	140.0032	500	491	1249-1271	Samples #1269-1270 -> no duplicates collected.
66	MK1	2018-09-29 16:48	70.2247	140.0025	250	210	1272-1284	Sample #1279 -> oxygen redrawn
67	CB28aa	2018-09-29 18:30	69.9993	139.8793	60	53	1285-1294	

5.2.2 XCTD

Table 14. XCTD cast deployment locations for 2018-81.

File name starting with C3 means XCTD-1 probes was used and File name starting with C5 means XCTD-3 probes was used. S/N = serial number of the probe launched

Filename	Event number	CAST START DATE and Time (UTC)	Latitude (°N)	Longitude (°W)	S/N	Cast Depth (m)	Comments
Baffin Bay							
C3_00002.EDF	1002	2018-08-09 16:46	62.5573	77.7074	1705681	250.0	
C3_00003.EDF	1003	2018-08-10 1:57	62.0083	68.3044	1705681	243.0	
C3_00004.EDF	1004	2018-08-10 13:18	61.8876	63.6561	1705681	499.9	
C3_00005.EDF	1005	2018-08-10 22:00	63.7585	62.3917	1705681	190.9	
C3_00006.EDF	1006	2018-08-11 14:26	67.0000	61.0000	1705682	499.9	
C3_00007.EDF	1007	2018-08-11 18:24	67.7529	62.0705	1705682	499.9	
C3_00008.EDF	1008	2018-08-11 23:37	68.5211	63.3725	1705682	499.9	
C3_00009.EDF	1009	2018-08-13 23:30	70.3322	68.3193	1705682	250.0	
C3_00010.EDF	1010	2018-08-14 10:17	70.3322	68.3193	1601700	499.9	
C3_00011.EDF	1011	2018-08-14 21:41	71.6689	69.4524	1705681	499.9	
C3_00012.EDF	1012	2018-08-15 15:12	72.1546	74.9107	1705681	250.0	
C3_00014.EDF	1014	2018-08-18 23:07	72.0782	71.0927	1601700	499.9	
C5_00015.EDF	3015	2018-08-19 15:03	70.0000	68.9290	1601676	250.0	
C3_00016.EDF	1016	2018-08-20 23:22	67.4680	63.6135	1705681	499.9	
Canada Basin							
C3_00017.EDF	1017	2018-09-11 2:26	72.1572	132.4703	1601700	1100.1	ship speed = 10 kn
C3_00018.EDF	1018	2018-09-12 1:00	71.1932	133.7995	1705682	624.5	ship speed = 10 kn
C3_00019.EDF	1019	2018-09-12 3:56	71.8227	133.9435	1512646	1064.7	ship speed = 10 kn
C3_00020.EDF	1020	2018-09-12 7:02	72.1023	136.0016	1512646	1093.9	ship speed = 10 kn
C3_00021.EDF	1021	2018-09-12 9:02	72.5141	136.0046	1512646	1100.1	ship speed = 10 kn
C3_00022.EDF	1022	2018-09-12 15:05	73.1797	137.0189	1512646	1100.1	
C3_00023.EDF	1023	2018-09-12 21:28	73.2244	138.9780	1512646	1100.1	ship speed = 10 kn
C3_00024.EDF	1024	2018-09-13 3:32	73.2512	141.3806	1512646	1047.5	ship speed = 10 kn
C3_00025.EDF	1025	2018-09-13 5:24	73.5005	142.7490	1512647	1100.1	ship speed = 10 kn
C3_00026.EDF	1026	2018-09-13 9:15	73.5012	139.9924	1512646	1100.1	ship speed = 10 kn
C3_00027.EDF	1027	2018-09-14 2:35	74.1498	141.6334	1512646	1100.1	ship speed = 10 kn
C3_00028.EDF	1028	2018-09-15 2:40	73.8381	138.2550	1512646	1100.1	ship speed = 10 kn
C3_00029.EDF	1029	2018-09-15 6:13	73.6756	136.3193	1512647	282.1	ship speed = 10 kn

C3_00030.EDF	1030	2018-09-15 6:19	73.6705	136.2606	1512647	1100.1	ship speed = 10 kn
C3_00031.EDF	1031	2018-09-16 5:42	74.0914	134.3839	1601704	1100.1	no ship speed data entered in daily log
C3_00032.EDF	1032	2018-09-16 17:07	74.7486	137.7079	1601704	1031.3	ship speed = 10 kn
C3_00033.EDF	1033	2018-09-17 2:55	75.5252	140.0000	1601703	1100.1	no ship speed data entered in daily log
C3_00034.EDF	1034	2018-09-17 11:49	76.1629	138.5750	1601703	1091.1	ship speed = 3 kn
C3_00035.EDF	1035	2018-09-18 0:07	76.4006	137.1670	1601703	1100.1	ship speed = 3 kn
C3_00036.EDF	1036	2018-09-18 15:06	76.7577	137.8411	1601704	586.0	no ship speed recorded in daily log
C3_00037.EDF	1037	2018-09-19 4:05	77.4518	139.8586	1601704	1100.1	ship speed = 2.5 kn
C3_00038.EDF	1038	2018-09-20 1:09	77.6644	141.5735	1601702	1100.1	ship speed = 3 kn
C3_00039.EDF	1039	2018-09-20 13:21	77.4748	144.8617	1601702	1100.1	ship speed = 2 kn
C3_00040.EDF	1040	2018-09-21 4:20	77.8537	148.3029	1601702	1100.1	ship speed = 10 kn; position is end location; in open water, approximatly 15 mile patch where wind/eddy has pushed into ice edge.
C3_00041.EDF	1041	2018-09-22 1:02	78.3824	149.9295	1601702	1100.1	ship speed = 10 kn
C3_00042.EDF	1042	2018-09-22 9:00	78.5300	151.5994	1601703	755.0	no ship speed recorded in daily log
C3_00043.EDF	1043	2018-09-22 16:44	78.1699	151.0778	1601702	1100.1	ship speed = 10 kn
C3_00044.EDF	1044	2018-09-23 5:27	77.4926	149.9499	1601703	1047.7	ship speed = 9 kn
C5_00045.EDF	3045	2018-09-23 12:42	76.7447	151.4463	1601676	1000.2	ship speed = 6 kn
C5_00046.EDF	3046	2018-09-23 14:48	76.4999	152.9526	1601676	1000.2	ship speed = 13 kn
C5_00047.EDF	3047	2018-09-23 16:36	76.2696	151.4762	1601676	1000.2	ship speed = 15.6 kn
C5_00048.EDF	3048	2018-09-23 23:11	75.7675	148.4079	1511561	1000.2	ship speed = 10 kn
C5_00049.EDF	3049	2018-09-24 1:00	75.4992	146.6876	1511561	1000.2	ship speed = 15 kn
C5_00050.EDF	3050	2018-09-24 2:47	75.0935	146.7146	1511561	1000.2	no ship speed recorded in daily log
C5_00051.EDF	3051	2018-09-24 9:22	74.8432	148.3499	1511561	1000.2	ship speed = 16kn
C5_00052.EDF	3052	2018-09-24 23:54	75.1638	151.8082	1511562	1000.2	ship speed = 16kn
C5_00053.EDF	3053	2018-09-25 6:42	74.9331	153.2532	1511561	1000.2	ship speed = 15 kn
C5_00054.EDF	3054	2018-09-25 8:44	74.4994	153.2843	1511562	1000.2	ship speed = 10 kn
C5_00055.EDF	3055	2018-09-25 10:53	74.7544	151.6785	1511561	1000.2	ship speed = 13 kn
C5_00056.EDF	3056	2018-09-26 0:57	74.5183	149.9351	1511562	1000.2	ship speed = 13.5 kn
C5_00057.EDF	3057	2018-09-26 8:30	73.7498	151.7512	1511561	1000.2	ship speed = 8 kn
C5_00058.EDF	3058	2018-09-26 11:08	73.5013	150.0038	1511562	1000.2	ship speed = 16 kn
C5_00059.EDF	3059	2018-09-26 13:41	73.2447	148.2316	1511562	1000.2	ship speed = 15.3 kn
C3_00060.EDF	1060	2018-09-26 21:55	72.5105	150.0387	1601703	1100.1	ship speed = 11.6 kn

C5_00061.EDF	3061	2018-09-28 1:04	71.7025	150.4156	1601674	1000.2	ship speed = 12 kn
C5_00062.EDF	3062	2018-09-28 2:58	71.9271	149.0198	1601674	1000.2	ship speed = 11 kn
C5_00063.EDF	3063	2018-09-28 5:19	72.1440	147.6206	1601674	1000.2	ship speed = 14 kn (start time from ships log)
C5_00064.EDF	3064	2018-09-28 8:43	72.3032	145.9895	1601674	1000.2	ship speed = 10 kn
C5_00065.EDF	3065	2018-09-28 15:49	72.4088	143.2165	1601674	1000.2	ship speed = 13 kn
C5_00066.EDF	3066	2018-09-28 17:52	72.2136	141.6519	1601674	1000.2	ship speed = 10 kn
C5_00067.EDF	3067	2018-09-29 4:30	71.2973	140.0219	1601674	1000.2	software set-up for XCTD 3 but launched an XCTD-1. Also possible time out error.
C5_00068.EDF	3068	2018-09-29 11:20	70.6504	140.0024	1601674	1000.2	Second XCTD at the same location. I converted file XCTD-1 probe type using " tools -> convert but data does not change. New file is c3_000609.edf.
C3_00069.edf	1069	2018-09-29 23:12	70.5055	137.3972	1601703	837.9	ship speed = 11 kn
C3_00070.EDF	1070	2018-09-29 23:20	70.5085	137.3806	1601703	915.9	ship speed = 16 kn

5.2.3 Zooplankton – Vertical Bongo Net Hauls

Table 15. Zooplankton vertical bongo net hauls.

Summary of samples taken at each station. At each station 2 samples were collected; based on net mesh size (150 and236 µm). The 236 µm samples were preserved in 95% ethanol, while the 150 µm samples were preserved in buffered formalin.

Net Event #	CTD cast #	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Net Mesh (um)	Bottom Depth (m)	Wire angle (°)	RBR depth (m)	Comments
1	16	8-Sep-18	23:55	70.558	122.910	236 150	648	10	100.0	Bridge did not record GPS so they estimated it. Event and CTD cast numbers written wrong on internal jar labels, correct CTD cast is 16. Flowmeter end initally read as 84959. Flowmeter spun quite a bit at surface. One jelly preserved in separate ethanol jar.
2	17	10-Sep-18	20:32	71.957	130.867	236 150	790	5	100.0	
3	18	11-Sep-18	5:29	72.350	134.001	236 150	2069	<5	99.0	
4	18	11-Sep-18	5:52	72.349	134.003	236 150	2069	<5	200.0	Pteropod samples: only 1 *Limacina helicina*, handpicked and dried. Rest of sample dumped.
5	19	12-Sep-18	11:56	72.895	135.988	236 150	2735	<5	100.0	
6	20	12-Sep-18	17:23	73.448	137.000	236 150	3122	5	98.2	
7	21	12-Sep-18	23:32	72.998	140.009	236 150	3220	10	94.1	
8	21	12-Sep-18	23:53	72.998	140.011	236 150	3220	10	196.9	A few very small *L. helicina* from the 150 µm mesh sample handpicked and dried, maybe ~40 individuals -> likely a new cohort.
9	22	13-Sep-18	12:31	73.995	140.136	236	3510	10	99.3	

						150				
10	24	14-Sep-18	5:13	74.302	143.300	236 150	3698	5	100.1	Some yellow rope fibres in 150 µm mesh sample - could not pick out without removing some sample so left them in.
11	24	14-Sep-18	5:34	74.303	143.300	236 150	3698	5	201.7	150 µm mesh flowmeter end number changed afterwards, so bottle label is short 100 revolutions.
12	26	15-Sep-18	12:00	73.485	143.350	236 150	2900	0	98.9	
13	28	16-Sep-18	10:19	74.474	135.366	236 150	3249	10	104.0	
14	29	16-Sep-18	21:08	75.000	140.010	236 150	3623	10	102.6	
15	29	16-Sep-18	21:33	74.998	140.011	236 150	3623	5	204.8	Two tiny *L.helicina* from 150 µm for Michiyo Yamamoto-Kawai (TUMSAT).
16	30	17-Sep-18	6:34	76.006	140.009	236 150	3652	5	82.0	Nets initially went to 5 m and then brought up to fix winch counter. Not washed down before next downcast due to weather. RBR frozen, so recorded depth is wrong
17	31	18-Sep-18	5:24	76.535	135.512	236 150	3570	5	102.9	
18	31	18-Sep-18	5:44	76.534	135.514	236 150	3570	5	187.3	RBR frozen, so recorded depth is wrong. Sample used for science "open house" for crew, so not saved. One *L.helicina* handpicked.
19	32	18-Sep-18	21:08	77.009	139.930	236 150	3726	5	99.7	RBR frozen, so recorded depth is wrong.
20	32	18-Sep-18	21:41	77.006	139.920	236 150	3726	5	499.8	Most of the *L.helicina* from both cod ends handpicked - 1 adult for Matt Miller (Uvic) and >100 very tiny juveniles for Michiyo Yamamoto-Kawai (TUMSAT).
21	34	19-Sep-18	11:56	77.953	139.939	236 150	3748	<5	100.8	
22	35	19-Sep-18	6:55	77.282	143.170	236 150	3777	5	99.9	

23	36	20-Sep-18	23:49	77.694	146.671	236 150	3803	10	115.5	Couldn't zero the winch counter, so the nets went a bit too deep. This could explain the higher than usual flow meter revolution readings.
24	36	21-Sep-18	0:14	77.694	146.653	236 150	3803	10	218.7	Couldn't zero the winch counter, so the nets went a bit too deep. This could explain the higher than usual flow meter revolution readings.
25	36	21-Sep-18	0:50	77.692	146.647	236 150	3803	10	507.2	We couldn't zero the winch counter, so the nets went a bit too deep. This could explain the higher than usual flow meter revolution readings. Stopped briefly on the way up under bridge's orders to try to fix the frozen block - it wasn't rotating.
26	39	21-Sep-18	11:27	78.029	149.644	236 150	3814	5 to 10	103.3	Winds = 15 knots.
27	40	22-Sep-18	4:45	78.639	150.114	236 150	3820	5	99.5	
28	40	22-Sep-18	5:06	78.638	150.117	236 150	3820	5	249.6	Event # written as 27 on inside labels in both samples. Two adult *L.helicina* handpicked from 150 µm mesh cod end.
29	43	23-Sep-18	19:39	75.993	149.993	236 150	3824	0	97.6	
30	44	24-Sep-18	5:05	74.696	146.700	236 150	3773	5	99.6	Flow reading incorrect on inside label of the 150 µm mesh sample - should read 01289 start.
31	44	24-Sep-18	5:28	74.695	146.701	236 150	3773	10 to 15	236.8	~15 tiny *L.helicina* handpicked for Michiyo Yamamoto-Kawai (TUMSAT) from 150 µm mesh cod end.
32	45	24-Sep-18	12:04	75.015	149.881	236 150	3825	n/a	99.8	
33	46	24-Sep-18	2:51	75.298	153.283	236 150	3836	0	100.1	Small hole discovered in 150 µm mesh net (~1/2 inch straight cut), likely from exposed screws in the nets' wood storage box.
34	46	24-Sep-18	3:11	75.298	153.284	236 150	3836	5	249.3	1 adult *L.helicina* and ~ 8 juveniles handpicked for Matt Miller (Uvic) and Michiyo Yamamoto-Kawai (TUMSAT), respectively. Hole repaired after this station using patches on inside and outside of net.
35	48	26-Sep-18	17:36	73.001	150.007	236 150	3746	5 to 10	102.0	Flow starts changed by ~200 since last station, likely from wind during net hole repair. Likely flow start reading error.

36	48	26-Sep-18	18:01	73.002	149.998	236 150	3746	5 to 10	299.0	Seven very small juvenile *L.helicina* handpicked for Matt Miller (UVic) and ~10 for Michiyo Yamamoto-Kawai (TUMSAT).
37	50	27-Sep-18	2:34	71.963	150.237	236 150	3006	40	118.2	Just before this cast, we deployed a ~20m 'fake' cast.
38	50	27-Sep-18	3:03	71.965	150.233	236 150	3006	0	320.9	Seven small *L.helicina* each for Matt Miller (Uvic) and Michiyo Yamamoto-Kawai (TUMSAT) - in total 10 from 150 µm mesh cod end and 4 from 236 µm cod end.
39	51	27-Sep-18	6:17	71.824	150.750	236 150	2585	5	101.1	Forgot to record the end flow reading.
40	51	27-Sep-18	6:30	71.824	150.749	236 150	2585	0	319.1	Forgot to record the end flow reading.
41	51	27-Sep-18	7:08	71.828	150.749	236 150	2585	5	149.0	Two adult *L.helicina* handpicked from 150 µm mesh cod end.
42	52	27-Sep-18	9:08	71.681	151.184	236 150	2070	5	103.0	
43	52	27-Sep-18	9:30	71.682	151.182	236 150	2070	5	299.4	150 µm mesh sample: interior label says end flow reading was 29742, should be 19742.
44	55	27-Sep-18	15:17	71.519	151.583	236 150	1132	<5	300.3	Approx 1/20th of 150 µm mesh sample spilled on lab bench - collected and re-jared.
45	57	27-Sep-18	20:41	71.363	152.077	236 150	81	10	63.9	Bottom time and position not recorded by bridge, so used start here.
46	58	27-Sep-18	22:37	71.466	151.807	236 150	520	10	101.0	Net hole repair from event 33 failed, the patch fell off.
47	59	28-Sep-18	11:52	72.596	144.707	236 150	3428	25	120.9	Winds = 20-25knts, flow meters may have spun in the wind, overestimating the flowthrough.
48	60	28-Sep-18	21:20	72.000	139.994	236 150	2696	5	99.1	Flow meters spun at surface a bit, overestimating the flowthrough.
49	60	28-Sep-18	21:44	72.001	139.988	236	2696	5	302.1	

						150				~20 juvenile *L.helicina* handpicked for Michiyo Yamamoto-Kawai (TUMSAT) - 12 from 150 µm mesh and 8 from 236 µm mesh cod ends. Small fish in 150 µm mesh sample, possibly a hake? Was still alive so took pics and released - see file in 2018-81 / data / zoop / zoop pics. Spilled most of sample in sink, couldn't recover.
50	60	28-Sep-18	22:16	72.001	139.981	236 150	2696	10	308.1	
51	61	29-Sep-18	2:06	71.568	140.008	236 150	2481	5	102.6	
52	61	29-Sep-18	2:30	71.568	140.010	236 150	2481	5	322.8	Seven small *L.helicina* for Matt Miller (UVic), and ~20-30 for Michiyo Yamamoto-Kawai (TUMSAT) - about 60% from 150 µm mesh cod end and 40% from 236 µm mesh cod end.
53	62	29-Sep-18	6:27	70.996	139.987	236 150	2075	5	101.6	
54	62	29-Sep-18	6:52	70.996	139.982	236 150	2075	0	299.8	One adult *L.helicina* for Matt Miller (UVic) and ~15 juveniles for Michiyo Yamamoto-Kawai (TUMSAT) - about 60% from 150 µm mesh cod end and 40% from 236 µm mesh cod end.
55	63	29-Sep-18	9:34	70.811	140.002	236 150	1524	0	99.7	
56	63	29-Sep-18	9:47	70.010	140.001	236 150	1524	0	99.6	Pteropod samples - 2 adult *L.helicina* from 150 µm mesh cod end.
57	64	29-Sep-18	12:22	70.571	140.005	236 150	766	0	100.4	
58	65	29-Sep-18	14:49	70.402	140.006	236 150	501	5	99.9	
59	66	29-Sep-18	16:52	70.225	140.005	236 150	217	0	99.9	Bottom time and position not recorded by bridge, so used start here

5.2.4 Microbial Diversity Casts

Table 16. Locations of microbial diversity stations.

At each station, 8 depths were consistently sampled and were defined as either: surface (usually ~ 5 m), mixed layer (~25 m), subsurface chlorophyll maximum, the core of the Pacific Summer Water (32.3), core of the Pacific Winter Water (33.1), temperature maxim (T-max), the Atlantic halocline at 1500 m and the bottom depth. In addition, surface samples were also collected from the underway loop (10 m).

Station	Cast #	Date	Bottom depth (m)	Microbial Sample #
AG-5	15	9/08/2018	650	1-8
CB31b	18	9/10/2018	2055	9-16
CB27	21	9/12/2018	3220	17-24
CB21	23	9/14/2018	3495	25-31
CB21	25	9/14/2018	3495	32
C51W	27	9/15/2018	2721	33-40
CB40	28	9/16/2018	3249	41-48
CB17	30	9/18/2018	3696	49-56
PP7	31	9/17/2018	3570	57-64
CB15	32	9/18/2018	3720	65-72
CB16	33	9/19/2018	3743	73-79
CB9	37	9/20/2018	3816	81-87
CB9	39	9/20/2018	3816	88
CB11-2018	40	9/21/2018	3880	89-96
CB10	41	9/22/2018	3824	91-104
CB7	43	9/23/2018	3818	105-112

CB4	45	9/24/2018	3825	113
CB4	47	9/25/2018	3825	114-120
CB3	48	9/25/2018	3823	121-128
CB2	49	9/26/2018	3746	129-136
BL8	50	9/26/2018	3206	137-144
StnA	59	9/26/2018	3463	145-152
CB28b	62	9/28/2018	2075	153-160

Additional Ice Core samples were also collected during the trip. A total of 5 cores, 3 cores from Station 1 and 2 cores from station 2 were collected. Each core was divided into 3 equal parts namely top, middle and bottom, which were then slowly melted overnight and filtered.

5.2.5 Mooring Operations

Table 17. Location of mooring recovery and deployments.

Mooring Name	2017 Location	2018 Recovery (UTC)	2018 Deployment (UTC)	2018 Location	Bottom Depth (m)
BGOS-A	75° 1.0420' N 150° 8.6919' W	24-Sep 16:14	25-Sep 22:41	75° 0.0072' N 150° 0.0075' W	3827
BGOS-B	78° 1.0488' N 149° 58.7219' W	21-Sep 15:24	23-Sep 1:08	78° 0.352' N 149° 57.066' W	3827
BGOS-D	74° 0.2476' N 140° 0.3005' W	13-Sep 17:52	14-Sep 23:52	74° 0.1940' N 140° 0.0073' W	3512

Table 18. 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 and Time (UTC)	Location
1	ITP107 / SIMB	17-Sep-18 21:00	76° 22.9' N 137° 37.3' W
2	ITP110	19-Sep-18 20:00	78° 1.4' N 140° 15.0' W

3	ITP109	20-Sep-18 18:42	77° 34.0' N 145° 7.8' W

Table 19. Ice-Tethered Profiler (ITP) recoveries.

Recovery	Buoy	Date and Time (UTC)	Location
1	ITP108	09-Sep-18 16:30	70° 17.6' N 122° 23.4' W
2	ITP101	10-Sep-18 2:38	70° 6.5' N 126° 54.9' W
3	ITP100	30-Sep-18 7:34	70° 29.5' N 133° 58.3' W

Table 20. pCO2 and pH sensors summary (UMontana)

Measurement system	Instrument IDs	Location	Duration
Underway infrared-equilibrator pCO_2	SUPER (Sunburst Sensors)	Entire cruise track (see IOS report in this document)	9/7/2018 - 10/1/2018
ITP SAMI-CO_2 and Seabird Microcat w/ DO sensor	WHOI ITP 107, SAMI-CO2 (C180)	First ITP deployment, CO2 ~ 4.5 m depth, Microcat ~ 4 m depth (see WHOI cruise report in this document)	9/17/2018 - present
ITP SAMI-CO_2 and Seabird Microcat w/ DO sensor	WHOI ITP 110, SAMI-CO2 (C181)	Second ITP deployment, CO2 ~ 4.5 m depth, Microcat ~ 4 m depth (see WHOI cruise report in this document)	9/19/2018 - present
SAMI-CO_2 / SAMI-pH	CO2 : C48u pH : P68u	BGOS-A mooring	9/25/2018 – present
SAMI-CO_2 / SAMI-pH	CO2 : C38 pH : P47u	BGOS-B mooring	9/23/2018 - present
SAMI-CO_2 / SAMI-pH	CO2 : C37 pH : P5	BGOS-D mooring	9/14/2018 - present

5.2.6 Microplastics

Sampling from Seawater Loop

UTC Date	UTC Time	Latitude (N)		Longitude (W)		Loop	Count	Filter Type	(start/end)	Water volume (L)	Air Sample	Procedural Blank	Notes
1-Sep-18	4:14:53	71	58.6020	92	46.6560	7	1	Sieve	Start	125.0			east of bellot St. (125L from 10m at 4.8sec/L), using sieve w/ lid, processed on counter in main lab.
1-Sep-18	4:31:48	71	59.5632	92	35.5452	7 end			End - after processing sample				
2-Sep-18	23:01:23	71	35.5248	96	41.8308	30	2	Sieve	Start	304.0			Using sieve with lid. 56min w Flow at 11.1sec/L+ 1L used inrinsing. We are in 9/10 of first year (1m) sea-ice with snow cover. Processed in fume hood that is turned off. Sampler wearing black cotton hoody with tyvec suit on top.
2-Sep-18	23:58:43	71	33.7092	96	55.6752	30 end			End - a little after the end of sampling				
4-Sep-18	3:39:13	69	37.0620	99	47.0640	34	3	Sieve	Start	176.0			Using sieve with lid. 17 min at flow of 5.8 sec/1L. We are 2/10 ice.
4-Sep-18	3:59:38	69	36.9984	99	46.7316	34 end			End				

4-Sep-18	14:14:28	69	08.9616	100	43.6236	35							TSG just changed to warmer, saltier,high cdom water
4-Sep-18	22:21:08	68	51.6576	105	24.4392	36							outside of cambridge bay
5-Sep-18	4:00:13	68	46.4700	108	01.6620	37	4	Sieve	Start	214.3			Using sieve with lid and aluminum foil cap. 20 min at flow of 5.6 sec/1L. We are in open water in Dease St. Process in fume hood that is turned off. Sampler wearing black cotton hoody. Sample bottle not from Van Aqua. Rinsed well with the loop water before being filled with the sample.
5-Sep-18	4:20:18	68	44.4768	108	14.4444	37 end			End				
8-Sep-18	19:40	70	31.5852	122	47.7456	39	5	Sieve	Start	67.0	x		Near Station AG5. Flow rate out of CDOM = 3.182L/min. Air blank taken while collected sample from sieve.
8-Sep-18	20:01:00	70	33.2952	122	54.9564	39			End				
9-Sep-18	16:48:13	70	18.9696	122	19.2012	42	6	Candle	Start	1000.1			Using Candle filter. Sample was from rinsed filter so no filter was left in the mason jar (samplebottle). Flow rate was 7.5L/min chnaging to 6.8L/min at end of sample period using the Gardiner gauge. Flow was turned off when the sample reached 1000L.
9-Sep-18	19:08:03	70	28.5672	123	29.6556	42 end			End				
10-Sep-18	23:33:38	72	00.6204	131	09.7104	47	7	Candle	Start	1001.7	x		At Station CB-1. Using candle filter, flow rate 10.1L/min, sample with cleaned and removed filter. Near CB-1. Took Air Filter sample while processing loop sample.
11-Sep-18	1:14:58	72	05.3052	131	55.6812	47 end			End				

10-Sep-18	23:42:48	72	01.0656	131	13.2624	48	8	Sieve	Start	102.8		x	At Station CB-1. Using metal sieve with flow rate 2.97L/min, concurent with candle filter. Took a procedural blank.
11-Sep-18	0:20	72	02.1264	131	30.5028	48			End				
11-Sep-18	2:28:43	72	09.6120	132	29.1684	50	9	Candle	Start	1000.7			Near Station CB-1. Using candle filter, flow rate 11.1L/min, sample with filter left in jar. This pseudo-replicate of loop 47 taken 2hrs after first.
11-Sep-18	3:57:08	72	14.5140	133	15.8580	50 end			End				
14-Sep-18	1:05:58	74	00.9408	140	21.3360	67	10	Sieve	Start	184.3		x	Station CB-21. All three microplastic methods at once. Using sieve with metal cap and aluminum foil top
14-Sep-18	2:12:08	74	07.1148	141	19.3416	67 end			End				
14-Sep-18	1:05:58	74	00.9408	140	21.3360	67	10	Inline (3)	Start	124.3		x	Station CB-21. Using assembly of 3 inline filters with 60,230, and 400 mesh. Procedural blank for all 3 mesh.
14-Sep-18	2:12:08	74	07.1148	141	19.3416	67 end			End				
14-Sep-18	1:05:58	74	00.9408	140	21.3360	67	10	Candle	Start	1014.0	x		Station CB-21. Using the candle filter. Sample was rinsed off of filter so sample bottle has water, no filter. The candle filter was seated but we could see it wobble slightly in holder. Air sample collected during loading and processing of filter. Stopped flow at 1014L and flow was reading 14.7 L/min.

14-Sep-18	2:12:08	74	07.1148	141	19.3416	67 end			End				
23-Sep-18	1:50	77	58.1160	149	58.0596	109	11	Candle	Start	1101.0	x		Station CB-9. Using candle filter at 15.0L/min and ran for 1101L. Took air sample while processing filter.
23-Sep-18	3:00:50	77	49.6368	149	52.9740	109 end			End				
23-Sep-18	1:50	77	58.1160	149	58.0596	109	11	Inline (3)	Start	145.2			Station CB-9. Using assembly of 3 inline filters with 60,230, and 400 mesh. Flow at 2.02L/min
23-Sep-18	3:00:50	77	49.6368	149	52.9740	109 end			End				
23-Sep-18	1:50	77	58.1160	149	58.0596	109	11	Sieve	Start	194.9			Station CB-9. Using sieve w/lid and under aluminum foil. Flow at 2.71 L/min
23-Sep-18	3:00:50	77	49.6368	149	52.9740	109 end			End				
23-Sep-18	3:28	77	45.9900	149	51.3444	110	12	Candle	Start	1084.0			Station CB-9. Using candle filter at 15.0L/min; Not seeing the same rust flecks that we were earlier. We are still in ice, but maybe less than for first sample. Flow stopped at 1084L. This is a pseudo-replicate of the last candle filter, Loop 109.
23-Sep-18	4:47	77	35.0196	149	54.1332	110 end			End				
25-Sep-18	23:23:14	74	55.3176	150	00.0480	126	13	Candle	Start	1039.8	x		Station CB-4. All three methods running concurrently.Leaving station CB4. Using candle filter with flow rate 14.4 L/min
26-Sep-18	0:34:53	74	36.9540	149	56.9052	126 end			End				
25-Sep-18	23:23:14	74	55.3176	150	00.0480	126	13	Inline (3)	Start	128.6		x	Station CB-4. Using assembly of 3 inline filters with 60,230, and 400

													mesh. Procedural Blank for all three mesh.
26-Sep-18	0:34:53	74	36.9540	149	56.9052	126 end			End				
25-Sep-18	23:23:14	74	55.3176	150	00.0480	126	13	Sieve	Start	206.2		x	Station CB-4. Using sieve w/lid. Procedural blank taken after processing the sample.
26-Sep-18	0:34:53	74	36.9540	149	56.9052	126 end			End				
26-Sep-18	1:14:19	74	26.7912	149	55.5360	127	14	Candle	Start	1173.0	x		Station CB-4. Using candle filter with flow rate 15.5 with same filter used for Loop 126. This is a psuedo-replicate of Loop 126.
26-Sep-18	2:11:34	74	11.9592	149	57.5268	127 end			End				
27-Sep-18	23:24	71	29.8848	151	37.5696	142	15	Sieve	Start	214.6			Station BL-3. Using sieve w/lid
28-Sep-18	0:36	71	38.7228	150	46.6464	142 end			End				
27-Sep-18	23:24	71	29.8848	151	37.5696	142	15	Inline (3)	Start	136.4			Station BL-3. Using assembly of 3 inline ss filters with 60,230, and 400 mesh.
28-Sep-18	0:36	71	38.7228	150	46.6464	142 end			End				
27-Sep-18	23:24	71	29.8848	151	37.5696	142	15	Candle	Start	1029.0	x		Station BL-3. Using candle filter with new filter. Filter was rinsed so sample does NOT contain filter. Filter reused for next sample (143) and stored in that sample.
28-Sep-18	0:36	71	38.7228	150	46.6464	142 end			End				
28-Sep-18	0:56:05	71	41.1804	150	31.3152	143	16	Candle	Start	1370.0	x		Station BL-3. Using candle filter with flow rate of about 15.5L/min. Filter

													saved in sample. This is a psuedo-replicate of Loop 142.
28-Sep-18	2:24:55	71	51.1812	149	23.7108	143 end			End				
28-Sep-18	14:15	72	32.5080	144	19.2756	149	17	Sieve	Start	217.6		x	Station Stn-A. Using sieve w/lid. Blank collected.
28-Sep-18	15:29	72	26.4708	143	27.9768	149 end			End				
28-Sep-18	14:15	72	32.5080	144	19.2756	149	17	Inline (3)	Start	139.1		x	Station Stn-A. Using assembly of 3 inline ss filters with 60,230, and 400 mesh. Blank collected.
28-Sep-18	15:29	72	26.4708	143	27.9768	149 end			End				
28-Sep-18	14:15	72	32.5080	144	19.2756	149	17	Candle	Start	1098.9	x?		Station Stn-A. Using Candle filter. Flow stopped at 1099. Flow rate about 14.5L/min.
28-Sep-18	15:29	72	26.4708	143	27.9768	149 end			End				
29-Sep-18	19:11	70	01.8108	139	44.7636	159	18	Sieve	Start				Statoin CB-28aa. Using sieve w/lid
29-Sep-18	20:17	70	10.5792	139	04.0140	159 end			End				
29-Sep-18	19:11	70	01.8108	139	44.7636	159	18	Inline (3)	Start				Statoin CB-28aa. Using assembly of 3 inline ss filters with 60,230, and 400 mesh.
29-Sep-18	20:17	70	10.5792	139	04.0140	159 end			End				
29-Sep-18	19:11	70	01.8108	139	44.7636	159	18	Candle	Start	1042.9	x		Statoin CB-28aa. Using candle filter. Filter rinsed so sample does NOT contain filter. Flow stopped at 1043L. Flow rate was 15.5L/min.
29-Sep-18	20:17	70	10.5792	139	04.0140	159 end			End				

29-Sep-18	20:47	70	14.5788	138	44.5188	160	19	Candle	Start	1361.5	x		Statoin CB-28aa. Using candle filter with flow rate varied from 14.9 to 15.4L/min. Flow stopped at 1362L. Filter rinsed and not kept with sample. This is a pseudo-replicate of Loop 159.
29-Sep-18	22:18	70	26.2548	137	46.6308	160 end			End				

Table 21. Microplastic depth profile sample summary.

Cast	Station	Date, Time (UTC)	Latitude (°N)	Longitude (°W)	Niskin	Pressure (dbar)	Volume (L)	NOTE
25	CB-21Plastic	2017-09-14 12:20: PM	74.0022	140.0102	6-9	1000	40.72	
					10-13	470	40.72	t_{max}
					14-17	227	40.72	33.1 psu
					18-21	77	40.72	Deep chlorophyll-a maximum
					22-24	5	40.72	surface

5.3 CTD/Rosette Sensor Configuration

CTD Specifications

Cast 24 CDOM sensor changed out.
Cast 48 CDOM sensor swapped back to first though continued to be poor.
Cast 49 CDOM swapped back to second and behaved fine.
Cast 61 Altimeter changed out.

Table 22. CTD Accuracy, Calibration and Sensor List for 2018-81

CTD

CTD#	Make	Model	Serial#	Used with Rosette?	Casts Used
Primary	SeaBird	911+	756	Yes	All

Sensor		Pre-Cruise		Post Cruise		Comment
Name	S/N	Date	Location	Date	Location	
Pressure Sensor	91164	26 Feb 2010	SeaBird Lab			Raw cruise data using offset of 0.19dbar
Temperature, SBE3plus	4322	1 Dec 2017	SeaBird Lab	8 Nov 2018	SeaBird Lab	
Conductivity, SBE4C	2809	1 Dec 2017	SeaBird Lab	6 Nov 2018	SeaBird Lab	
Pump, SBE5T	5-3869					
Secondary Temp., SBE3plus	4239	1 Dec 2017	SeaBird Lab	9 Nov 2018	SeaBird Lab	
Secondary Cond., SBE4C	2810	1 Dec 2017	SeaBird Lab	6 Nov 2018	SeaBird Lab	
Secondary Pump, SBE5T	5-3671					

Sensor		Pre-Cruise		Post Cruise		Comment
Name	S/N	Date	Location	Date	Location	

SBE 43 Dissolved Oxygen sensor	2599	02 Nov 2016	SeaBird Lab	8 Nov 2018	SeaBird Lab	On Primary pump; Will fit to water samples; After cruise air was found in electrolyte so there is both a post-cruise calibration and an after-modifications calibration.
Datasonics Altimeter, Benthos	PSA-916D, 62670	28 May 2014	Benthos			Used on Casts 1 to 60
Datasoncis Altimeter, Benthos	PSA-916D, 72114	31 Mar 2005	Benthos			Used on Casts 61 to 67
Seapoint Fluorometer (Chl-a)	SCF 3797	27 Jun 2017 (new)	Seapoint			On Secondary Pump; Not Calibrated to water samples
Wetlabs Transmissometer	C-Star CST-1047DR	01 Jun 2018	IOS (In-house bench test)			
WETLabs ECO CDOM	4305	14 Mar 2016	WETLabs	29 Nov 2018	WETLabs/ SeaBird Lab	Used on Casts 1 to 23, 48; After cruise sensor was tested at Seabird and no problem identified.
WETLabs ECO CDOM	1076	11 Jun 2006	WETLabs			Used on Casts 24 to 47, 49 to 67
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	**1231**	New 2018

5.4 Underway Measurement

Details on set-up, operation, instruments and performance are below.

5.4.1 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.
For 2018, the manifold leaks were repaired and the permanent tubing from manifold to TSG replaced. No in-line flowmeter was used with the TSG this year.

Figure 21. Seawater loop system – 2017 (similar for 2018)

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 22. TSG manifold. (similar for 2018)

Figure 23. The Moyno pump installed in the engine room. This picture is from 2016 but same layout for 2018.

Figure 24. Seawater passes through a filter before going to the pump (in background). 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 picture is from a previous year but is the same strainer configuration for 2018.

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 25. Honeywell controller for the pump, 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).

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 (Temperature in-lab used for Salinity, Conductivity)	3297	13 Jan 2018	SeaBird Lab	pending	SeaBird Lab	
Seabird Temperatrue SBE-38 (Intake temperature)	0870	17 Feb 2016	SeaBird Lab	pending	SeaBird Lab	Used 25 Aug to 22 Sep.
Seabird Temperatrue SBE-38 (Intake temperature)	0319	5 Jan 2017	SeaBird Lab	pending	SeaBird Lab	Used 22 Sep to 2 Oct.
Seapoint Chlorophyll Fluorometer	SCF3652	Jun 2014	Seapoint			Use with 30x gain cable (0 to 5ug/l range)
Wetlabs ECO CDOM Fluorometer	WSCD-1076	11 Jun 2006	Wetlabs			Used 27 Aug 20:01 to 2 Sep 12:32. CDOM water samples collected
Wetlabs ECO CDOM Fluorometer	WSCD-1281	9 Jun 2011	Wetlabs			Used 2 Sep 13:39 to end of cruise. CDOM water samples collected
Interface Box	3274					

Computer for data logging	T2012-02 Beaufort					Used 25 to 27 Aug.
Computer for data logging	WNBCIOS9011688					Used 27 Aug 20:01 to end of cruise

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 measurement to use for sea-surface temperature (as opposed to the TSG's lab temperature).

Figure 26. 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 fluorometer and CDOM sensors were plumbed off a second manifold output. No debubbling or extra flow controls were in place.

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 used 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.

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 an infrared equilibrator-based system (SUPER-CO2, Sunburst Sensors) owned by Mike

DeGrandpre (UMontana) and operated onboard by Cory Beatty. Data were recorded through the cruise with discreet DIC, Alkalinity water samples drawn for comparison. For more information please see the report: DeGrandpre-Beatty 2018 Cruise Report.docx.

Flow rate was measured manually

For 2018:
Using the Honeywell controller, pressure set point was 18 PSI.
Kates flow controller set to tick mark between 8.2 and 11.0 GPM

Measured flow rates to the sensors were approximately:

TSG	3.2s/L (18.5 L/min)
Fluorometer pair	19.6 s/L (3.1 L/min)

Water samples

Discrete water samples for nutrients, salinity, DIC, Alkalinity and CDOM 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.

Microplastic samples were collected from the seawater loop using three methods. The first two were off a 4th manifold arm using a Y-valve to an in-line system with 3 filters of different sizes (60, 230,450um), an in-line candle-style 60um filter. The third method used the fluorometer line with flow into a 60um sieve as used in previous years. Volume of samples ranged from 100 to 1000L and were collected at the same time for comparison. Please see the microplastic report (2018-81_Microplastics_report_SAQ_2018-10-22 .docx) for more information.

5.4.2 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.

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 below:

Position, Time, Date, Speed and Course over ground - $GNRMC and $GPRMC

File: RMC-RAW_*.Raw, 26 Aug to 24 Sep 2018
Time interval 1 second

Description of *.RAW file string
RMC-RAW_20180921-172810.Raw
09/21/2018,00:00:00.762,$GNRMC,000007.00,A,7741.63767,N,14640.02323,W,0.126,47.9,210918,999.9,E,D*06
09/21/2018,00:00:02.012,$GNRMC,000008.00,A,7741.63769,N,14640.02310,W,0.124,48.8,210918,999.9,E,D*0B

File: GPRMC_*.Raw, 15 Sep to 4 Oct 2018
Time interval 1 second

Description of *.RAW file string
GPRMC_20180915-003814.Raw
09/15/2018,00:38:15.903,$GPRMC,003824.00,A,7358.8475,N,14001.9940,W,13.6,104.9,150918,21.4,E*4B
09/15/2018,00:38:16.919,$GPRMC,003825.00,A,7358.8466,N,14001.9803,W,13.6,104.9,150918,21.4,E*4E

Comma delimited column after string name

a. Time HHMMSS.S
b. Status A= Active, V=Void
c. Latitude
d. Latitude N or S
e. Longitude
f. Longitude E or W
g. Speed over ground in knots
h. Course over ground in degrees (True)
i. Date DDMMYY
j. Magnetic variation in degrees
k. Checksum data, always begins with *

Position - $GPGGA
Position information

File: GGA-RAW_*.Raw – updated for 2018, 24 Aug to 24 Sep, then follows format below until 4 Oct 2018
Time interval of GPS is 1 second.
Description of *.RAW file string
GGA-RAW_20180906-000000.Raw
09/06/2018,00:00:00.570,$GPGGA,000003.0,6804.43784,N,11418.90538,W,5,18,0.6,33.9,M,-22.3,M,7.0,1015*71
09/06/2018,00:00:01.570,$GPGGA,000004.0,6804.43780,N,11418.90515,W,5,17,0.7,33.9,M,-22.3,M,8.0,1015*7C

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

File: GPGGA-RAW_*.Raw – updated for 2018 (SS.S is now SS.SS), 15 Sep to 4 Oct, 2018
Time interval of GPS is 1 second but location will update more frequently.
Description of *.RAW file string
GPGGA_20180929-000000.Raw
09/29/2018,00:00:01.325,$GPGGA,000011.00,7149.1055,N,13958.9628,W,2,11,0.8,15.8,M,-4.2,M,,*5B
09/29/2018,00:00:01.325,$GPGGA,,7149.108,N,13958.962,W,2,,,,,,,*44

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

Course and Speed Over Ground - $GNVTG and $GPVTG

File: VTG-RAW_*.Raw, 24 Aug to 24 Sep 2018
Track made good
Time interval varies, 1 to 2 seconds

Description of *.RAW file string

VTG-RAW_20180920-000000.Raw
09/20/2018,00:00:01.518,$GNVTG,215.95,T,-783.95,M,8.71,N,16.13,K,D*24
09/20/2018,00:00:02.521,$GNVTG,215.59,T,-784.32,M,8.69,N,16.08,K,D*2D

File: GPVTG_*.Raw, 15 Sep to 4 Oct 2018
Track made good
Time interval varies, new data about 1 second

Description of *.RAW file string
GPVTG_20181002-000000.Raw
10/02/2018,00:00:22.551,$GPVTG,109.7,T,88.3,M,17.427,N,32.275,K*74
10/02/2018,00:00:22.754,$GPVTG,,,,,017.4,N,032.2,K,A*3B

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 - $GNZDA and $GPZDA
Time and date information in UTC.

File: ZDA-RAW_*.Raw, 24 Aug to 21 Sep 2018
Time interval varies from 1 to 11 seconds.

Description of *.RAW file strings
ZDA-RAW_20180824-135405.Raw
08/24/2018,13:54:06.459,$GNZDA,135729.029,24,08,2018,00,00*4D
08/24/2018,13:54:17.278,$GNZDA,135739.030,24,08,2018,00,00*44

File: GPZDA_*.Raw, 15 Sep to 4 Oct 2018
Time and date information in UTC.
Time interval varies from 1 to 11 seconds.

Description of *.RAW file strings
GPZDA_20180915-003814.Raw
09/15/2018,00:38:15.903,$GPZDA,003825.00,15,09,2018,00,00*6C
09/15/2018,00:38:17.122,$GPZDA,003826.00,15,09,2018,00,00*6F

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)

File: HDT-Gyro_*.Raw, 24 Aug to 4 Oct 2018
Time interval varies from less than 1 second to 10 seconds

Description of *.RAW file string
HDT-Gyro_20180905-000000.Raw
09/05/2018,00:00:00.365,$HEHDT,296.24,T*14
09/05/2018,00:00:00.365,$HEHDT,296.25,T*15
09/05/2018,00:00:00.568,$HEHDT,296.26,T*16

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

Ship's Heading - $GPHDT (POSMV) – NOT Available in 2018
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 – "Sounder"
Sounder and String Changed in 2018
Depth is measured using the 3.5, 12 or 30kHz transducers using a new for 2018 Knudsen CHIRP 3260 Echosounder, labeled "Science". The CHS-purchased CHIRP 3260 is still there but was not used. The old 320BR Knudsen sounder has been removed.
The depth value has been increased by the listed ship's draft for each transducer. The depth is calculated using a specified sound speed. Both the draft and a nominal soundspeed variables are set by the user in the Knudsen software. To improve accuracy post-cruise, a new sound speed based on the CTD data could be applied. The currently applied draft and sound speed are given in the data string.

Time interval is less than a second but values updates every 5 to 7 seconds.

The sounder did not work well in deep waters even in open water but typically could pick up the bottom, with coaxing, when the ship was on station. We did not use the 3.5 kHz unless necessary due to the loud pinging noise that could be heard in the occupied 600 staterooms.

File: Knudsen-Sounder_*.Raw 26 Aug to 4 Oct 2018

Description of *.RAW file string
Knudsen-Sounder_20180826-155202.Raw
08/26/2018,15:52:03.787,Sounder,25082018,230524,,,,,,,30.0kHz,0.00,0.00,150
0
08/26/2018,15:52:03.787,Sounder,25082018,230524,,,,,,,30.0kHz,0.00,0.00,150
0
Knudsen-Sounder_20180930-000000.Raw
09/30/2018,00:00:01.097,Sounder,30092018,000015,,,,12.0kHz,0.00,9.00,,,,147
5
09/30/2018,00:00:01.097,Sounder,30092018,000015,,,,12.0kHz,0.00,9.00,,,,147
5

Comma delimited column after string name

1) Date UTC: DDMMYYYY
2) Time UTC: hhmmss
3) Sounder frequency (3.5kHz)
4) Depth (3.5kHz)
5) Applied draft (3.5kHz)
6) Sounder frequency (12kHz)
7) Depth (12kHz)
8) Applied draft (12kHz)
9) Sounder frequency (30kHz)
10) Depth (30kHz)
11) Applied draft (30kHz)
12) Soundspeed m/s

Meteorological data from AVOS (Automatic Voluntary Observing Ships System) - $AVRTE

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

File: AVOS-serial-AVRTE_*.RAW, 24 Aug to 3 Oct 2018
Description of *.RAW file string

AVOS-serial-AVRTE_20181003-000000.Raw
10/03/2018,00:00:01.151,$AVRTE,181002,235900,00840,CGBN,17.1,254,43,,,,1019.42,,-6.6,102,,,,19.4,,,211.0,13.4*7D
10/03/2018,00:00:02.151,$AVRTE,181002,235901,00840,CGBN,16.8,252,41,,,,1019.45,,-6.6,102,,,,19.4,,,210.3,13.5*74

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)
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)

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.

File: TSG-serial-*.Raw, 24 Aug to 3 Oct 2018

Description of *.RAW file string
TSG-serial-_20180929-000000.Raw
09/29/2018,00:00:05.434, -0.13 -0.87 26.888 22.751 0.093 0.09280 0.07814 271.999988

09/29/2018,00:00:10.434, -0.14 -0.87 26.889 22.751 0.093 0.09280 0.07814 272.000046

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)

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.

File: SBE-38-serialport-*.Raw, 24 Aug to 3 Oct 2018
Time interval is about 1 second.

Description of *.RAW file string
SBE-38-serialport-_20181003-000000.Raw
10/03/2018,00:00:00.276, 0.9955
10/03/2018,00:00:01.151, 0.9957

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

Surface PAR

The continuous logging Biospherical Scalar PAR Sensor QSR2150A (S/N 50228, calibration date 21 June 2016), was mounted above the CTD operation area and next to the CTD surface reference PAR (mid-ship, starboard side, on railing two decks above the CTD (boat) deck) 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, aft 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).

File: ASCII-PAR-serialport-*.Raw, 26 Aug to 3 Oct 2018
Time interval is 10 second.

Description of *.RAW file string
ASCII-PAR-serialport-_20181003-000000.Raw
10/03/2018,00:00:05.339,D|46.097
10/03/2018,00:00:15.691,D|45.972

10/03/2018,00:00:26.004,D|46.007

Comma delimited column after SCS date and time stamp

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

5.4.3 Issues with the underway system and data

SCS in general –
Number and size of files: Every time SCS is restarted, the daily file logging option must be re-selected. If this is missed, the data are written to a single file (per sensor). This selection was missed a few times, including Sep 21st to 24th.

Sep 14th SCS program was frozen. Program closed and restarted. With the thought that the PAR error messages might have bogged down the program, the PAR sampling rate was changed to every 10 seconds, but see the error messages are tied to the feed rate, not the recording rate, so this did not have an effect on the reported errors on the screen.

GPS –
Some of the GPS records in SCS have gaps due to the string names.
New SCS records were started mid-cruise from a more stable GPS feed.
The GPS string going to the TSG and Ozi Explorer mapping system were interpreted without a problem and location has been saved in their files.

Marine Star GPS
GNRMC, GNVTG, GNZDA, GPGGA: The Marine Star GPS was set up by the Canadian Hydrographic Service and has a special feature of generating a processed GPS feed with labels like "GNRMC" instead of "GPRMC". An exception though, was the GGA string was still called "GPGGA". When CHS are onboard and running the multi-beam sounder, they turn on the "POSMV" string which gives them very precise position information. POSMV is turned off during the non-CHS cruises although SCS is still set up to record these data.

The NOAA server was set up to take the Marine Star feed and redistribute to other applications (TSG, Ozi, ie any networked computer needing access to GPS). The "GN" string name was new this year and SCS settings were changed to accept these new names. However, these strings were frequently dropping out for hours at a time, being replaced by "GP" strings and then switching back to "GN" names on their own.

Sep 3rd, recording changed from 10 seconds to "-1" to record all VTG and ZDA data.

Sep 24th, about 1900UTC, Scott the IT/Electronics tech disconnected the Marine Star and planned to remove the antennae in Kugluktuk. It was only understood at this point that the NOAA Server was using Marine Star GPS. There is about a 5 hour gap between the Marine Star GPS being turned off and a new distribution feed being set up on the NOAA server. This means that the TSG, and Ozi are missing GPS feeds during this transition.

Furano GPS
GPRMC, GPVTG, GPZDA, GPGGA: The ship maintains two Furano GPS systems. They have two side by side displays on the center island (map/logbook station) on the bridge and they are integrated to switch between the two if one loses enough signal (ie some number of satellite signals). Amongst other distribution, this GPS feed is joined in with the Gyro feed.

Sep 15th 00:39 UTC, The Furano GPS data is added to SCS, after setting up a new instance of GPSgate to pull out the GPS from the same feed used for Gyro. These string names are steady (no switching between GP and GN). New SCS records were created to log these strings in addition to the "GN" Marine Star files.
Sep 24th, 2300 UTC, The Furano GPS feed becomes the NOAA Server's distributed (networked) GPS feed, replacing the now disconnected Marine Star GPS.

AVOS –
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.

The AVOS system did not have the ship's Gyro data connected but instead used its fluxgate compass when calculating true windspeed and direction. These data should be recalculated using the ship's gyro for accurate data.

Sep 2, The AVOS GPS died. This affects users of the *.AVMTD strings.

Sounder –
The sounder typically did not pick up the bottom depth while underway, even in ice-free conditions. Also, 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.

27 Aug, 2215 UTC Time given in the sounder string data (not the SCS time stamp) was incorrect until now.

Gyro –
Aug 27th to Aug 30th 18:37, recording of heading accidentally turned off.

Sep 3rd, recording changed from 10 seconds to "-1" to record all heading data.

PAR -
Independent files (ie not through SCS) have data collected every 1 second.

Sep 14th, SCS recording rate changed from every 1 second to every 10 second.

TSG-
Computer problems caused data acquisition to stop a few times during the first few days of acquisition at the start of the cruise. The computer would reboot itself during the middle of data acquisition. This was a similar problem to last year, but updating Window 10 to the professional version did not help. A replacement laptop was installed Aug 27 1826 with no further computer problems.

Two CDOM sensors were used during the trip through the archipelago, before JOIS began.

s/n FLCDRTD -1076, 27 Aug (20:01) to 2 Sep (12:32), questionable data
The first sensor, sn#1076, meant for a profiling application, was installed in a PVC "can" with inlet at bottom of the can and outlet at top. The cdom sensor face sat in the top ~3cm of the can looking downward with an o-ring seal to keep water flowing through the can but not out the top. Sea-water was plumbed from the Chl fluorometer outlet into the can, giving a time-lag of ~30seconds between sensors. The data from this set-up was reasonable in that they varied with time however there were unrealistic offsets in the reading, perhaps associated with bubbles caught on the sensor face. Also, the readings were in general high, perhaps due to a background fluorescence off the PVC. No CDOM water samples were taken during the use of this sensor for comparison

Figure 27. Outlfow from Chl fluometer feeds into the CDOM "can" with fluorometer sn1076.

Figure 28. TSG setup without microplastics or pCO2 system.

s/n WSCD-12812 Sep (13:39) to end of cruise

The second sensor, sn#1281, is the same through-flow sensor used in past years. The sensor had a thorough cleaning prior to the cruise but the barbettes that screw-on to the two ends of the sensor for seawater tube attachments were not sent back out with the insturment. From Sep 2nd to 6th the through-flow was achieved by butt-joining the seawater tube to the hole in the face of the instrument. This seemed to work fine with no leaking from the joint. The barbettes were added Sep 7th, the in and outlet sea-water tubing attached to the barbettes, creating a set-up consistent with prior years. CDOM water samples were taken with both configurations.

Figure 29. Outlfow from Chl fluometer feeds into the CDOM fluorometer sn1281. Barbettes added to CDOM sensor Sep 7th.

Seawater contamination from Sea-Bay
Unique this year we encountered unrealistically high sea-surface temperatures while in the ice. Using a thermometer it was confirmed that the water was indeed 8C, in agreement with the intake and lab seawater temperatures. From discussion with the engineers it was found that new this year, water was being pulled from the sea-bay that the TSG inlet pipe runs through to cool the ship's engine machinery and run the toilets. In the ice-forming water the sea-bay had plugged up with frozen seawater requiring the addition of a substantial amount of steam (heated freshwater with rust-inhibiting additives) to thaw the sea-bay.
The engineers had added a lot of steam to bring the temperature up initially, and once the bay had warmed they adjusted the level of steam. They would then turn it off when no longer needed. After we understood what was happening we asked if they would keep a log of when steam was added however at that point they were able to switch sea-bays and steam was not added again.

Reviewing diagrams and write-ups of the TSG plumbing, the inlet for the TSG is outside the ship, however the pipe then runs through a sea-bay on its way into the ship. If the pipe is intact then the only contamination would be to the sea-water temperature (and properties dependent on correct sea-surface temperature like pCO2). Because the TSG temperature responded so quickly to the sea-bay temperature change, one worry is that there is a crack in the piping (perhaps the weld?) so that the system was actually drawing in sea-bay water with its contaminated salinity and chemical additives. We couldn't figure out a way to easily test this so leave it as an item to be checked at the next dry-dock.
Chemical additives:
"AT" potassium hydroxide and salt (basic)
"OX"

pH test strips look the same from regular loop water, heated loop water, and Niskin bottle water

Flow – With the heating removed the TSG did have some issues with sea-ice blocking the pump inlet or affecting the flow rate. We had no flowmeter installed this year. To identify poor flow, large differences between the intake and lab temperature readings (ie over 2C) indicate sluggish or stopped water allowing more warming and higher temperature of the lab temperature. Also, spiky salinity data is typically due to air bubbles being sucked through the system when the intake strainers are clogged.

SBE38 Intake Temperature – The intake temperature value was stuck on the same value for a number of hours so the SBE 38 was changed out Sep 22 from sn870 to sn319. The stuck value may actually been a problem with the computer communication program GPSgate, however after re-establishing communication there were no further SBE38 problems.

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. Highlights below:

Aug 24th	Pump control set to automatic with Set Point = 18. Gives 4.66 process variable and 35% output. Started TSG acquisition but CDOM and Chl fluorometers not yet plumbed in so values for these properties are values 0.
Aug 25th	Fluorometer sn3652 added.
Aug 27th	01:02 Computer had rebooted itself again and seasave had to be restarted.
Aug 27th	18:26 After making up cable for CDOM sn 1076, compared values of CDOM (1076 and 1281) and Chl w/ each plugged separately and together. CDOM 1076: V1 is 0.1 in air Flr 3652 : V0 is 1.9 CODM 1281: V1 is 0.094 in air, V1=0.08 in water
Aug 27th	20:01 Swapped out laptop T2012-02 Beaufort and swapped in WNBCIOS9011688 CDOM 1076 installed in PVC "can" with outflow from Chl fluorometer. Flowrate of TSG outflow and fluorometer outflow measured using the big white bucket with 1L markings. At pump SP of 18.0 and Output at 23.9%, measuring time for 10L, the TSG is running at 3.2 sec/L and Flr at 19.6 sec/L Flowrate varied from fast to slow to fast to slow with no change in CDOM reading (1.7, 1.7, 1.6, 1.7v). Chl-a was to varying too much with no pattern (1.3, 1.5, 0.9, 1.1 to 0.9 to 0.8v).
Aug 30th	21:00 Rebooted computer and lost output to TCPIP 49161 (TSG to SCS) so mucked around with this creating a few files with rebooting and restarting files.
Aug 31st	02:25 Removed CDOM to see if this is affecting Chlorophyll stability as we are stationary, tied up next to CCGS Radisson for fuelling for the night.
Aug 31st	18:35 Plugged CDOM back in. Microplastic sampled using fluorometer output (?) with flow rate of 4.8sec/L
Sep 2nd	13:39 CDOM #1076 swapped out and replaced with CDOM #1281.
Sep 2nd	16:39 Stop and restart acquisition so data could be processed. Microplastic sampled with flow rate of 11.1 sec/L
Sep 5th	04:02 Microplastic sampled with flow rate of 5.6 sec/L

Sep 7th 17:23 CDOM sensor #1281 “barbettes” installed so now through-flow is the typical setup.

Sep 10th 15:20 T1 and T2 reading 4.5 and 8C. Unrealistically high.

Sep 10th 15:42 T1 and T2 reading 8C. . Unrealistically high temperature. Water is running fine so not a heating issue due to stalled flow.
Engineers confirmed that they have been adding steam to the sea-bay.

Sep 10th 23:23 Scott (One of the First Engineers) explained that they are adding steam to the sea-bay that our TSG intake pipe runs through. Our pipe should not be bringing in sea-bay water is heating up due to the hot water in the sea-bay. See “Seawater contamination from Sea-Bay” in the section under TSG above.

Sep 11th 03:15 Flow rate on microplastic “gardenia” flow meter agrees with observed flow rate using the calibrated bucket.

Sep 12th 07:05 Closed and started new file so data could be processed.

Sep 15th 15:00 T1 5.99, T2 1.55, more steaming of sea-bay.

Sep 16th 08:13 T1 4.5, T2 4.16, still in ice, more steaming of sea-bay.

Sep 16th 12:09 T10.05, T2 -0.73, back to reasonable temperatures.

Sep 16th 17:13 T1 -0.08, t2 -1.23

Sep 16th 18:05 Kevin (another of the First Engineers) says they are adding chemicals to the fresh water being used to steam the bay (AT and OX). pH test strips used to compare steamed and unsteamed water with no difference in color.

Sep 17th 20:36 Stopped and restarted new seasave file. Misnamed new file …09-27-2036 and this should be 09-17-2036.

Sep 19th 20:51 Stopped and restarted new seasave file.

Sep 20th 09:42 Breaking channel in ice. Bubles in TSG outflow. The debubbler is almost empty.

Sep 22nd 09:55 Grey ice and 3/10 of old and new ice. Debubbler is almost dry.

Sep 22nd 17:05 T2 (inlet temperature) values are not changing (T2 is -1.2015C) since Julian Day 264.9. Engine room contacted.

Sep 22nd 15:59 Inlet temperature (SBE38) changed out from sn 870 and replaced with sn 319.

Sep 22nd 18:00 Restarted acquisition but T2 is reading -9.9990. Low flow issue but engineers looks at pump strainer and removed ice but flow is still low.

Sep 22nd 18:24 Check port assignments, reset GPSgate Com6 output and now T2 is reading about -1.2 so now looks good.

Sep 23rd 01:38 See that pump is only reading 4PV and in manual mode. This was changed back to auto mode with SP=18 and flow has returned. This might have been the issue of low flow back to Sep 20th?

Sep 23rd 04:00 Spiky salt but flow is good. Not sure how air is getting into the TSG but perhaps the debubbler is not running properly. Lowered the flow slightly so now there is no overflow out the top of the debubbler.

Sep 24th 12:50 Stopped and restarted seasave file.

Sep 27th 07:55 Stopped and restarted seasave file twice as the seasave display was frozen on the first try.

Sep 30th In ice and de-bubbler is empty at times.

Sep 30th 14:11 de-bubbler is half full

Sep 30th 15:50 de-bubbler is full

Oct 1st 12:41 Pump is off with no flow due to heavy ice. Seasave closed and TSG power turned off.

Oct 1st 17:13 Ship is on the move again. Restarted TSG and seasave. Still in heavy ice but data seem OK for now.

Oct 1st 18:12 Had trouble starting seasave: closed and opened software, unplug and replug USB to COMM port cables, cycle power on interface box and finally data came through but then flow had stopped due to heavy ice.

5.4.4 Data Files

TSG-2018-08-24-1617.hex	No Chl-a or CDOM fluorometer
TSG-2018-08-25-1223.hex	Restart (after auto re-boot)

TSG-2018-08-25-2218.hex	Chl sensor sn3652 added
TSG-2018-08-27-0109.hex	Restart (after auto re-boot)
TSG-2018-08-27-1958.hex	CDOM sn1076 added and config file changed to *2018Aug27_SBE21_3297_withNMEA_with1076.xmlcon* New laptop running data acquisition
TSG-2018-08-27-2041.hex	New file so old data could be processed (?)
TSG-2018-08-30-2146.hex	New file after rebooting computer Note CDOM unplugged while sitting overnight next to Raddisson (Aug 31 0225 to 1835) Stopped flow at Sep 2nd 12:32 to Chl+CDOM.so could remove CDOM sn1076 and replace with sn1281 Sep 2nd 13:39.
TSG-2018-09-02-1638.hex	New file so old data could be processed.
TSG-2018-09-10-1550.hex	New file so config file could be checked. Temperature problems due to steaming of sea-bay.
TSG-2018-09-12-0705.hex	New file so old data could be processed. Temperature problems due to steaming of sea-bay.
TSG-2018-09-17-2036.hex	New file so data could be processed. Steaming in this sea-bay may have stopped.
TSG-2018-09-19-0051.hex	New file so data could be processed. Towards end of file the intake temperature value was stuck at -1.2015C
TSG-2018-09-22-1804.hex	Seasave stopped so in take temperature sensor, SBE38, could be changed. SN 870 removed and SN317 put in. Unclear if sensor SN870 had problem or just a communication glitch.
TSG-2018-09-24-1250.hex	New file so data could be processed.
TSG-2018-09-27-0757.hex	New file so data could be processed.
TSG-2018-10-01-1808.hex	New file so data could be processed.

TSG-2018-10-02-0256.hex New file so data could be processed.

5.4.5 For 2019

- Bulkhead connector on Chl sn 36512 and CDOM 1076 have chewed up rubber around some of the pins.
- SBE38 SN 870, used from start of program to Sep 22nd. Last calibration was 17 Feb 2016. Needs calibration and also confirm it is working correctly as there was an issue with stuck value but that may have just been a GPSgate communication glitch.
- SBE38 SN319, last calibration 5 Jan 2017, needs calibration.
- For SCS adjust timestamp to all show 1 second, PAR keep at 10 seconds. (May currently be "-1" in SCS sensor configuration >message definition > Logging Rate.)
- For SCS should be able to remove the VTG-Raw, GGA-Raw, ZDA-Raw, RMC-Raw (GN) records or at least disable them and just keep the GPxxx records. And could consider JUST keepin GPRMC?
  Also need to check which GPS is running…

- Scott was going to let Environ Can about gyro string not going into avos
- Trial in-line non-recording flow meters to give instantaneous flow readouts? This worked well for the microplastics though constant use might overwhelm sensor.