Joint Ocean Ice Study (JOIS)
Beaufort Gyre Observing Program (BGOS)
2024 Cruise Report

Photo by Paul Macoun

Report on the oceanographic research conducted aboard the *Canadian Coast Guard Ship Louis S. St-Laurent*

Dates: August 29th to September 26th, 2024*
IOS Cruise ID: 2024-011

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* Sail dates, within this time frame science had 25 days.

Contents

1 Overview

The Joint Ocean Ice Study (JOIS) in 2024 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 researchers from Fisheries and Oceans Canada (lead: Bill Williams) and, in the USA, from Woods Hole Oceanographic Institution (lead: Isabela Le Bras) and Yale University (Mary-Louise Timmermans). The scientists from WHOI and Yale lead the Beaufort Gyre Exploration Project, which maintains the Arctic Observing Network's Beaufort Gyre Observing System (AON-BGOS), funded by the National Science Foundation (NSF).

The 2024 program includes collaborations with researchers from the following nations and institutions:

USA:
- Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.
- Yale University, New Haven, Connecticut.
- University of Montana, Missoula, Montana.
- Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Oregon State University, Corvallis, Oregon.
- University of Delaware, Newark, Delaware.

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 (TUMSAT), Tokyo.
- Kitami Institute of Technology, Kitami, Hokkaido.
- University of Tokyo, Tokyo.

Switzerland:
- ETH Zurich, Zurich.

Canada:
- Fisheries and Oceans Canada, Institute of Ocean Sciences (DFO-IOS), Sidney, British Columbia
- Fisheries and Oceans Canada, Bedford Institute of Oceanography (DFO-BIO), Dartmouth, Nova Scotia
- Université de Sherbrooke, Sherbrooke, Québec
- Université Concordia, Montreal, Québec
- University of British Columbia, Vancouver, British Columbia
- Environment and Climate Change Canada (ECCC), Meteorological Service of Canada, Toronto, Ontario
- Canada's Nuclear Laboratory, Ontario

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 Exploration Project	https://www2.whoi.edu/site/beaufortgyre/
Beaufort Gyre Observing System dispatches	https://www2.whoi.edu/site/beaufortgyre/expeditions/2024-expedition/
Ice-Tethered Profiler buoys	https://www2.whoi.edu/site/itp/
Ice Mass Balance buoys	http://imb-crrel-dartmouth.org/
Arctic Ocean Flux Buoy	www.oc.nps.edu/~stanton/fluxbuoy/
ARGO buoys	https://argo.ucsd.edu/ https://www.aoml.noaa.gov/argo/

2 Cruise Summary

The JOIS/BGOS science program onboard the *CCGS Louis S. St-Laurent* began August 29th, departing from Cambridge Bay, NU and finished September 26th, 2024, back in Cambridge Bay, with 25 days dedicated to science. The research was conducted in the Canada Basin from the Beaufort Slope in the south to close to 80°N in the north by a research team of 25 people from 9 institutions in 3 countries, including 7 students (undergraduate and graduate 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. ARGO floats were deployed for year round measurements. 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. New this year a glider measuring CTD and turbulence was deployed and recovered during the cruise. The location of science stations, the primary sampling at each station, and the total number of each type of station, are shown in Figure 1 below.

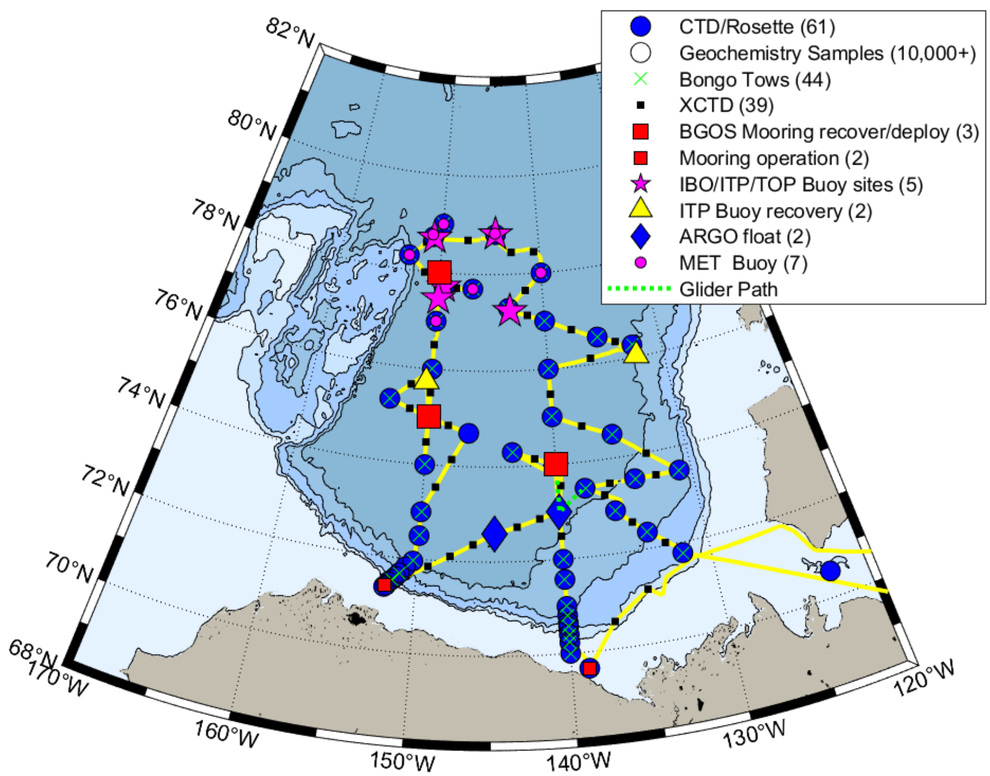


Figure 1. The JOIS/BGOS-2024 cruise track showing the location of science stations.

2.1 Program Components

Measurements:

- At CTD/Rosette Stations:
    - 61 CTD/Rosette Casts at 52 Stations (DFO) with 1187 Niskin bottle water samples collected for hydrography, geochemistry and pelagic biology (bacteria, microbial diversity, phytoplankton and biotoxin) analysis (DFO, U. Sherbrooke, TUMSAT, WHOI, Yale, U. Concordia, JAMSTEC, ETH Zurich, U. Delaware).
    - Water samples taken:
        - At all full depth stations: Salinity, dissolved O_2 gas, Nutrients (NO_3+NO_2, PO_4, SiO_4), ^{18}O isotope in H_2O, Bacteria, Alkalinity, Dissolved Inorganic Carbon (DIC), Fluorescent Dissolved Organic Matter (FDOM), Chlorophyll-a, ^{13}C isotope in DIC
        - At selected stations: microbial diversity, radio-nuclides (^{129}I), Barium, Dissolved Organic Matter (DOM), Lignin-phenols (from underway system only), Ammonium and BioToxins
    - 45 Zooplankton Vertical Net (“Bongo”) Casts at 43 CTD/Rosette stations. One 100 m cast per station using two nets with mesh size of 150 µm. One set of samples for genetic testing preserved in ethanol and the second set of samples for identification preserved in formalin (DFO).
- 39 XCTD (expendable temperature, salinity and depth profiler) Casts typically to 1000 m depth. (DFO, JAMSTEC)
- 13 UCTD (underway temperature, salinity and depth) combination of profiles and repeat yo-yos. Testing ability of UCTD to measure the upper 20m ocean structure while underway.
- Mooring operations at 5 sites (WHOI-lead, U. Montana, U. Sherbrooke)
    - 3 Mooring Recoveries and Re-deployments in the deep basin (BGOS-A,B,D; WHOI)
    - 1 Mooring Recovery performed in support of another program (AON, BS-3; WHOI)
    - 1 Mooring Recovery and Deployment in support of another program (BSMO HI-2023/HI-2024; DFO)

- Buoy operations at 7 sites (WHOI, Yale, CRREL,U Montana, NPS)
    - Recovery of Ice Tethered Profiler (ITP 136, WHOI)
    - Open Water Deployment 1
        - Tethered Ocean Profiler (TOPV 13, WHOI)
    - Ice Based Observatory (IBO) 1 Ice Station with:
        - Tethered Ocean Profiler (TOP014 w/ T-chain, WHOI)
        - Seasonal Ice Mass Balance Buoy (SIMB-2024#6, CRREL)
        - OpenMetBuoy (UTokyo)
        - Meteorological Buoy (ECCC)
    - Ice Based Observatory (IBO) 2 Ice Station with:
        - Tethered Ocean Profiler (TOPV 12, WHOI)
        - Arctic Ocean Flux Buoy (AOFB 49, NPS)
        - Ice-Tethered Profiler w/ SAMI-CO2 and Optode (ITP 142, WHOI, U. Montana)
        - Seasonal Ice Mass Balance Buoy (SIMB-2024#7, CRREL)
        - OpenMetBuoy (UTokyo)
        - Meteorological Buoy (ECCC)
    - Open Water Deployment
        - Tethered Ocean Profiler (TOP 15 with T-chain, WHOI)
    - Open Water Deployment
        - Ice Tethered Profiler with SAMI-CO2 and Optode, (ITP 143 WHOI, UMontana)
    - Open Water Recoveries of instruments no longer profiling.
        - Tethered Ocean Profiler (TOP 6, WHOI)

Ice Observations (KIT/OSU)

- Visual ice observations were made hourly from the bridge during daylight hours while in ice.
- Automated photographs were taken of the sea-ice from the bridge
    - A new camera system was mounted in the starboard side of the bridge. It had both forward and downward views, a GPS receiver and inertial sensor. Photographs were taken at 3 minute intervals.

        - A forward facing GoPro camera was mounted on the port side of the bridge, recording at 1 minute intervals however problems with the internal recording created a substantial gap in images this year.

        - The network cameras (Netcams) that had been used from 2007 to 2023 were not installed this year. They had been installed above the bridge with views forward and side-looking, taking pictures every 1 minute or more frequent depending on the year. The quality of the image was growing poorer each year and the new systems are preferred.

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

    - Ship Performance looking at speed, motor power (kW), and open water and sea-ice conditions

    - Passive Microwave Radiation measurements taken at select stations in sea-ice and open water to validate and improve algorithm for estimation of the Arctic snow/sea-ice total thickness from the AMSR2 satellite data[Krishfield et al., 2014]

    - New this year were measurements of surface temperature using a thermal camera with the goal of investigating the temperature difference between sea-ice and open-water.

    - On-ice measurements at the ice-stations including:

        - Drill-hole ice thickness transects

        - Snow structure observations

        - Ice-cores for temperature, salinity and structure profiles

        - New this year was the installation of a wave buoy at each ice station. The purpose of the buoy is to measure waves propagating under the sea-ice. Data were transmitted back to shore via iridium satellite.

    - Underway collection of meteorological, bottom depth, and navigation data, and near-surface seawater measurements of salinity, temperature, chlorophyll-a fluorescence, FDOM fluorescence, pCO2, and Oxygen/Argon (DFO-IOS, U. Sherbrooke, U. Montana, U. Delaware).

Water samples (102) were collected from the underway seawater loop for salinity, nutrients, chlorophyll, DIC, alkalinity and oxygen (DFO), FDOM (U. Sherbrooke) and Tritium and Deuterium (CNL).

- Daily dispatches to the web (WHOI/Yale)

- 2 ARGO floats were deployed for year-round measurements of the upper 2000m every 10 days (DFO)
- A glider fitted with CTD, oxygen and a turbulence instrument was deployed at the start of the trip and recovered at the end (UBC, DFO)

2.2 Comments on Operations

Due to the ice conditions associated with the timing of the cruise, we chose to travel counterclockwise around the Beaufort Gyre. This is the preferred direction in late September, allowing us to work in the heavier ice area of the southeast Beaufort before freeze-up began in earnest, to reach the northern area where the ice-buoys were deployed before losing too much daylight, and to allow some freeze-up to begin in the western Beaufort which can help dampen waves in high winds. This year however, with the lack of sea-ice, the direction was chosen as it puts the buoy and mooring operations earlier in the program and gives some maneuverability with dates if the sea-state affects the schedule.

The two on-ice stations were performed by parking the ship within an ice floe, lowering the gangway for people to walk out to the ice. The ship's crane transferred gear to and from the ice. This method worked well. Multiple science teams could start working quickly once the gangway was down and gave easy access to the ship for workers on the ice. This year three of the five buoy deployments were in open water. The success of this method and data returned will be important for future years, as open water deployments may become a necessary standard.

There was an ice specialist from the Canadian Ice Service on board. She prepared daily briefings for the ship regarding weather, sea-state and ice-conditions. Knowing current conditions and forecasts helped us decide how to budget program time, the order of operations, and successfully find suitable ice for the buoy placements.

The three mooring recoveries this year were for systems that had been in place for 1 year. The transponders and acoustic releases worked as planned which made the operations run as smoothly as possible. The recoveries were all in open water, simplifying the process without need to pre-break ice or range on the near-surface pinger. Redeployments were in 1 to 2m swell.

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.

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.

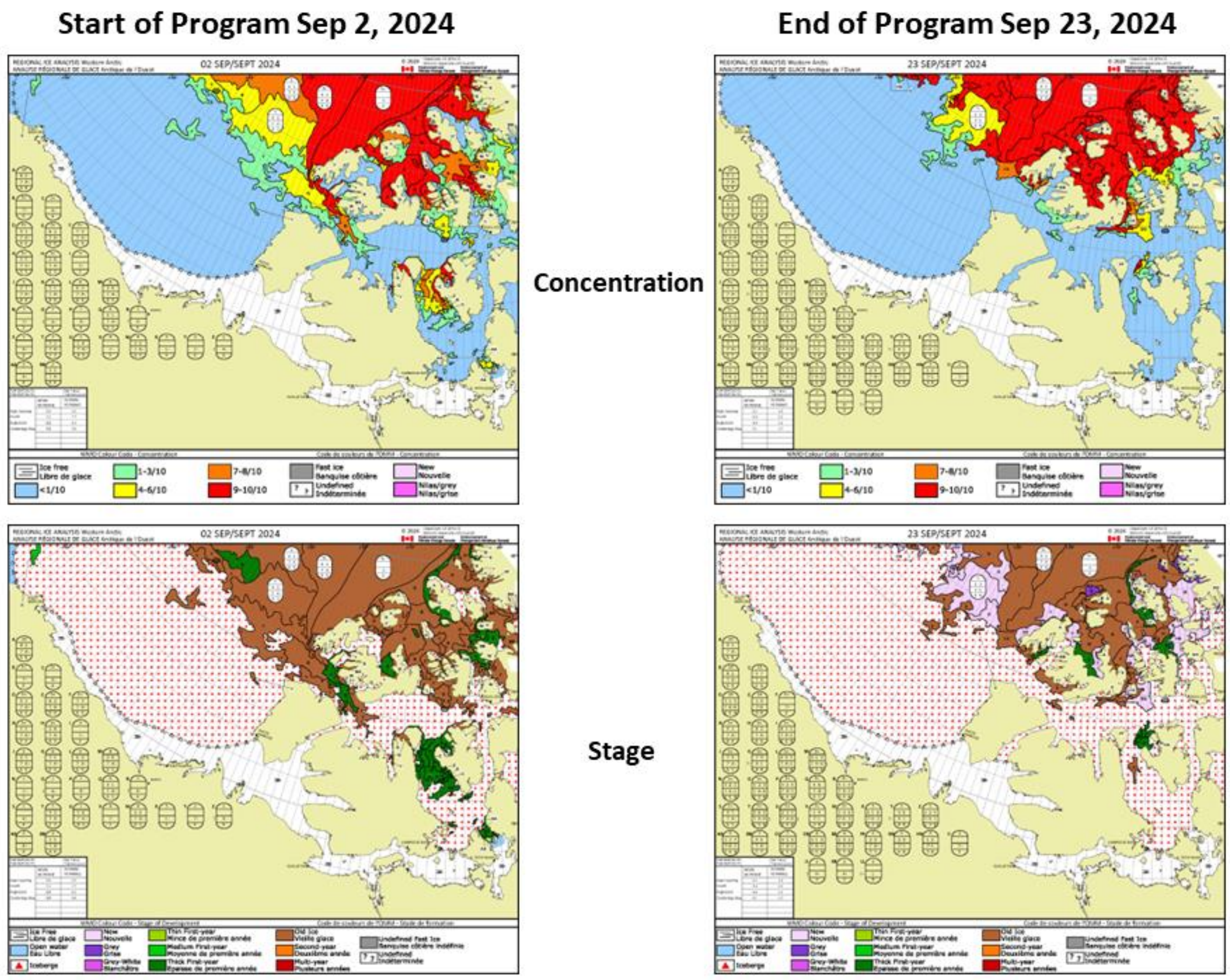


Figure 2. Ice conditions at the start and end of the program (source: https://iceweb1.cis.ec.gc.ca/Archive/page1.xhtml).

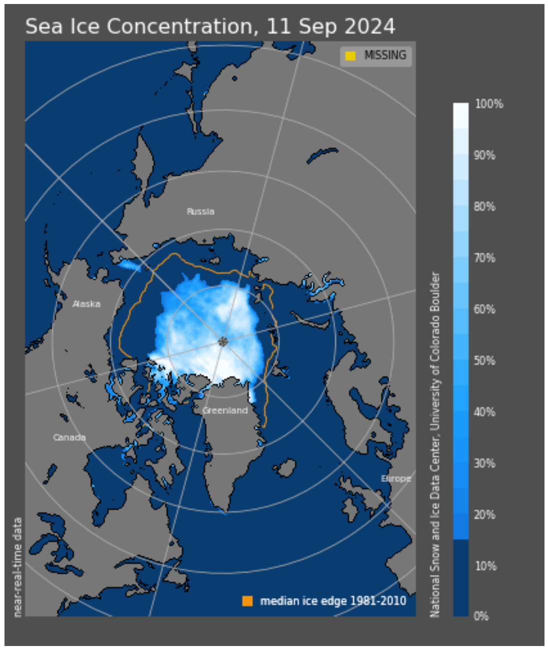
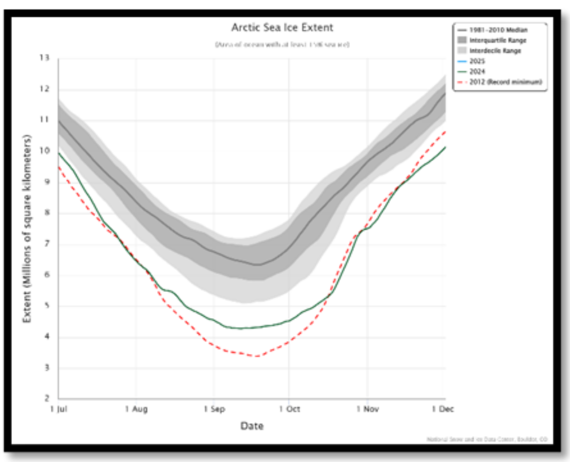
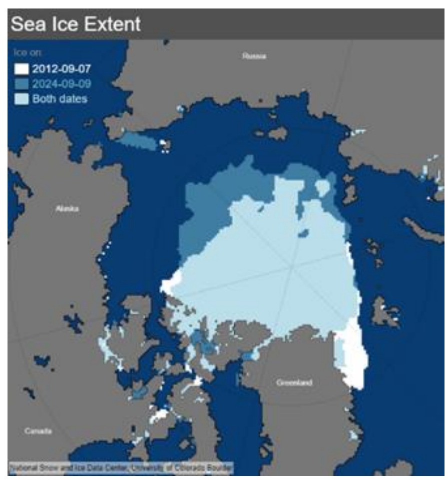


Figure 3. Sea Ice Concentration from the midpoint of this year's cruise. Image from the National Snow and Ice Data Center (NSCIDC.org):
[Index of /pub/DATASETS/NOAA/G02135/north/daily/images/2024/09_Sep]





Figures 4. Sea Ice Extent for all years and a comparison of 2012 (lowest on record) and 2024, from National Snow & Ice Data Center (source: http://nsidc.org/arcticseaicenews/)

Graph: https://nsidc.org/sea-ice-today/sea-ice-tools/charctic-interactive-sea-ice-graph#anchor-working-with-the-images

Map: Sea Ice Spatial Comparison Tool | National Snow and Ice Data Center

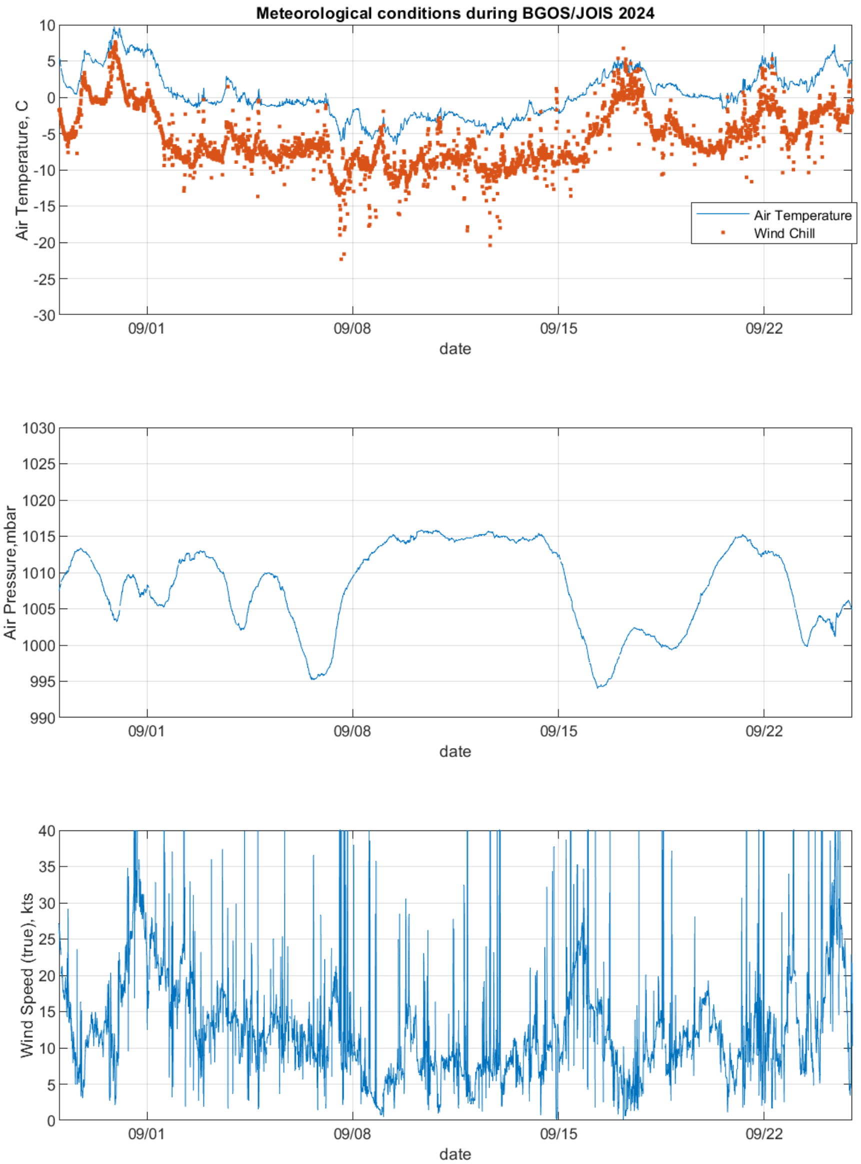


Figure 5. Temperature (blue) and wind chill temperature (red) in top plot, air pressure (middle plot) and wind speed (bottom plot) during the expedition from the ship's AVOS weather station above the bridge of the CCGS Louis S. St-Laurent.

Acknowledgements

Figure 6. **All crew and science on board**.

The science team would like to thank Captains Byron Briggs and Wayne Duffett, the crews of the *CCGS Louis S. St-Laurent* and the Canadian Coast Guard for their support.

We appreciate the pre-cruise planning and improvements made to the ship and at-sea, we were very grateful for everyone's hard work and dedication to the delivery of the program. The specialist from the Canadian Ice Service gave daily briefings that were helpful to operational decision making. The Health Officer onboard provided any needed care. The helicopter pilot and engineer provided great time-savings assistance with transit loading/offloading.

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 JOIS Program's 22nd consecutive year in the Beaufort Sea, and the exciting and valuable scientific results now in hand are a direct result of the experienced, well trained and professional crews of the *CCGS Louis S. St-Laurent*.

3 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.

3.1 Rosette/CTD Casts

Mike Dempsey, Paige Hagel, Paul Macoun, Sarah Zimmermann (DFO-IOS)
PI: Bill Williams (DFO-IOS)

Overview

A Seabird 9/11+ CTD system was used with SBE9+ s/n 1493 CTD the entire cruise. The CTD was mounted on an ice-strengthened rosette frame configured with a 24-position SBE-32 pylon s/n 1231 with 10L Niskin bottles fitted with internal stainless steel springs. The rosette has been 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 (s/n 1281or s/n0689) and computer running Seasave version 7.26.7.107 acquisition software. The CTD was set up with two temperature sensors (SBE03), two conductivity sensors (SBE04), dissolved oxygen sensor (SBE43), and chlorophyll fluorometer (Seapoint SCF), all with pumped flow. Also on the CTD was a transmissometer (WetLABS CSTAR-DR), CDOM fluorometer (WetLabs EcoCDOM), cosine PAR (Satlantic) and altimeter (Valeport). In addition, an Alec RINKO III dissolved oxygen sensor was used for comparison and sensor testing purposes for all casts.

Similar to last year, WHOI added an experimental “D2” CTD sensor and logger battery pack to the rosette frame. The temperature and salinity sensor was mounted as close as possible to the sensors of the SBE9+ in order to be able to reasonably compare data.

A surface PAR sensor (Biospherical QSR2200) connected to the CTD deck unit was integrated into the CTD data for all casts. In addition, a serial communicating surface PAR sensor (Biospherical QSR2150) providing continuous 1hz data was mounted beside the other SPAR unit. Continuous PAR data was collected for the whole cruise. These 1-minute averaged data are reported with the underway suite of sensors.

A typical station started with a CTD cast down to 10 m off the seafloor. While the CTD rosette was in the water, at most stations where weather allowed, a zooplankton vertical net haul (bongo nets) to 100m took place from the foredeck. At 5 stations, a shallow CTD cast for microbial diversity sampling (“RNA/DNA”) was performed followed by a full geochemistry cast. This year we were able to combine the casts at one of these station due to the shallow depth and reduced sampling. Extra casts were also sometimes needed at mooring and ITP/TOPP/flux buoy deployment and recovery sites for calibration purposes. During JOIS 2024, there were a total of 61 CTD/Rosette casts.

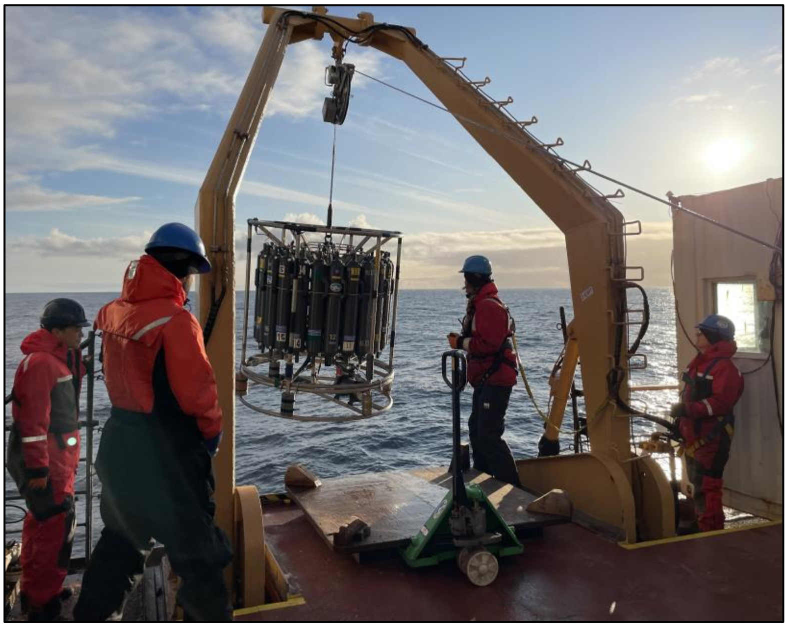


Figure 7. Typical rosette deployment(photo 2023 but similar for 2024).

Figure 8. Rosette operation on deck with Hawboldt winch and Brooks Ocean Instrumented Sheave display box mounted on the right. (photo 2022 but similar for 2024).

Figure 9. CTD operator and acquisition display in the CTD lab.

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 10m and the pumps turned on. This soak cools the sensors to ambient sea water temperature and removes bubbles from the sensor plumbing. 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 at 900m to make operations smoother.

Niskin bottles were closed during the upcast, normally without a stop. For surface bottles, and where multiple bottles were closed at the same depth, the rosette was “yo-yo’d” to mechanically flush the bottle, meaning it was stopped for 30sec, raised 1m, lowered 2m, raised 1m, and stopped again for 30 seconds before bottle closure. The bottles closed using this method are indicated in the rosette log and water sample data spreadsheet (“chemistry spreadsheet”).

For 2024, “yo-yo” Niskin closures were increased to five standard depths to reduce the chance of bottle flushing issues. In addition to the surface (5m), the yo-yo’d depths were at the chlorophyll maximum, and where salinity is 32.3, 33.1 and 34.4 PSU. Due to the ship’s minimal ship-rock due to working in ice and being a large ship, the yo-yo stop of +/- 1m is much more effective at matching bottle to CTD value than a common alternative used on other ships of a 30second wait. Given the Niskins are 1m long, this artificial mixing is within the same scale as the sampling equipment.

The instrumented sheave (Brooke 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 during the cast. After the cast the rosette was brought back on deck and rolled using a pallet jack into the heated rosette sampling room.

Performance Notes

CTD

We used the SBE9plus s/n 1493 with s/n 756 as backup. The temperature, conductivity and dissolved oxygen sensors will have pre and post cruise calibrations to compare and decide on best options for data processing. Salinity, Oxygen and Chlorophyll water samples will be used for further sensor calibration.

Uniquely this year, jellies were seen more than just around the BL stations.
Cast 15 (CB13) – jelly caught on rosette frame
Cast 20 (IBO-1) – small jelly seen in water around the rosette.
Cast 37 (CB2a) – jelly caught on rosette frame
Cast 42 (BL4) – jelly strand in primary temperature and conductivity plumbing. Use secondary sensors. Need to determine if CTD oxygen is useable.

Assembly – Sensors

The CDOM sensor s/n 6677, cosine PAR s/n 517, altimeter s/n 80262, and transmissometer s/n 1052 were mounted in roughly the same positions as 2022. These all performed well throughout the cruise.

Pylon/ Water Sampler

We used the SBE32 Pylon s/n 1231 for the entirety of the 2024 cruise. Generally the system performed well, but there were a quite a few cases where the trigger mechanism did not fire due to “stickiness” assumed to be from the CTD wire’s lubricant residue. Due to our wire on the Hawboldt winch being over lubricated, the trigger mechanism s/n 452 was routinely swapped with s/n 498 for cleaning. The removed trigger head was thoroughly cleaned with soapy hot water and isopropanol to remove the sticky lubricant residue. Towards the end of the program, latches on s/n 498 were sticking even after cleaning, so only s/n 452 was used.

Figure 10. Water sampling around 24 bottle rosette.

Niskin Bottles

All o-rings were changed prior to the 2022 cruise on the 24 Niskin bottles on the rosette, and were checked and replaced as needed during the 2024 cruise. Silicon rubber o-rings are used on the spigots to reduce sticking in cold conditions. The lanyards were also checked, modified and replaced as needed during the cruise. There were a few integrity problems (leaky spigots, endcap seating) with the 24 Niskins during JOIS this year. We tracked any pattern issues, and replaced o-rings, spigots, and vent screws as needed. Some bottle closure issues were related to suspected lanyard hang-ups or sticky trigger issues (due to wire lubricant in the trigger).

Per usual, due to the instrumentation on the rosette, we had to cock some of the Niskins bottom end caps slightly to the side rather than straight back. One Niskin was replaced throughout the cruise: Niskin 10 had chip in top. New bottle put in for Cast 7.

Seasave and CTD data

Seasave worked reasonably well throughout. There are still issues when zooming in/out and replotting the display plots with the profile becoming corrupted (graphics only, not the actual data). More computer memory was added prior to the 2022 cruise, however the same problem persisted. We suspect this is a limitation of the Seasave program itself, but again are unsure.

SBE11 Deck Unit

We used one SBE11 deck unit for the duration of the cruise without issue.

GPS feed

The GPS feed managed with GPSgate software worked well this year. No observed dropouts on the CTD computer.

Instrumented Sheave (BOT)

The Instrumented Measurement System (IMS) and the Brooke Ocean Technology (BOT) block bridge display feed worked well throughout the cruise. We used the IMS display on the Knudsen computer and had it distribute the data to the local network.

Transmissometer

There were problems with both the primary and spare WetLabs CSTAR transmissometers with no good data on any cast. Both read normally in air with expected values for light and dark. The first, s/n 1050, went to full scale as soon as it entered the water. The second, s/n 1052, shifted and jumped with depth. Both sensors had been to Seabird for servicing prior to this program. Tests were done with no remedy (swap cable, change CTD port, removed second channel, on deck wet test). The sensor was removed before Cast 25. Note that a replacement CSTAR transmissometer brought up for the following program using same cables and CTD and worked fine.

Altimeter

The Valeport VA500 s/n 80262 worked well, kicking in at full range (99m) without spiking. The altimeter was mounted in the same position as 2021/2022, on a piece of aluminium pipe hose-clamped to the main frame. Recommend making this mounting area permanent for future cruises.

FDOM fluorometer

The WetLabs FLCDRTD (s/n 6677) fluorometer worked well.

Rinko III dissolved oxygen sensor

An Alec Rinko III s/n 0259 dissolved oxygen sensor was mounted on the rosette next to the SBE43 oxygen sensor for all CTD casts. The RINKO was configured on a splitter Y cable with the Satlantic cosine PAR sensor. Raw voltage measurements were recorded in the Seasave data file using the User Poly option. The Rinko has a fast 2 s response time but is thought to drift between casts. It is hoped that the drift found in this sensor can be corrected for, and the Rinko can be used to provide accurate dissolved oxygen profile data when an oxygen analyst cannot be present on board cruises (programs C3O, CBS-MEA, CROW etc). Analysis of the data collected will be used to prepare a method for independent oxygen measurements. A 2-point calibration was performed on the sensor twice during the cruise, between casts and once shortly after the cruise.
Calibration performed before Cast 29 and Cast 33, and after Cast 61 at start of next program.

CTD Rosette frame

No issues.

CTD wire issues and re-termination

The CTD wire was new for JOIS 2022. Wire was cut back 60m and re-terminated before start of program.

The wire was heavily lubricated in 2022, and we were still having issues with excess lubricant in 2024 although much less then the last two years. This excess lubricant was still coming off the wire over the course of the cruise, mostly via the BOT block and level wind rollers. Its believed the wire lubricant caused issues with the trigger mechanism, leading to Niskins not firing.

Sea cable and communications worked well without issue.

CTD Winch

The CTD winch, the Hawboldt model SRO 75, with 75hp, has been a part of JOIS since 2005. In Dec 2021, 7000 m of new 0.322” 3 conductor UNOLS wire was installed.

Some issues were observed with spooling of the wire on the forward side of the winch drum, where the wire will cross over itself and lay incorrectly when changing direction against the cheek of the drum. This is a persistent issue from previous years. It is possible that the fairlead levelwind rollers are not quite adjusted correctly. This happened twice over the course of the trip, but can otherwise be mitigated by paying close attention and/or slowing down slightly when spooling the forward cheek of the drum.
Cast 26 – had to relower CTD ~100m to get the wrap to lay correctly.

Cast 27 – Adjusted the spooling 4mm forward during the downcast at 1800m.

As in 2023, there was an occasional issue in which the winch began surging/pulsing in high gear.
Cast 50 – stopped at 388m to fix noise.
Cast 51 – on downcast at 2050m to fix noise. Changed back to low gear and then stopped cast early at 3100m.
Notes from 2023 for reference:

Surging/pulsing in high gear @ ~ 3200m – 3500m wire out. Senior engineer was consulted but there was no obvious issues identified. Issue is resolved by stopping the winch and slowly engaging the valve on the control stick. If the control stick is moved too quickly (i.e. valve opened too quickly), the winch will surge again. It is possible the valve is faulty, but it is also possible that it is just the limitation of the winch's acceleration with so much wire/weight out. It is suspected that the issue presents itself if the winch operator unintentionally moves the control stick too quickly/erratically at >3000m.

Maintenance suggestions for next year

1. Calibrate T,C&O sensors on SBE 9plus s/n 1493
2. Inspect Niskin o-rings and lanyards for replacement of worn items
3. Inspect BOT block cabling; clean off wire lubricant and Loctite retaining screws
4. Make new mounting location for altimeter permanent
5. Consider replacing rosette with different style to alleviate bottle closing issues.

See appendix for CTD sensor configuration and calibration information.

3.2 Chemistry Sampling

Table 2 below lists the sampled properties.

Please see the Rosette Sample Log for the full list of each sample drawn.

Table 1. Water Sample Summary from CTD/Rosette – JOIS 2024 program

Parameter	Canada Basin Casts	Depths (m) or properties	n (duplicates)	Analyzed	Investigator
Dissolved Oxygen	All casts (geochemistry)	Full depth	1112 (121)	Onboard	Bill Williams (DFO-IOS)
DIC	All casts (geochemistry)	Typically to S=34.7 (5 to 400m)	701 (62)	Onboard	Bill Williams (DFO-IOS),Michiyo Yamamoto-Kawai(TUMSAT)
	Mooring sites and a few on 140W : CB29, CB21, CB17, CB15, CB9, CB4, Stn-A, AG5	Full depth			
Alkalinity	Same as DIC, analyzed from same bottle.	Same as DIC	701 (62)	Onboard	Bill Williams (DFO-IOS),Michiyo Yamamoto-Kawai(TUMSAT)
FDOM	All casts (geochemistry)	5, Chl Max,S=33.1, S=34.4, AtlW Tmax, 1000, 2000, DeepTmin, Bot-100	501	Onboard	Celine Gueguen (U Sherbrooke)
	In addition, on all 140W stations and BL-Line sample to match Barium	5 to S=33.1			
Chl-*a*	All casts (geochemistry)	5-200 (select)	274 (274)	Onboard w/extra reps onshore	Bill Williams (DFO-IOS)
Bacteria	All casts (geochemistry)	5, 20, Chlmax, S=32.3, S= 33.1, 34.4, Tmax, 1000, Bottom	457	Shore lab	Celine Gueguen (U Sherbrooke David Walsh (Concordia)
Nutrients	All casts (geochemistry)	Full depth	1126 (122)	Onboard	Bill Williams (DFO-IOS)
Salinity	All	Full depth	1177 (101)	Onboard	Bill Williams (DFO-IOS)

$\delta^{18}O$	All casts (geochemistry)	5-400 (typically to S=34.7 or 34.8)	766 (59)	Shore lab	Bill Williams (DFO-IOS)Michiyo Yamamoto-Kawai(TUMSAT)
	Mooring sites and some extra stations along 140W: CB18, CB17, CB15, CB16, CB9, CB4, Stn-A, CB21, CB27	Full depth		Not all collected samples will be analyzed.	
Barium	All 140W stations and BL-Line	5m to S=33.1	190	Shore lab	Celine Gueguen (USherbrooke)
DOM	Along 150W: CB11, CB9, CB8, CB7, CB4, CB3, CB2, CB2a, BL-8,-6,-4,-3-,2	A mix: At least S=33.1, at most 5m, S=33.1 (PWW), S=34.4 (AH), Tmax AtlW, 1000m	26	Shore lab	Celine Gueguen (USherbrooke)
Lignin/Phenol	CB5, CB4, CB23a, CB3, CB2	Surface from TSG system (Seawater Loop)	5	Shore Lab	Celine Gueguen (USherbrooke)
Microbial Diversity (DNA/RNA)	AG5, CB4, CB9, CB21, IBO2 (Farthest North)	5, 20, Chlmax, S= 33.1,	56	Shore lab	David Walsh (Concordia)
	High spatial coverage not collected this year.				
Ammonium (NH4)	150W all stns from shelf to CB2 140W all stns from shelf to MK6	5m to S=34.4 (AH)	182 (182)	Onboard	Bill Williams (DFO-IOS)
^{129}I	CB10, CB5, BL4, StnA	Full depth (15 select depths)	59	Shore lab	Nuria Casacuberta (ETH Zurich), John Smith (DFO-BIO)
BioToxin	AG5, CB1,CB51,PP7,CB16, CB9, CB4, BL-1,-2,-3,-4,-6, CB28aa, MK-1,-2,-3,-4	5m, ChlMax, Bottom (sometimes not all 3)	41 (5)	Shore lab	Mackenzie Mueller, Andrew Ross (DFO-IOS)
DIC^{13}C	Most casts	Full depth	872 (72)	Shore lab	Wei-Jun Cai (UDelaware)
	CB5, CB6, CB10, CB12, IBO2, CB13, PP7, PP6, CB40, CB50, CB51	5m to S=34.7 (5 to 400m)			
	HI, IBO1	Not sampled			

3.2.1 Dissolved Oxygen

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

Overview

Dissolved oxygen concentrations were measured on board the CCGS Louis S. St-Laurent (LSSL) from August 28th to September 22th, 2024 during the JOIS mission in the Canada Basin – Cruise 2024-011. A total of 1114 samples were collected from 55 stations. The cruise starting and ending in Cambridge Bay, NU. All samples were analyzed on the SIO Winkler oxygen titration kits. Oxygen concentrations ranged from 5.401-9.470 ml/L with ~10% of samples analyzed in duplicate. The pooled standard deviation (s_p) for duplicate samples was 0.005 ml/L after the removal of 3 outliers based on Chauvenet's criterion. Four duplicates were removed from the study due to an analysis problem. The mean deep water (>3000 m) DO value in the Canada Basin was 6.525 ± 0.019 mL/L.

Pre-cruise preparation

Reagents and Standards

All reagents and standards were prepared in soap and acid-washed glassware and plastic ware and were prepared using chemicals of the highest purity available at the time of purchase. Reagents and Thio were made in 2000 ml and 4000 mL glassware and the KIO_3 standards were prepared in 2000 mL or 1000 mL Class A volumetric flasks. All chemical batches were prepared in 2021, 2022, 2023, and 2024. No chemicals were left on board from the previous year.

Equipment Calibrations

Bottle Top Dispensers: Bottle top dispensers were purchased new in April 2019. Before the 2024 field season the bottle top dispensers were thoroughly cleaned in acid baths for a minimum of 1 hour. Gravimetric checks were performed in April – June 2024 prior to the cruise ensuring the accuracy and precision of the volume dispensed. For the most part the bottle top dispensers worked well. On occasion bubbles were drawn in from the dispensing tip on the NaOH/NaI bottle (common problem that typically develops over the course of a cruise). This problem was remedied by a series of quick flushs periodically on recirculation. At one point in time the NaOH/NaI bottle top dispenser was changed out in an attempt to improve smooth delivery of chemical, however, the samplers preferred the original and thus it was restored. All bottle top dispensers exhibited the problem of leaking chemical when mixed. The leak is typical between the adapter piece for the bottle and the dispenser and a fix for this would make for a cleaner and safer user of the chemicals.

Oxygen Sample Flasks: A flask file for 2023 was prepared by Kenny Scozzafava prior to the cruise and loaded into the appropriate LVO2 directories by Erinn Raftery. No calibrations or spot check were performed for 2024 due to staffing shortages. 7 new flasks were added to replace those that were broken in 2019. Two of three flasks were broken during the 2024-011 survey. One flask was dropped, another two had the tops snapped off (narrow glass top flasks).

10 mL Exchange Units: Calibrations were performed in June 2024 to determine the exact volume delivered at 20°C using the broad dosing tip. It was discovered that the backup exchange unit, #11, had been damaged and would no longer connect to the Dosimat base. It was swapped out with the Laurier / Kit A exchange unit #1. Both 10 mL exchange units were calibrated with the primary and spare Dosimat base for dispensing KIO_3. For each calibration, ten 10 mL aliquots of deionized water were dispensed into a clean 100 mL glass beaker and each weight was recorded. The mean weight of the 10 aliquots was used along with the temperature of the water to determine the exact volume dispensed at 20°C using the SIO program "glasscal.exe". The appropriate volume for the exchange unit and Dosimat combo in use was entered into the operating parameters at the beginning of the cruise.

Computers

A new computer was used – Lenovo Thinkpad software installed July 2024. There was some trouble with driver installations for the serial to USB adapter.

Sampling

Samples were collected in nominal 125 mL calibrated ground glass stoppered iodine flasks. Seawater temperatures at the time of sampling were measured with a digital probe thermometer (Fisher Scientific) potted into one arm of a Y-connector with sampling tubing attached to the other two arms (one to the Niskin bottle spigot and one into flask). The samples were immediately fixed with 1.0 mL of $MnCl_2$ and 1.0 mL of NaI/NaOH, stoppered, and shaken to preserve the dissolved oxygen in precipitate form. Samples were re-shaken immediately after all biogeochemical samples were collected, water-sealed and allowed to settle again to ensure that if any expansion occurred, no precipitate would be lost from the sample. The bottles were then moved to the temperature-controlled (21.5-25°C) oxygen lab. All samples were analyzed onboard within 24 hours of collection.

Analysis at sea

All samples were analyzed by Mark Belton (DFO-IOS) on the Scripps Institution of Oceanography (SIO) Winkler-based UV titration kit B. Refer to previous years' reports for system details.

Blank and Standard Preparation

Blanks and standards were run just prior to sample runs every day. A dedicated Dosimat was used to accurately dispense either 1.00 mL of KIO_3 for blanks or 10.00 mL of KIO_3 for standards. Blanks and standards were always prepared in ultrapure deionized water and were run in sets of 4 with the criteria that 3 out of 4 titers had to agree to within 0.0003 mL. Generally, this was easy to achieve; only occasionally did an additional set of standards or blanks need to be run. Variability in reagent dispensing was likely the primary cause of poor blank replication as the 2nd titers were generally more consistent. Blanks were not always run with every standard set if no reagent changes had occurred in the interim. The temperature of both the standard and the thiosulfate were recorded by the program and used to correct the delivered mass of both reagents to 20°C in order to calculate the Thio titrant normality.

Analytical Procedure

Prior to analysis each day, the UV light source and stir plate were turned on and allowed to warm up and until stabile. The water bath, which holds the sample flasks, was drained, cleaned and refilled with fresh deionized water to ensure good light transmission. The Dosimat lines leading from the Thio and KIO_3 bottles were checked thoroughly for bubbles and were purged as needed. The bottle top dispensers connected to the three reagent bottles and the Dosimat burettes were primed prior to dosing. Stirring was optimized to ensure rapid mixing without drawing bubbles into the light path.

Following the standardization procedure described above, the sample run was started. Sample flasks were inspected for bubbles and the water seal was removed from atop the stopper. A 1.0 mL aliquot of sulfuric acid and a stir bar were added to the flask, which was then placed inside the water bath. The Thio burette dose tip was inserted into the flask and the titration initiated until endpoint was reached. The two options at the end of every sample run were either "FINISH SAMPLE", which displays the dissolved oxygen (DO) value and resets the Thio burette, or "OVER-TITRATE" (OT), which allows one to salvage a bad titration curve (or an over-shot endpoint) by adding 1.0 mL of KIO_3 standard and re-titrating the sample. The amount of Thio needed to titrate 1.0 mL of KIO_3 is then subtracted by the software from the final titer. After every sample, the DO value was noted on the rosette log sheet. All endpoints were inspected for accuracy and either over-titrated, or had corrected titers determined after the fact by the "O2CHECK" function of the LVO2 software. These updated titers were then entered into the "Recalculations" tab of the dissolved oxygen spreadsheet so that new DO values could be calculated using the relevant flask volume and standardization parameters.

Thio normality

Two batches of Thio (#2402, #2403) and three batch of KIO_3 standard (#2402, #2403, #2404) were used during the cruise and the stability of the Thio for both batches had a maximum change of 0.00029 N, with the noted exception that two standardizations were omitted due to the occurrence of a leaky piston on the Thio burette; one standardization was definitely effect and the other possibly and thus discarded.

Precision and Accuracy

Of the 1114 unique samples collected during the course of this survey, 123 were collected in duplicate. Of the replicated samples, the first replicate was always chosen as the Final DO value except when a problem was noted with it during analysis (i.e. sample redrawn due to bubble addition during fixing). The precision of the dissolved oxygen replicate measurements had a pooled standard deviation (s_p) of 0.005 mL/L after the removal of 3 outliers by the Chauvenet's criterion. Four duplicated were removed from the study due to analysis problems resulting from a leaky piston.

Accuracy is much harder to assess than precision but the stability of the deep water (>3000m) DO content in the Canada Basin can act as a proxy reference standard. Although this value has been decreasing over the course of the JOIS program, starting in 2003, and can't be assumed to be completely constant, it has generally been stable over the past decade with an average of 6.53 ml/L (Figure 1). The 2024 value was 6.525 +/- 0.019.

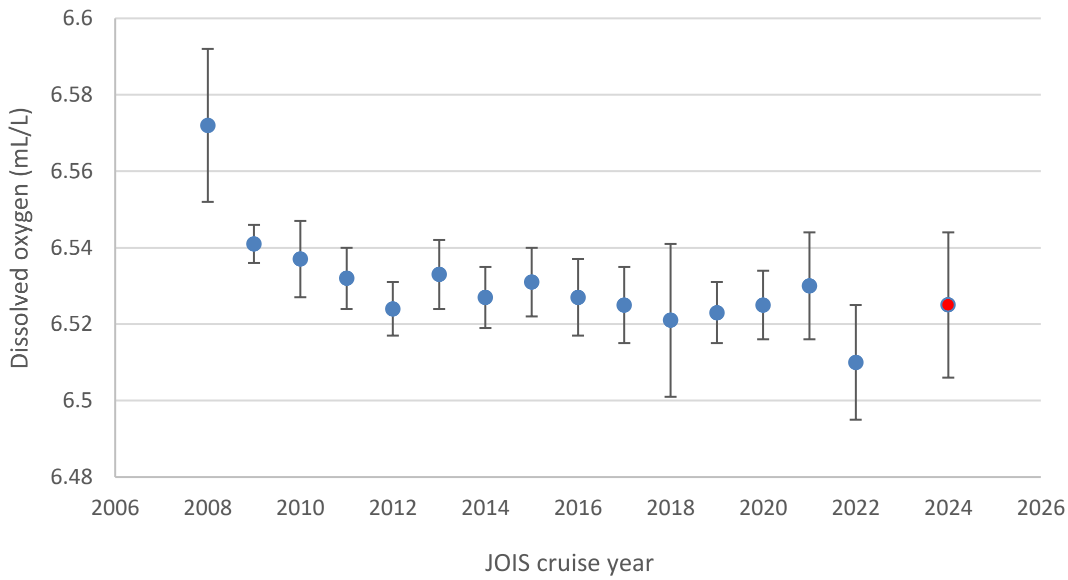


Figure 11. Mean annual dissolved oxygen concentration (mL/L) for the Canada Basin reference stations at all depths below 3000m. Error bars represent standard deviations.

Issues during sampling and analysis

There was a problem with establishing communication between the instrument and the computer via a serial to USB adapter. Although three different serial-USB adapters were tried none of them had the correct drivers installed on the computer. Eventually a driver was downloaded and installed from the internet for a 'keyspan' adapter. Applicable drivers could be organized into a folder on the desktop for reinstallation as drivers often have a way of disappearing.

There was a problem during setup with the primary 1mL dosimat/exchange unit. During flushing the dosimat and the computer indicated volume being push through the system however, the piston on the dosimat was not moving. The primary 1mL exchange unit #2 was replace with the backup #12 and the top of the dosimat was thoroughly cleaned to remove any grease, etc. The new exchange unit docked and functioned.

On occasion titrations would begin with a flat looking curve when displayed (> 1.6V) and not increase in voltage as dosing proceeded. Another, type of curve would occasionally result with the titration not being displayed until near the end point (ie. Close to 2.5V). I suspected that this may have been a result of slow mixing as titrant was added as it occurred usually during running standards/blanks. The stir bars in the standards flask are round as opposed to the triangle shaped stir bars for samples. The round stir bars require a faster stir rate and the triangle shape a slower stir rate. This is however, only speculation, but better titrations seemed to occur when the rate was increased for the round stir bars.

There was a problem with bubbles periodically being drawn up through the tubing coming from the Thio reagent as titrations proceeded. It was found only after tightening the tubing on top of the bottle extremely tight that the problem was relieved.

Some variability developed on running standards towards the 12th and particularly the 13th of September. It was hoped that after a standard change this might relieve the problem as nothing appeared obviously wrong with the system. Following a standard change on the 14th and some reproducible results analysis proceeded. There was some thought to run standards less frequently as a lot of reagent was being used for trouble shooting and thus on the 15th sample analysis proceeded using the standardization from the 14th. During analysis it became evident there was a leaky piston problem with 1mL Thio burette as condensation and liquid was observed below the piston head. Because there were issues with the primary 1mL exchange unit rather than swapping the exchange units the piston on the backup (#12) was replaced with a spare piston. The new piston fit much more tight into the burette (the replaced piston was quite loose and apparently worn out?). There was some trouble re-docking the exchange unit onto the dosimat and it was only after successfully docking the exchange unit on the backup dosimat (and removing) that it was able to successfully dock onto the primary dosimat. Having discovered this problem, I decided to re-run standards as the previous set may have been affected by this leaky piston (despite consistent dosing at the time – bad luck that this occurred during a Thio change). The newly run standards were much different (than the last) and reconfirmed later in the day and of course subsequent days (found to be very consistent after this). As a result, samples run on Sep 13th (with variability in the standardization that day – potentially a problem with that leaky piston) were recalculated with standardization from Sep 12th and samples run on Sep 14th and 15th were recalculated using the standardization following the piston change that showed consistent results for the rest of the cruise.

Throughout the cruise there appeared to be phases of less than ideal precision. This could have been a results of 1) leaky piston head mentioned above 2) poor sampling/pickling technique 3) sampling tubing seemed a bit worn out and catching bubbles during flask filling (sometimes difficult to spot). Possibility 1 was addressed above, possibility 2 was communicated to watch leaders and samplers/picklers with further training, possibility 3 was addressed by changing sampling draw tube, however this did not appear to change things either way. At the end of the day the precision for the cruise more or less fell within historical norms.

The last day of analysis the gain on the detector was turned up to maximum in order to achieve ~2.5V indicating perhaps the UV lamp is getting exhausted.

Future Recommendations

1. Have drivers/software in an easily located place on the desktop for future users.

2. Annually replace the pistons for the exchange units (not sure if the 1mL wears out more often?). I had this same problem in 2016. It is not the easiest problem to diagnose as the burette is amber coloured and the thermistor can block view of the chamber below the piston to see liquid or condensation develop. I was aware of this potential problem, was looking for it and feel I was still a bit late in observing it; having a Thio change at an inopportune moment didn't help either.

3. Can something be done to prevent/reduce leaking on the botte top dispensers?

4. Replace the UV lamp – gain has to be turned all the way on the last day.

5. There was some issues with dosimat/exchange units not docking easily or not working well together. Are these instruments getting old or require some maintenance to function more robustly?

6. Could or should a fifth bottle of standard be sent out? I feel there is lots of Thio but maybe a little bit limited on standard? Admittedly I probably changed out standard more often than necessary (could have stayed with the same bottle longer), however, with flushing, standards, blanks, over-titrations, more flushing I feel ~ 100mL could be used daily. A bottle has ~ 900 mL and should probably be changed out with no less than 200 mL so that makes it good for 1 week with daily standardization. On a four week cruise that takes all four bottles. An additional bottle would help if there is a lot of trouble with priming or other troubleshooting. At one point I felt I should budget my standard but also wanted to use lots to confirm stability during troubleshooting.

3.2.2 Dissolved Inorganic Carbon

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

Sampling

Seawater was transferred to a glass 250 mL reagent bottle following the collection of dissolved oxygen samples. The sampling tube was connected to the spigot of the Niskin bottle and, by holding the tube above the spigot, was rinsed by flowing approximately one tube volume of sea water through the tube. Any trapped air bubbles were removed by tapping or squeezing the tube. The bottle was filled smoothly from the bottom (tubing touching the bottom of the bottle) and the bottle overflowed by two times its volume. The tubing was withdrawn to the neck and the spigot valve closed or the flow in the tubing squeezed off before the tubing was removed from the bottle. One percent of the stoppered sample volume was removed to leave a headspace (about 1 % of the bottle volume - i.e., 2.5 mL for a 250 mL bottle) by inserting a nylon plug into the bottle. All samples were analyzed on the ship using VINDTA 84 and a coulometer 5017O. DIC, then alkalinity were measured from the same sample. A total of 787 samples were collected, of which 61 were in duplicates.

Analysis

Samples were analyzed by Marty Davelaar and Mackenzie Mueller, while on the voyage, using a VINDTA 3D - analysis system to determine the concentration of dissolved inorganic carbon (or total carbon dioxide). The VINDTA (Versatile Instrument for the Determination of Titration Alkalinity) is a sea-going, computer-controlled automated dynamic headspace analysis, constructed in Kiel Germany by Ludger Mintrop of Marianda Instruments. The VINDTA uses a Windows based PC and LabView software along with a coulometric detector (UIC Coulometrics, model CM 5017O). The VINDTA dispenses and acidifies a known volume of seawater, strips the resultant CO_2 from solution, dries it and delivers it to the coulometric detector.

At the start of each day, seawater was run through the system to condition the cell. Next a system blank is started. If the blank is below 0.50 □g Carbon or approximately 360 counts in a ten-minute period a Dickson CRM sample is analyzed to confirm the system is working properly. For each analysis (standard or sample) a peristaltic pump is used to pull the sample out of the bottle and into the water-jacketed calibrated pipette. The water from the pipette is then forced into a scrubber compartment with UHP nitrogen to which approximately 0.5 mL of 8.5 % ortho-phosphoric acid had been added. UHP nitrogen is then pushed through a bottom mounted frit, the nitrogen pushes the CO_2 which has been stripped from the sample by the acid through a Peltier cooler and an Orbo-53 tube which are used to keep water vapor and impurities from entering the cell where the CO_2 is titrated The coulometer was operated in the counts mode. The software then uses the counts total along with the pipette's temperature, the salinity of the water and other constants to calculate the μmol/kg value of each sample. At the start of each sample or standard, the system is rinsed twice with the sample being analyzed and a system clear check is performed to ensure there is no CO_2 in the system. DIC values are not corrected to the CRM values

Problems and Solutions

System endpoint was not reached on some titrations near the end of the cruise, most likely due to a damp Orbo-53 tube.

Precision, Standards, and Blanks

Chemistry Sample	Precision (s_p) umol/kg	Units	Number of Replicates (*n*)	Outliers removed	Minimum Range Umol/kg	Maximum Range Umol/kg	
DIC	1.85	µmol/kg	59	2	1740.56	2240.44	

Table 3. The accuracy of the DIC analysis was assured by daily analysis of certified reference material (batch #202, concentration of S=33.356, DIC=2043.33 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 1.85 µmol/kg, where n = 59 pairs after removing 2 outliers identified using Chauvenet criteria.

3.2.3 Analysis for Alkalinity

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

Sampling

During the 2024 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 701 samples were collected from Niskin bottles, 5 were lost. Of these, 63 samples were taken in duplicate. In addition, 24 samples from the TSG system and 2 samples from ice stations were analyzed.

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 (25 °C) at least 5 minutes before being analyzed. The total alkalinity was determined by potentiometric titration using 0.1N HCl using an open cell system ATT-05 or Scripps's alkalinity system (IOS-ID: 876-3) based on DOE (1994). 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. 85 mL 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.

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.

Problems

On September 5, alkalinity data became suspicious and system was changed from ATT-05 to 876-3. QF=4 was assigned to samples measured by ATT-05 on this day (station CB-18).

Precision and Standards

Chemistry Sample	Precision (s_p)	Units	Number of Replicates (n)
Alkalinity	2.06	µmol/kg	60

Table 4. Water Sample Precision

The accuracy of the alkalinity analysis was assured by daily analysis of certified reference material (batch #202, concentration of S=33.356, alkalinity=2215.13 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 2.06 µmol/kg, where n = 60 pairs.

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3.2.4 Stable Isotope of Dissolved Inorganic Carbon (δ^{13}C-DIC)

Tianyu Zhou (University of Delaware)

P.I.: Wei-Jun Cai (University of Delaware)

Overview

To better understand how the acidified Pacific Winter Water (PWW) accelerates the subsurface ocean acidification associated with anthropogenic carbon storage, we collected data of stable isotopes (δ^{13}C-DIC) in addition to the routine survey of biogeochemistry during BGOS/JOIS 2024. Such new observations will serve as a useful tool to distinguish the contributions of dissolved inorganic carbon (DIC) to PWW from air-sea gas exchange and organic matter remineralization. It will also provide more direct evidence that the remineralization of organic matter in the bottom water of the Chukchi/Beaufort Seas mainly contributes high DIC to PWW in the Canada Basin, and hence strengthens ocean acidification. In addition, we will also gain more insight into seasonal variation of oceanic carbonate chemistry, especially for the late growing season. Finally, observations of δ^{13}C-DIC will provide a baseline study for monitoring the long-term trends of anthropogenic carbon storage in the western Arctic Ocean.

Sampling and Analysis

A total of 948 samples were collected from 46 stations, with the sampling procedures following DOE (1994). All samples were collected from Niskin bottles into 250 mL borosilicate glass bottles and preserved with 100 µL $HgCl_2$. During sampling, the sampling tube was connected to the spigot of the Niskin bottle and, by holding the tube above the spigot, was rinsed by flowing approximately one tube volume of sea water through the tube. Any trapped air bubbles were removed by tapping or squeezing the tube. The bottle was filled smoothly from the bottom (tubing touching the bottom of the bottle) and the bottle overflowed by two times its volume. The tubing was withdrawn to the neck and the spigot valve was closed or the flow in the tubing squeezed off before the tubing was removed from the bottle. One percent of the stoppered sample volume was removed to leave a headspace (about 1 % of the bottle volume - i.e., 2.5 mL for a 250 mL bottle) by inserting a nylon plug into the bottle. Grease was applied around the ground glass stopper. The stopper was inserted completely and twisted to squeeze the air out of the grease to make a good seal. Finally, a rubber band and a clamp were used to positively reinforce closure, then the bottle was inverted several times to disperse the mercuric chloride solution thoroughly. All samples were stored in a 4ºC science fridge and will be shipped back to University of Delaware after the cruise. δ^{13}C-DIC will be analyzed using a Picarro-based δ^{13}C-DIC analyzer (Su et al., 2019; Deng et al. 2022).

Accuracy

Of the 948 samples collected during this survey, 73 were collected in duplicate. The precision of analysis will be evaluated by the results of the duplicated samples. Based on previous practices both in the lab and on board, the analytical precision is better than ±0.05‰. We will ensure the accuracy of the analysis by calibrating against 2-3 $NaHCO_3$ internal standard solutions and comparing with selected samples analyzed at the UC Davis Stable Isotope Facility. DIC Certified Reference Materials (CRMs) will also be used for quality control purposes.

References

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3.2.5 Colored and Fluorescent Dissolved Organic Matter Sampling

Céline Guéguen, Magali Pucet, Margot de Mecquenem (USherbrooke)
P.I.: Céline Guéguen (USherbrooke)

Overview

Colored and Fluorescent Dissolved Organic Matter (CDOM and FDOM) samples were collected for Céline Guéguen (USherbrooke), following the protocol given below. A total of 502 samples were collected at 45 stations and 48 from the underway seawater loop system between September 01st and September 23rd, 2024 on board the CCGS Louis S. St-Laurent during the Joint Ocean Ice Study-Beaufort Gyre Observational System 2024.

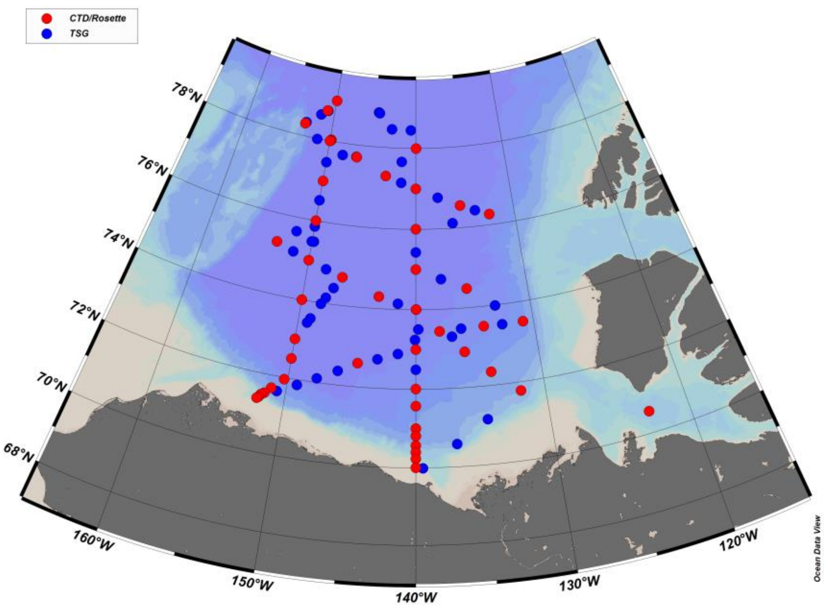

Figure 12. Map of the Canada Basin representing the sampling sites of the CTD/Rosette stations (red) and the loop samples (blue).

Rosette Casts Samples

Samples > 200m

The bottom spigot of Niskin was opened to allow stream of seawater to flush the 40 mL amber glass vial used for FDOM 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 2 depths (Surface 5m and 33.1) at CB11, CB09, CB08, CB03, CB04, CB07, CB02, CB02a, BL8, BL6, BL4, BL3, and BL2, for a total of 21 samples. The samples were acidified and solid phase extracted immediately after collection.

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.

Underway Samples and Under Ice Samples

Three (3) 20L water samples were collected from the underway system for lignin phenol analysis before arriving at IB01, IB02, CB12, and CB10. The samples were acidified and solid phase extracted immediately after collection.

Forty eight (48) FDOM samples were collected from the underway system while the ship was steaming, generally at XCTD sites. Seawater from the TSG outlet was used to flush the 40 mL amber glass vial used for FDOM sampling. Vials and caps were rinsed 3X with sample before collecting the actual sample. Upon collection of each sample from the underway system, FDOM sensor reading (volts and counts), latitude, longitude, UTC time, sample ID etc. was noted. Samples for nutrients, salinity, and chlorophyll were collected once a day to post-calibrate the sensor.

The University of Sherbrooke real-time FDOM sensor was tested and compared to the old one.

Storage

After collection, FDOM samples were analysed onboard within 12h of collection.

The DOM and Lignin-Phenols extracts were stored in the -80°C freezer and transferred to the University of Sherbrooke for analysis.

A selection of FDOM samples were kept in the fridge (4°C) and will be transferred to the University of Sherbrooke for CDOM analysis.

3.2.6 Barium

Celine Gueguen, Magali Pucet Margot de Mecquenem (USherbrooke)
P.I.: Celine Gueguen

Background

Barium is naturally released from rocks during the weathering process and is dissolved in river water. The naturally occurring concentration of barium in North America is higher than in Eurasia resulting in different concentrations in rivers from the two continents. When studying the source of fresh water in the Arctic Ocean, the oxygen isotope ratio can identify river water from sea-ice melt, and barium can further distinguish which continent the river water is from (Guay and Falkner, 1998; Guay and Falkner, 1997).

Sampling

201 barium samples were collected along the BL and 140W lines, typically from 5m to salinity 33.1. Barium samples were drawn from the Niskin and filtered at 0.3um into small (~20 mL) pre-rinsed plastic vials. Once at room temperature the caps were retightened for storage until analysis back onshore.

Analysis

Barium concentrations will be determined at the University of Sherbrooke on an 7800 Agilent inductively coupled quadrupole mass spectrometer using isotope dilution. Briefly, 250 µL aliquots of sample were spiked with an equal volume of a ^{135}Ba-enriched solution (Oak Ridge National Laboratories) and diluted with 10 mL of 1% HNO_3.

References

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3.2.7 Chlorophyll-a

Paige Hagel, Sarah Zimmermann, Mark Belton, Mackenzie Mueller, Seth Fleming-Alho (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)

Onboard Sampling and Filtering

Chlorophyll-a was sampled from the upper 200m. Samples were taken in triplicates (A, B, and C) from the beginning of the cruise until September 19 (CB-21) at all geochemistry stations. Since chlorophyll analysis was run onboard this year, triplicates were taken so that Sample C could be analyzed onshore at IOS to a)have a backup sample if the onboard analysis was not of good quality and b) to confirm onboard and onshore analysis give the same value. Once enough chlorophyll data were analyzed that we had confidence in the onboard analysis through replicates and running a standard on the fluorometer, we no longer took triplicate samples. From September (CB-19) through the end of the cruise, samples were taken in duplicate (A/B).

In addition to the samples at geochemistry stations, 16 loop samples were taken, most in replicate (31 total).

Samples were drawn from each of the selected Niskins into pre-calibrated 530mL brown Nalgene bottles (calibrated at IOS in 2021 and 2022). Each bottle and cap was rinsed three times with the sample water. The bottle and cap were both filled and the cap quickly put on resulting in the fullest bottle possible.

The sample water was filtered immediately under low pressure onto ~0.7 µm pore size GF/F 25mm filters. If the samples could not be filtered immediately, they were kept cool and in the dark until filtered, and the time elapsed until filtered noted. Samples A and B were put in glass vials and stored in the -80°C freezer until they were analyzed onboard. Sample C was folded in half in another GF/F filter (90mm) and wrapped in foil, stored in the -80°C freezer, and brought back to shore for analysis.

Each sample took approximately 10-15 minutes to filter.

Chlorophyll-a samples were filtered by Jennifer Kosty, Seth Fleming-Alho, Ashley Arroyo, Paige Hagel, Tianyu Zhou, Margot de Mecquenem, Céline Guéguen, Mike Dempsey, Sarah Zimmermann, Yusuke Kohama, and Yukihide Ishiyama.

Blanks were prepared for each box of filters used. Two samples bottled were filled with artificial seawater, and two were filled with filtered seawater from the carboys. The filters from the blanks were placed in glass vials and stored in the -80°C freezer until analysis. Filtration of the “sample” and handling of the filter with filtered seawater was performed as usual.

Onboard Analysis

Chlorophyll-a analysis was performed in Lab B during 2024-011. The Turner Trilogy fluorometer (Arctic Group) was placed in a fume hood and under green light. The fluorometer was calibrated by Paige Hagel and Erinn Raftery on 2 May, 2024, and the following equations were determined for chl-a and phaeopigments:

- Primary stock solution = 3508.04 µg/L chlorophyll-a
- Chl-a (µg/L) = $0.000315*(1.696/(1.696-1))*(F_o-F_a)*(v_{ext}/v_{filt})$
- Phaeophytin (µg/L) = $0.000315*(1.696/(1.696-1))*((1.696*F_a)-F_o)*(v_{ext}/v_{filt})$

where F_o = initial fluorescence, F_a = acidified fluorescence, 0.000315 = path length, 1.696 = F_o/F_a = average tau factor from calibration standard curve, v_{ext} = volume extracted and v_{filt} = volume filtered.

Figure 13. Chlorophyll (and Ammonium) analysis lab

Extraction/Analysis

Samples were extracted in batches of ~ 24. Each sample was extracted in glass scintillation vials with 10.01 mL of 90% Acetone/10% double deionized water for 24 hours at -20°C and in the dark. One hour before sample reading, they were removed from the freezer and placed in the dark to equilibrate to room temperature. Filter blanks were treated the same as the samples.

Samples were transferred to new borosilicate test tubes before their initial reading (F_o), after which 1 drop of 1N HCl (Reagent grade) were added to the cuvette while sitting in the Trilogy fluorometer. The second readings (F_a) were recorded after one minute.

New borosilic test tubes were used for each sample to eliminate possible contamination with acid to the next sample.
Scintillation vials were also new, however they will be cleaned after use back on shore by soaking in hot soapy water, rinsed with hot tap water, double-deionized water and air dried.

Standards and blanks

Acetone blanks and two solid standards (one giving a low and one a high fluorometer readings) were analyzed at the start and end of each batch of samples

Liquid standards from Turner were run mid-cruise (date?? September) to check the calibration of the instrument.

Quality Control and Assurance measurements and precision

Low and high solid state standards were measured daily during analysis to track any drift in the system, and were stable throughout the analyses.
The precision was calculated as the pooled standard deviation (s_p) of the replicates.
Chauvenet criterion was used to identify outliers.

Chl a:	Sp was 0.011 µg/L, n = 270 after removing 2 outliers.
Phaeopigments:	Sp was 0.010 µg/L, n=265 after removing 7 outliers.

3.2.8 Bacteria Sample Collection

Céline Guéguen, Magali Pucet, Margot de Mecquenem (USherbrooke)
P.I. : Céline Guéguen (USherbrooke)

Sampling

Bacteria samples were collected at every station at select depths on all geochemistry casts. Flow cytometry (FCM) samples for bacteria were collected following the protocol given below. Samples were collected and processed alternately by Magali Pucet (USherbrooke) and Margot de Mecquenem (USherbrooke).

The sample depths were 5, 20, Chlmax, S=32.3, S= 33.1, S=34.4, Tmax, 1000, Bottom. Additional samples were collected along the BL and 140W lines to match the Ba sampling.

The same protocol (see below) used since 2013 was followed this year.

Methods

Sampling:

1. Take one sample from each Niskin bottle. Rinse scintillation vial three times with sample water before collecting actual sample into the vial. Please make note of approximate time elapsed between sampling and adding paraformaldehyde fixative (below).
2. Pipet 1.8 mL of raw seawater sample (now held in scintillation vial) into a 2 mL capacity cryogenic vial. This is done using 1 squirt of pipet set for 1.8 mL. Between samples, ‘clean’ pipet by drawing and tossing 2 squirts of the new sample, then use next squirt for the cryogenic vial. Use a new tip for each station.

Fixation:

1. Paraformaldehyde (PFA, 10%) stock solutions (10mL) are provided in manufacturer glass ampoules which must be kept at room temperature until use. The ampoules are best opened using the plastic breaking tool supplied. Transfer ampoule contents into a scintillation vial to facilitate pipetting. PFA solution, once opened, should be kept cold (4C) in a refrigerator, but NOT frozen in the freezer.
2. Under the fume hood, pipet 0.2 mL of 10% paraformaldehyde (PFA) into the vial using the eppendorf repeating pipet (repipet). Do this by immersing the tip of the fully-depressed repipet pipet into the PFA, draw up plunger to fill the barrel, and then dispense two times back into the PFA container to help remove bubbles and drips from the pipet tip. Next slowly pipet the set 0.2 mL into several of the vials, being careful not to let the tip touch the seawater, nor to make a big splash when the PFA is injected. When there is less than 0.2 mL of PFA left in the repipet, empty and refill the repipet. The repipet can be left with its tip on but cover with aluminium foil to prevent contamination.
3. Note on the repeating pipet settings: The new eppendorf pipet is set on #1 to deliver 0.2mL and uses the blue labeled pipet tips. The old black repeater is set on #2 to deliver 0.2mL and uses the other tips.
4. Cap each vial using the threaded-screw cover.
5. Vortex mix the vial, and let it stand at room temperature for not less than 10 minutes.
6. Place the vial into storage box directly into the -80ºC freezer and leave onboard ship for offloading in St-John’s NL.

7. Log samples taken in logsheet recording cast number, niskin number and approximate time between sampling and adding fixative.

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

Mike Dempsey, Paige Hagel (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)

Overview

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 (rain, snow) than in the source water (i.e. seawater). Sea-ice formation and melt on the other hand, does not changes the source water's $^{18}O/^{16}O$ ratio (noted as $\delta^{18}O$) by much. 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.

Sampling

Samples for $\delta^{18}O$ were collected at all geochemistry stations, typically from 5 to 550 m depth. At the select stations, full depth profiles were collected. Samples were collected into 25 ml glass vials (with Phenolic PTFE/14B Rubber caps) after 3 rinses with sample water. Once at room temperature, the caps were retightened, secured with parafilm, and the vials inverted for storage. Samples will be analyzed with a Isotope Ratio Mass Spectrometer connected to a H_2O-CO_2 equilibration unit.

3.2.10 Nutrients

Sarah-Ann Quesnel (DFO-IOS)
P.I.: Bill Williams (DFO-IOS)

Sampling

Seawater samples for nutrient determination were collected at every station and depth into new 15 mL polystyrene tubes with no filtering after the tube and cap had been rinsed three times with the sample water. A total of 1124 samples were collected, of which 124 were in duplicate. At each station, 2 sets of samples and their duplicates were collected; one set of sample was analyzed onboard within 12 hours of collection, while the other set was frozen at -20 °C for later analysis, if required.

Additional samples were analyzed: 15 samples from the seawater loop system were collected in duplicate, and analyzed within 12 hours of collection.
A total of 64 samples were re-run onboard, after QA/QC processing to ensure the feature observed was real or not. Frozen replicates were thawed at ~45-50°C for 30 min, and let cool to room temperature before being analyzed.

Standards, reference material samples and reagents

Primary stock standards of nitrate (nitrate + nitrite, NO_3, phosphate (PO_4) and silicate (SiO_4) were prepared onboard from pre-weighted dry salts and were calibrated against Kanso certified reference materials lot CO (see table below for certified values). The primary stock standards were prepared in Milli-Q water, using pre-weighted high purity grade dry chemicals (Fluka puriss. grade for sodium hexafluorosilicate, and Fluka ultra p.a. for potassium nitrate and potassium phosphate monobasic), and grade "A" volumetric flasks, according to Barwell-Clarke and Whitney (1996).

A set of 5 working standards, were prepared daily from the primary standard solutions, using freshly prepared 3.4% sodium chloride/0.02% sodium bicarbonate solution and calibrated electronic pipette. Concentrations of the standards were selected to bracket the expected nutrient levels in the samples (NO_3: 0.00 to 23.11 µM, SiO_4 : 0.00 to 47.90 µM and PO_4: 0.000 to 2.433 µM).

For quality assurance and quality control purposes, Kanso certified reference material (CRM), lot CH and CR, deep water reference (DWR), medium check (2nd lowest working standard) and drift cup (D) samples were analyzed at the beginning, between stations and at the end of a day's run.

Table 5. The KANSO CRM values, at 25°C:

KANSO	Nitrate + Nitrite	Silicate	Phosphate
Lot CH	17.54 µmol/L	30.57 µmol/L	1.201 µmol/L
Lot CR	6.58 µmol/L	14.34 µmol/L	0.403 µmol/L

Onboard DWR samples were collected from station CB-18, cast#10, at 3687 db depth (sample #193). Water was collected into a carboy after 3 rinses, mixed well and sub-sampled into new polystyrene tubes, frozen at -20°C, and thawed as required in ~45-50°C water.

Reagents were prepared onboard, as required, using ACS grade, or better, dry chemicals (pre-weighted at IOS in April2023 and April 2024), and water from onboard Milli-Q Direct 8 water purification system that produced 18.2 mΩ-cm resistance Type I reagent grade water. The system was supplied with the ship's distilled water. New cartridges and 2 new pre-filters were installed before the Milli-Q Direct 8 system. In addition, the RO membrane was sanitized according to manufacturer' protocol with Cl2 tablet. This year we will leave the water system on until next field season, to ensure no bacteria starts growing on the RO membrane and within the system' plumbing.

Sample Analysis

Unfiltered nutrients (nitrate + nitrite , silicate and phosphate) samples were analyzed within 12 hours of collection by Sarah-Ann Quesnel onboard using a three channel Seal Analytical nutrient Auto-Analyser 3 High Resolution (AA3-HR), following the methods described by the manufacturer.

A 34 g/L solution of sodium chloride, 0.2 g/L sodium bicarbonate (Sigma, BioXtra grade) was prepared, as needed, and was used to rinse the system between samples, prepare the working standards and as the blank samples. The platen tubing was changed on September 21st, 2024. The cadmium column for nitrate analysis was changed as required to maintain the reduction efficiency greater than 96%, which occurred on a couple of occasions when air passed through the column.

At the beginning of each day, the AA3 was allowed to equilibrate for at least 60 minutes, with reagents and wash solutions connected to the platen tubing. Nitrate, phosphate and silicate were analyzed simultaneously with the AA3. A typical sample run would consist of a drift cup, carryover cup, 5 point standard curve, a set of reference material, a set of cadmium column recovery samples, blanks, followed by a station's samples and it's replicate. If multiple stations were analyzed in the same day, a set of reference material (medium check, Kanso, DWR, and drift cup) would separate each station. A set of reference material were analyzed at the end of a day's run, along with a second set of cadmium column recovery check samples. After each run, wash solutions were run through the system for cleaning the system for roughly 15 minutes, followed by ~30 min Milli-Q water. Data were logged digitally using the AACE software provided with the AA3 system. The software calculated all standards, reference materials and sample concentrations, correcting for drift, carryover and baseline. When the nitrate level in surface samples was the same or slightly lower than the sodium chloride solution it was reported as zero.

Precision, Accuracy and L.o.Q.

The precision was calculated as the pooled standard deviation (s_p), with outliers rejected by the Chauvenet statistic, and the values for the different sets of samples are given in Table 2 below.

Chemistry Sample	Units	Min Range	Max Range	L.o.D	Precision (s_p)	# Replicates (n)	Outliers removed	Accuracy (% recovery)
Nitrate (fresh)	mmol/ m^3	0.00	18.91	0.07	0.04	225	9	98.4-100.3
Silicate (fresh)	mmol/ m^3	1.33	47.06	0.04	0.03	220	14	97.3-99.2
Phosphate (fresh)	mmol/ m^3	0.377	2.034	0.015	0.005	223	10	97.9-100.2

Table 6. Water Sample Precision, L.o.D. and accuracy summary.

The accuracy of nutrient analysis was assured by daily analysis of Kanso CRM for Nutrients in Seawater (RMNS) (batch CH, NO3: 17.54 µmol/L, SiO4: 30.57 µmol/L; PO4: 1.201 µmol/L, salinity: 34.991 PSU).

Corrections were applied to the samples as follows:

$$[\text{sample}]_{corr} = [\text{sample}]_{uncorr} \text{ X } \frac{[\text{Kanso CRM}]_{exp}}{[\text{Kanso CRM}]_{daily\ avge}}$$

Where,

$[\text{sample}]_{corr}$ = corrected sample nutrient concentration
$[\text{sample}]_{uncorr}$ = measured, uncorrected sample nutrient concentration
$[\text{Kanso CRM}]_{exp}$ = expected Kanso certified material nutrient concentration
$[\text{Kanso CRM}]_{daily\ avge}$ = daily average measured Kanso certified material nutrient concentration.

A total of 76 each Kanso certified reference material Lot CH and CR were analyzed to ensure accuracy.

The limit of quantification was calculated as10 times the standard deviation of 10 samples consisting of NaCl/NaHCO3 spiked with 3 mL of standard 4 solution plus 3 times its standard deviation, and were 0.03 µmol/L for NO_3, 0.03 µmol/L for SiO_4 and 0.008 µmol/L for PO_4.

Problems and Solutions

General Issues

On the last few days, phosphate showed a significant upward drift, more than usual. Reagents were re-made, pump tubing changed and longer wash cycles at the end of the run, to try to fix the upward drift but nothing worked.
However, the AACE software corrected the data appropriately as seen in low %CV (<1) of the check samples.

Figure 14. Nutrients analysis on the AA3. Photo by Fred Marin, 2019, but similar set up for 2024.

3.2.11 Ammonium

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

Sampling

Ammonium samples were collected for the LSSL 2024-011 program along the Barrow (BL) shelf line and the Mackenzie River (MK) shelf line.

Ammonium samples were collected by Sarah Zimmermann (DFO-IOS) and Paige Hagel (DFO-IOS), and ammonium concentrations were measured by Paige Hagel with the help of Mark Belton (DFO-IOS) following the Holmes *et al.* (1999) protocol A (0 to 3 μM), modified for 40 mL sample volume. Samples of 40.5 (± 0.5) mL of seawater were collected into 50 mL acid washed clear glass test tubes, in duplicate, from 10 L Niskin bottles at each station. Sampling focused on the upper water column, from the surface to depth where Salinity = 34.4 PSU. Low ammonium seawater for blanks and standards (0 μM NH_4) was collected from the Tmax from stations CB4, BL8 and Stn A. Samples were processed onboard in Lab B between 30 minutes and 3 hours after sampling, by adding the working reagent (WR) to the samples. If samples were not spiked immediately after sampling, they were stored in a 4°C mini fridge in Lab B. After samples and standards had been spiked with WR, they were kept in a buckhorn container under the bench in Lab B to be protected from light exposure and kept at room temperature. A total of 182 unique samples were collected in duplicate (364 in total) at 15 stations and processed during the cruise along with 11 sets of standards.

Analysis

All glass test tubes and caps (plastic and liner-less were acid washed at IOS in June and packed with a small amount of 10% HCl before JOIS 2024. Tubes remained in the acid bath for a minimum of twelve hours. After removal from the acid bath, tubes were rinsed three times with Nanopure (DMQ), and 1-2 mL of HCl was added to each test tube. Tubes were then placed in Ziploc bags and stored in Lab B until use. Prior to sampling, the tubes were inverted, ensuring the entire tube and cap made contact with the acid. Tubes were rinsed three times with sample before filling. CB2a, BL8, BL6, BL4 and BL3 were all collected in HCl charged tubes, as well as the rack of standards that was run alongside the samples.

Samples from stations BL2, BL1, MK6, CB28b, MK4, MK3, MK2, MK1 and CB28aa and the corresponding standards were collected in WR charged tubes. After the analysis of samples, the sample and WR was kept in the tube. Following the same procedure as the HCl charged tubes, the WR-sample solution was inverted, disposed of in the Ammonium waste carbuoy and rinsed three times prior to collection. Both methods yielded good blanks.

During the 2024-011 cruise, samples and standards were prepared by adding 7.0 (±0.1) mL of working reagent (WR) to the sample, which was then left to sit in the dark for 6-8 hours at room temperature (~ 22 °C) in Lab B. After sitting for 6-8 hours, standards and samples were measured in Lab B with the Trilogy fluorometer and UV/CDOM module. Samples were sub-sampled into cuvettes before reading. The fluorometer was operated in UV mode with sensitivity calibrated depending on the expected range of sample concentration, having a range from 0.22 µM standard (s1) – 2.99 µM standard (s8). No samples had concentrations falling outside of calibrated standard curve.

Standard and Blank Preparation

Deep water for blanks and standards was collected from the Tmax (~400 m) from CB4, BL8 and StnA into acid-cleaned 4L amber bottles. The Low Ammonium Seawater (LASW) was kept in the rosette shack during ammonium sampling, and when not on the BL or MK lines, the water was stored in the fridge in Lab D. Two 4L bottles of LASW was used per line (BL and MK).

Two 4 L batches of the ammonium WR were prepared onboard the LSSL in St. John's during mobilization by Mike Dempsey.

One 4 L batch of the ammonium WR was prepared onboard the LSSL on 2024-011 by Paige Hagel.

All batches were tested prior to sampling. The first batch was not used.

The standard Ammonium Chloride solutions, primary (2499.48 uM) and secondary (174.96 uM), were prepared onboard by Paige Hagel on 9 September 2024.

11 sets of ammonium standards were prepared for each station, or group of stations, ranging from 0 µM to 2.99 µM using a 40 mL bottle-top dispenser and volume calibrated pipettes (S0: 0.00 µM, S1: 0.22 µM, S2: 0.44 µM, S3: 0.66 µM, S4: 0.86 µM, S5: 1.08 µM, S6: 1.30 µM, S7: 2.14 µM, S8: 2.99 µM).

During the cruise there were 11 standard runs in total, with an average r^2 value of all standard runs of 0.9956. The slopes of each linear calibration curve agreed well.

Problems & Solutions

Although the working reagent has been prepared pre-cruise in previous years, due to previous problems with the shipment sitting for weeks in the heat and resulting in a bad batch of WR, this year the working reagents were prepared onboard. Because ammonium sampling was not undertaken until the last week of the cruise, there was time to prepare a batch of WR in the weeks preceding sampling, in addition to the batches of WR Mike had made in St. John's during mobilization. With that being said, there were still problems with the sodium tetraborate dissolution. During mobilization, the sodium tetraborate took over 26 hours to dissolve in 30°C heat. During the cruise, the sodium tetraborate was left stirring for 3 days and still did not fully dissolve. It is believed that the solution was oversaturated and the remaining precipitate was decanted out. There were no apparent issues with the WR, however, in future years, consider dissolving in smaller volumes to avoid having a crust form.

As noted in previous reports, a possible contamination factor for Lab B is the washrooms down the hall. Similar to last year, the ship's crew was asked the not to use cleaning products which contain ammonia when cleaning the nearby washrooms, particularly during sampling/processing on the BL and MK lines. As well, the doors to both washrooms and Lab B were kept closed, and signage was posted to request that cleaning products containing ammonium not be used. Signage was also posted regarding smoking in/around/near the rosette shed.

Contamination appeared to be less of an issue this year due to the recommendations from previous reports. Specifically: adding 1-2mL fresh 10% HCl to each acid cleaned tube, shaking the acid in the tubes before emptying/sampling seawater (most importantly), and keeping lab B door for the duration of the BL and MK lines. Transporting samples from the rosette shack to Lab B in a buckhorn was also an effective method of transport. Dispensing LASW in the rosette shack and WR in Lab B was also effective.

3.2.12 Biotoxins

Mackenzie Mueller (DFO, IOS)
P.I.: Andrew Ross (DFO-IOS)

Sampling

Biotoxin samples were collected in 1L square plastic PETG bottles at select stations and depths. The sampling stations were: AG5, CB1, CB51, PP7, CB16, CB9, CB4, BL6, BL4, BL3, BL2, BL1, MK4, MK3, MK1 and CB28aa. Collection depths were at the surface, chlorophyll max and bottom at the majority of stations. At stations where the chlorophyll max was close to the surface, only surface was collected. Bottom samples were only collected along the BL and MK lines and at stations AG5 and CB51. Duplicate samples were collected at stations CB9, BL1 and CB28aa.

Following the rosette cast, water samples were collected from Niskin bottles. Biotoxin bottles were rinsed 3 times with sample water before filling. Sample bottles were filled to 1L using the graduation measure on the side of the bottle. Immediately after collection, samples were transferred to the lab for filtration. The approximate time elapsed from collection to beginning of filtration was noted on Biotoxin Filtration Record Sheet.

Filtration

Samples were filtered using a filtration apparatus (Fig 1.) connected to an electric vacuum pump. Pressure was set to 4 Hg and a 0.45um, 47mm MF-Millipore filter was used. Both filter and filtrate were collected. Filters were folded in half, placed into a sterile 5-mL Cryovial and immediately moved to -80C freezer. Filtrate was transferred into a sterile, square 1L plastic PETG bottle and were stored at -20C. Both samples were kept for later analysis on shore at IOS.

Each sample was expected to take 5-15 minutes to filter depending on depth and proximity to shore.

Biotoxin samples were filtered by Mackenzie Mueller and Marty Davelaar.

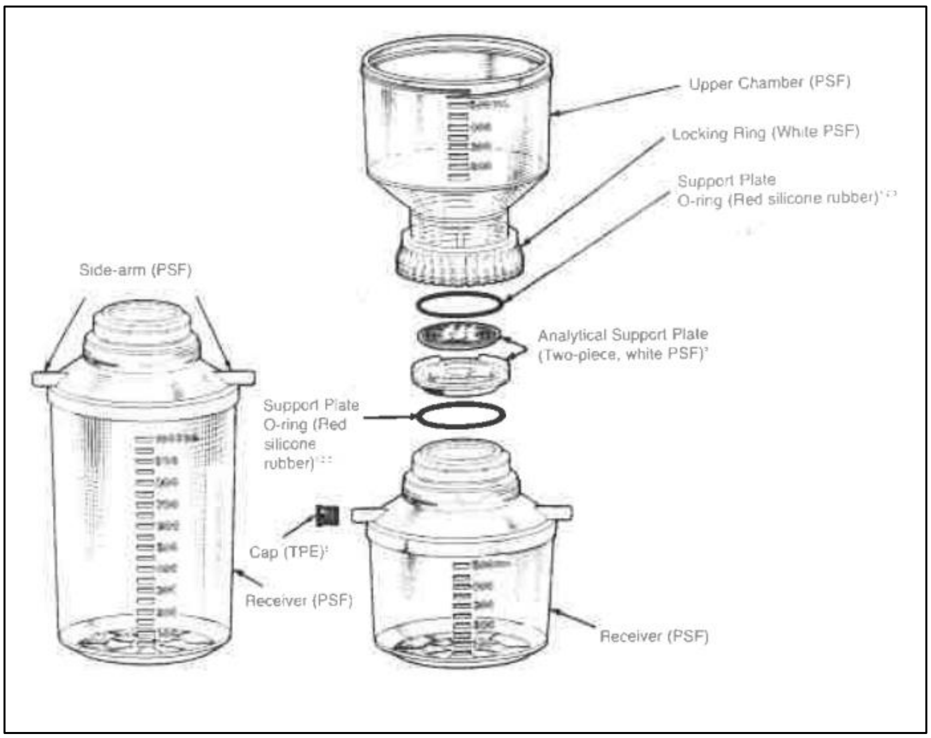


Figure 15. Diagram of Biotoxin filtration apparatus

3.2.13 Salinity

Paige Hagel, Seth Fleming-Alho, Mackenzie Mueller(DFO-IOS)
P.I.: Sarah Zimmerman (DFO-IOS)

Sampling

Salinity samples were collected from nearly all bottles on all rosette casts to be used for calibrating the CTD salinity and to verify Niskin sample was from intended location. Salinity samples were collected in 200 mL glass bottles sealed with disposable nylon inserts and screw caps. Approximately 10% of samples were collected in duplicate and stored in a separate case to be analyzed independently. Water samples were collected from Niskin bottles immediately following a rosette cast, after dissolved gas and other sensitive samples were collected. Salinity bottles and inserts were rinsed 3 times with sample water before filling. Samples were transferred to the temperature controlled lab for storage until they were analyzed onboard.

Analysis at Sea

All samples were analyzed onboard during the program. Samples were given time to reach room temperature before being run on the salinometer. The procedure followed is outlined in the standard IOS protocol for salinity analysis. Room and sample temperature was maintained consistently between 21°C and 24°C as much as possible.

An order placement system was established within the room whereby salinity cases were cycled in order to establish a constant sample temperature. This system ensured two things: 1) the analyst knew which case to begin with and the location of each subsequent case, and 2) each case was held at a stable temperature for an extended period of time before analysis. Bottles were inverted and mixed prior to analysis.

IAPSO Standard Seawater was measured before the beginning of every other day of analysis to standardize the instrument and identify drift or if the standby number changed by more than 2 units.

The standard water used was batch P166 (OSIL batch P166, expiry 6 April, 2025, K_{15} Value = 0.99987, Salinity = 34.995 PSU)

If the standard's conductivity ratio obtained was within ±0.0001 of the standard K_{15} value on the bottle, the value was accepted. If the value was greater, the cell was flushed and another reading was taken. If the ratio fell outside this range, the standardize dial was used to bring the conductivity reading back into specification.

Deep water reference samples (DWR, see below) were normally run at the beginning and end of each sample case (24 samples), or more often if deemed necessary to assess instrument stability.

Data are reported in practical salinity units (PSU; Lewis & Perkin 1978). **Error! Reference source not found.**Four sets of deep water reference (DWR) samples were collected throughout the cruise:

- DWR-CB50: CB50, Sample 121, 2925m, CTD = 34.954, WS=X
- DWR-CB9: CB9, Sample 505, 3781m, CTD=34.954, WS=34.955
- DWR-CB8: CB8, Sample 561, 3799m, CTD=34.954, WS=34.954
- DWR-CB27: C27, Sample 906 and 907, 3263m and 2566m, Blended water. CTD = 34.954 and 34.951, WS = 34.954 and 34.951.

To collect the reference samples, the remaining volume of each Niskin was collected into an 10L plastic carboy and mixed thoroughly before sub-sampling into individual 200 mL salinity bottles for storage and analysis as outlined above.

Precision is given by the pooled standard deviation (s_p) of sample duplicates and was 0.0020 PSU, where n = 210 pairs after removing 1 outliers identified using Chauvenet criteria.

Issues with Salinometer

On Sep 5th, during the first day of salinity analysis, the data logger was recording much too low salinities. The data logger software recorded temperature of tank as 20C when it had been at 24C. The hand recorded conductivity ratio values were used to re-calculate salinity and gave values that matched the CTD. Restarting software and reseating the data logger cables to the autosalinometer fixed the problem.
As in previous years the data logger software has an issue with files after ~100 or so reading. This required users to close and restart new files at regular intervals.

3.2.14 Iodine-129

Mike Dempsey, Paige Hagel (DFO-IOS)
P.I.: Nuria Casacuberta Arola, Annabel Payne (ETH Zurich)

Overview

Measurements of ^{129}I provide information about the spread and transit times of Atlantic-origin water labelled by discharges from European nuclear reprocessing plants. High concentrations of Iodineare expected in the mid-depth Atlantic layer, comprising Fram

Strait and Barents Sea Branch Water. Pacific-origin water (residing on top of the Atlantic layer) and old Atlantic water (deep and bottom waters) have very low concentrations of ^{129}I.

Sampling

Samples for ^{129}I were collected into 300mL plastic bottles after rinsing 3x with seawater from the Niskin. Caps were secured with parafilm or electrical tape. Samples were shipped to ETH Zurich, Switzerland, for analysis.
In total, 59 samples were collected at 4 stations.

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

Celine Gueguen,Margot de Mecquenem,Magali Pucet (Universite de Sherbrooke)
PI: David Walsh (Concordia University)

Introduction

Rising temperatures and atmospheric CO_2 are altering the ocean's chemistry and circulation, causing intense stress on the foundations of marine food webs such as microbes. The Arctic Ocean is experiencing fast environmental change brought about by a changing climate, leading to a decline in its ice cover. Our efforts to assess microbial diversity have shown that Arctic communities are altered by environmental change. This project aims to determine if the taxonomic changes in microbial assemblages observed in the Arctic are accompanied by genomic and metabolic changes which may potentially impact ecosystem functioning.

Methodology

This year we started the JOIS cruise from the South of the Beaufort Sea, in a counter clockwise direction in the Canada Basin starting at AG5. The JOIS cruise track followed a general path North following transect 140 W and proceeded west then south down transect 150 W. Beaufort Sea, in a counter clockwise direction in the Canada Basin. Surface water (5m), SCM (subsurface chlorophyll maximum), 20m, and Pacific Winter Water (salinity of 33.1) samples were collected at a total of 5 stations. The cruise proceeded in the order : AG5, IB02, CB9, CB4, and CB21. There is no PWW sample for AG5 station, it had been replaced by a Bottom-10 sample.

Seawater filtration

Stations AG5, IB02, CB4, CB9, and CB21 were designated as Meta stations, where a greater volume of water was collected for DNA/RNA extractions. Water was filtered first through a 3µm filter and then through a 0.22 µm filter. The first filter collected organisms greater than 3µm and that which filtered through was collected by the 0.22 µm filter. When all water had been filtered through the apparatus they were contained and preserved with RNAlater® solution and then stored at -80°C.

Single Cell Genomics

For each station and depth, 1.8 mL of sample were gently mixed with Glycerol-TE buffer before freezing at -80˚C for single cell genomic sequencing.

Additional Activities

Isolation Culture

At our most Northern and Southern Meta Stations (CB21, IB02), 1.5mL of seawater was collected from surface water (5m), 20m, SCM (subsurface chlorophyll maximum) and Pacific Winter Water (salinity of 33.1). Following this, 375µl of a 50% V/V glycerol/filter sterilized seawater solution was added to each vial and gently mixed; they were then stored in a cooling container at -80˚C.

3.3 Moorings and Buoys (Beaufort Gyre Observing System (BGOS) Cruise Report)

On board: Jeff O'Brien, Nico Llanos, Tim McDonough and Eric Trotto (WHOI), Mike DeGrandpre (U. Montana), and Mary-Louise Timmermans (Yale)
Other PIs: Isabela Le Bras (BGOS, WHOI), John Toole & Sylvia Cole (ITP/TOP, WHOI)

Summary

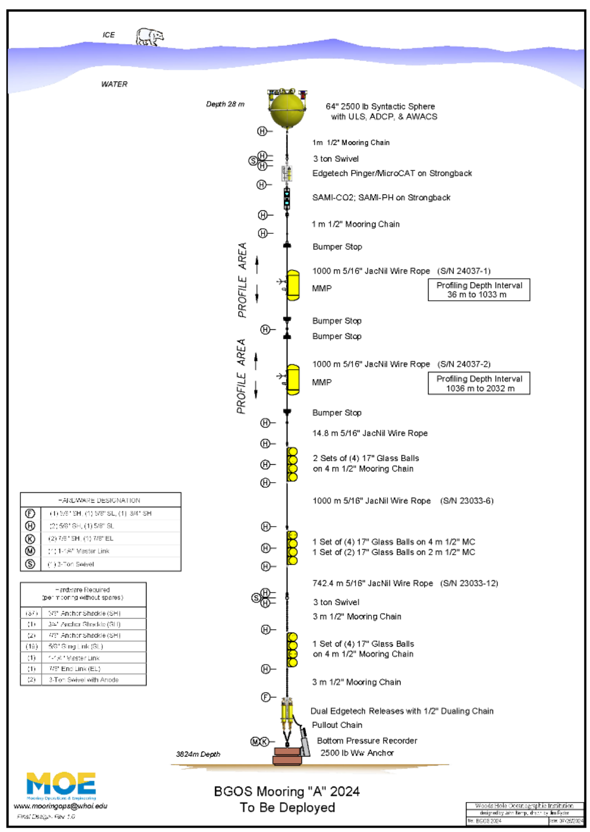
2024 operations from the CCGS Louis S. St-Laurent as part of the Beaufort Gyre Observing System (BGOS) included the recovery of three bottom-tethered moorings (deployed in 2023) and the deployment of three moorings at the same locations. Two ice-based observatories were installed, two Tethered Ocean Profilers (TOPs) were deployed in open water, and one Ice-Tethered Profiler (ITP) was deployed in open water. One ITP (surface float and package only) was recovered, and one complete TOP system was recovered. Additionally, we recovered a mooring (AON BS-3) off the coast of Utqiagvik that was deployed as part of another AON program (PI, Bob Pickart) but that could not be recovered earlier in the season due to heavy ice conditions in the vicinity of the mooring. Dispatches (by Ashley Arroyo, Yale) were sent daily and posted on the BGOS website. A summary of moorings and buoys recovered and deployed are listed in Tables 1 and 2, and descriptions of each activity are given below.

Table 7. BGOS mooring recoveries and deployments from CCGS Louis S. St-Laurent 2024. The mooring anchor was ranged on in the pre-recovery survey, but it was deemed not necessary to range on the acoustic pinger near the top of the mooring because all mooring recovery and deployments were in open water.

Mooring	Surveyed location (anchor*)	2024 Recovery	2024 Deployment	2024 Location (drop posn.)	Deploy bottom depth (m)
A	74 59.946 N 149 59.550 W *42 m from 2023 drop location	13 Sept. 13:50 UTC	14 Sept. 18:33 UTC	75 00.000 N 149 59.970 W	3825
B	77 59.999 N 150 00.034 W *10 m from drop	10 Sept. 14:55 UTC	12 Sept. 18:10 UTC	78 00.071 N 149 59.900 W	3828
D	73 59.989 N 140 02.853 W *24 m from drop	19 Sept. 14:49 UTC	20 Sept. 19:02 UTC	73 59.999 N 140 02.890 W	3527

3.3.1 Moorings

Bottom-tethered moorings have been maintained in at least three (up to four) locations under the BGOS program since 2003. The moorings and their nominal locations and deployment durations are as follows: Mooring A (75N, 150W; 2003-2024), Mooring B (78N, 150W; 2003-2024), Mooring C (77N, 140W; 2003-2008), and Mooring D (74N, 140W; 2005-2024). The moorings acquire time series at fixed locations of ice draft of sea ice



overlying the mooring, heat, freshwater, ocean currents, and sea-level variations, plus other properties. The top float is positioned about 30 m below the sea surface (see e.g., the schematic diagram [right] for Mooring A, deployed in 2024).

Instruments on each of the moorings are as follows: an Upward Looking Sonar (ULS) (i.e., Ice Profiling Sonar, IPS) sampling ice draft; an Acoustic Doppler Current Profiler (ADCP) sampling upper ocean currents; McLane Moored Profilers (MMPs, two on each mooring recovered and deployed in 2024) making profiles through the water column sampling ocean currents, temperature and salinity; a fixed-depth MicroCAT sampling temperature, salinity and pressure; a Bottom Pressure Recorder (BPR) sampling pressure fluctuations at the seafloor; and SAMI-CO2 and SAMI-pH instruments (University of Montana). In addition, moorings A and D include Acoustic Wave and Current Profilers (AWACs, University of Washington).

The vertically profiling MMPs sample conductivity-temperature-depth (CTD) and velocities in the water column from around 40-m depth to about 2050-m depth, making 2 profiles every two days.

Before each recovery, the mooring's location was determined precisely using Art Newhall's (WHOI) Acoustic Survey Software (available in MATLAB) to range on the releases at the bottom of each mooring. In 2024, all mooring operations were done in 0% or light ice cover and it was never deemed necessary to additionally range on the ELCAT acoustic pinger located just below each surface float. Recoveries in 2024 were all in 1-to-2-meter swell and the man basked was used each time to hook the surface float. Mooring recovery and anchor-first deployment operations are summarized by WHOI Technical Report 2005-05 (Kemp et al., 2005).

Data return from the recovered moored instruments was excellent. All units returned high quality data. The only record that was incomplete was from the MicroCAT on Mooring A, which had expired batteries (although each individual cell was tested prior to deployment); data were only returned for 46 days after deployment. The redeployment of this instrument was programmed for much more conservative sampling (every 2 hours instead of 10 minute intervals) to be cautious about battery use. We aim to have more spare MicroCAT units going forward. All other sensors on the moorings returned full records. Information on the SAMIs can be found in a separate data report.

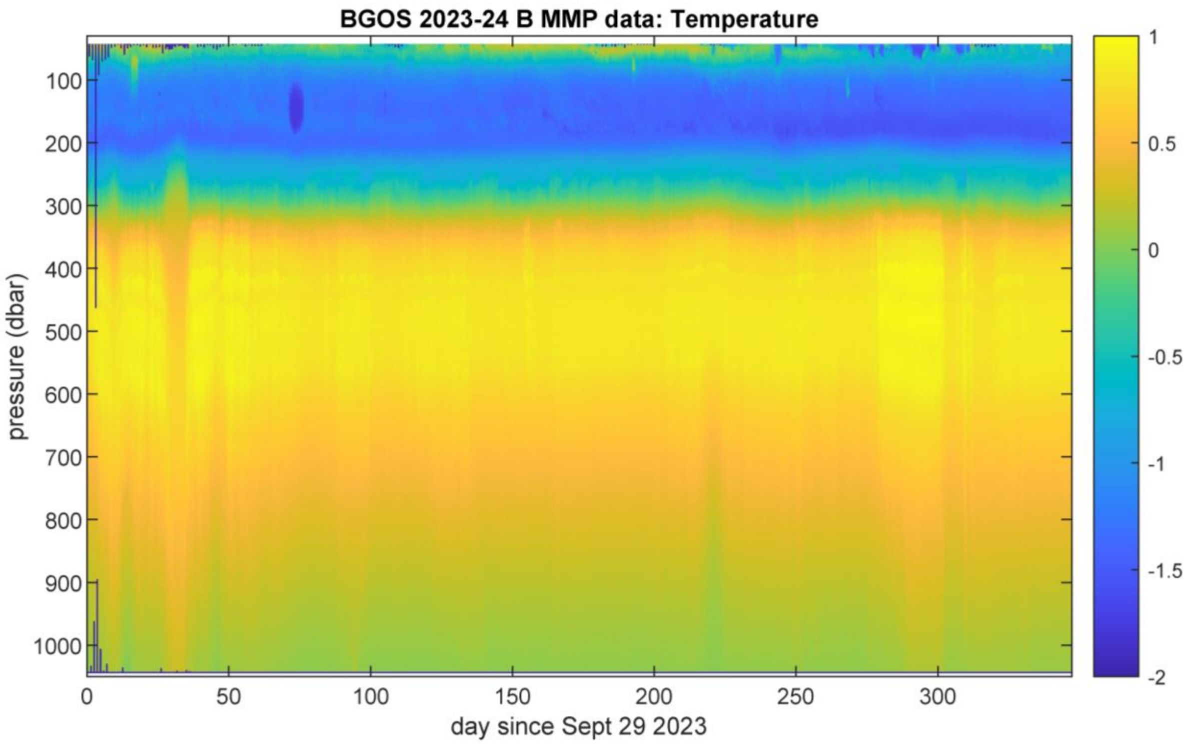


Figure 16. Data from the shallow MMP on BGOS Mooring B 2023-2024. Time-depth (m) section of temperature (ºC) over the course of the year-long deployment showing the rich variety of eddies and warm water layers.

Recovery of additional AON BS-3 (PI: Bob Pickart, WHOI):

Sept. 27, 2024 [71.4N, 152.0W], 145 m water depth:

Conditions at the start of this recovery were extremely foggy so it was deemed necessary to deploy the small boat (before release) as a backup in case we were not able get a visual on the surface float once released. We ranged on the mooring at 12:46 pm and its position was consistent with that given to us by Bob Pickart. At 1:20 pm, the mooring was released and the surface float was immediately spotted on the ship's radar. It was hooked from the small boat and the LSSL moved alongside. All components were on deck at 2:13 pm. The mooring had been deployed in near-coastal moorings for two years, and there was significant biofouling. A power washer (belonging to the ship) was needed for cleaning the non-sensitive parts of the instrumentation and mooring hardware, and all instruments were clean and secure in the forward hold by 3:17 pm. Only data from the eight MicroCATs were offloaded, and a full two-year record of data were recovered from each. The other instruments were left for offloading by Bob Pickart once they arrived back at WHOI.

3.3.2 Buoys

An important part of the BGOS program is the deployment of automated buoys, designed to drift with a host ice floe and return information about the upper water column, sea ice, snow and the atmosphere year-round and transmit data via satellite. Certain buoys can drift in open water as well as in ice. Six types of automated buoys were deployed during the 2024 expedition (**Table 2**):

1. Woods Hole Oceanographic Institution Ice-Tethered Profilers (ITPs), sampling temperature, salinity, and pressure (and sometimes dissolved oxygen) from ~5m to 760m depth (https://www2.whoi.edu/site/itp/)

2. WHOI Tethered Ocean Profilers (TOP), sampling temperature, salinity, & pressure (and sometimes velocity) from the ice-ocean interface to 200–750-m depth (https://www2.whoi.edu/site/itp/)

3. US Army CRREL Seasonal Ice Mass Balance Buoy (SIMB), sampling ice and snow thickness, temperature, and atmospheric pressure (https://www.cryosphereinnovation.com/). Two SIMBs (Dartmouth 2024 #6 & #7, in IBO1 and IBO2, respectively) were deployed.

4. Naval Postgraduate School Arctic Ocean Flux Buoy (AOFB), sampling turbulent ocean fluxes near the ice-ocean interface and met data (https://www.oc.nps.edu/~stanton/fluxbuoy/). One AOFB (AOFB 49) was deployed on IBO2.

5. Environment and Climate Change Canada (ECCC) MetOcean Telematics drifter buoys (MetBuoys), sampling atmospheric pressure and temperature. The following were deployed in 2024: IMEI 300534062598760 (in open water nearby IBO1); IMEI 300534062497970 (on IBO2)

6. OpenMetBuoy (OMB), measuring waves in ice and made in-house at the University of Tokyo (PI Takuji Waseda, deployed by his student, Yukihide Ishiyama; www.mdpi.com/2076-3263/12/3/110). The following were deployed in 2024: Iridium ID 211627 (IBO1); ID 212716 (IBO2).

Tethered Ocean Profiler and Ice-Tethered Profiler specifics:

A total of two ITPs were deployed during the 2024 expedition, ITP numbers 142 and 143. Each ITP system is configured to sample dissolved oxygen (with an O_2 optode), and each has a fixed-depth (5 m) SAMI pCO_2 with ODO and PAR sensor to sample upper ocean chemistry (CO_2, pH) and chlorophyll fluorescence. Four TOPs were deployed: TOP 13, 14, 12 and 15 (in order of deployment date). TOPV 12 and 13 each have RBR

CTD sensors and Nortek Signature 1000 current profilers to measure velocity, “V” (profiling up to 300-m depth). TOPs 14 and 15 each have D2 CTD sensors and thermistor chains along the length of their grounding poles; each can profile up to 760 m depth. ITP and TOP data are made available in real time at www2.whoi.edu/site/itp. As of this writing (September 24, 2024), ITP 142 is fully functioning and returning good data. The conductivity sensor on ITP 143 (deployed in open water) has issues, while temperature and dissolved oxygen look reasonable. All TOPs are returning good data. The newly implemented T-chain on TOP 14 (deployed in ice) is not returning temperature data from all notes, while the T-chain on TOP 15 is returning high-quality measurements in the atmosphere, and through the ice into the upper ocean. One ITP surface float and package (ITP 136) and one full-system TOP (TOP 6) were recovered.

Table 8. BGOS ice and open-water deployments/recoveries from CCGS Louis S. St-Laurent 2024. IBO = Ice Based Observatory; OW = Open Water deployment [all times local: local + 6 hrs = UTC]

Event	Buoy system	Date (2024)	Location	Ice thickness (m)
#1 Recovery 1	ITP 136	Sept. 5 09:10	76.025 N 132.34 W	N/A
#2 OW 1	TOPV 13	Sept. 6 09:40	77.23 N 143.17 W	N/A (open water)
#3 IBO 1	TOP 14 w. T-chain, SIMB 2024 #6, OMB + nearby o/w MetBuoy	Sept. 7 16:13	78 31.56 N 144 32.07 W	0.50 – 0.90
#4 IBO 2	TOPV 12, AOFB 49, ITP 142 w. O2 optode + SAMI, SIMB 2024 #7, OMB, MetBuoy	Sept. 8 17:24	78 43.55 N 150 43.47 W	0.50-0.60
#5 OW 2	TOP 15 w. T-chain	Sept. 9 18:17	77 43.90 N 150 00.00 W	N/A (open water)
# 6 OW 3	ITP 143 w. O2 optode + SAMI	Sept. 12 15:59	77 28.16 N 149 56.85 W	N/A
#7 Recovery 2	TOP 6	Sept. 14 16:36	75 44.12 N 150 24.25 W	N/A

Ice thicknesses (cm) at specific buoys: TOP014 = 90; SIMB #6 = 90; TOPV12 = 55; ITP 142 = 55; AOFB 49 = 50; SIMB #7 = 55 cm

Buoy Deployments & Recoveries

[*All times are given as local unless otherwise stated, where UTC = local + 6 hours.]*

#1, Sept. 5, 2024, ~ 76 N, 132.3 W; air temp.: -1ºC, winds: 2 knots; 0% ice; a little fog

ITP 136 Recovery. This ITP was deployed from the LSSL during the 2022 expedition (Sept 25, 2022 on a 1.2 m thick floe) and returned full profiles for nearly a year before it likely lost its profiling unit (it went up over the continental shelf around 77N, 130W, drifting together with TOP 5). It was still returning GPS positions, drifting approximately along route (16 nm south of station PP6), providing an opportunity for recovery. With hourly GPS locations, the buoy was located quickly at 8:15 am, drifting in open water in the fog. The surface float was lying on its side, confirming that the profiling unit and weight were missing.

At 8:53 am, the basket was sent over the side and the surface package was hooked. The surface package was still secured to the float with the red ratchet strap, but the surface float was delaminated around its middle (photo (b) below). Only about 20 meters of wire-rope was still there (Nico Llanos brought it on deck, hand over hand), frayed at the end. The surface float and package were on deck by 9:10 am, with the surface package in good condition, ready for refurbishment and redeployment on a future expedition.

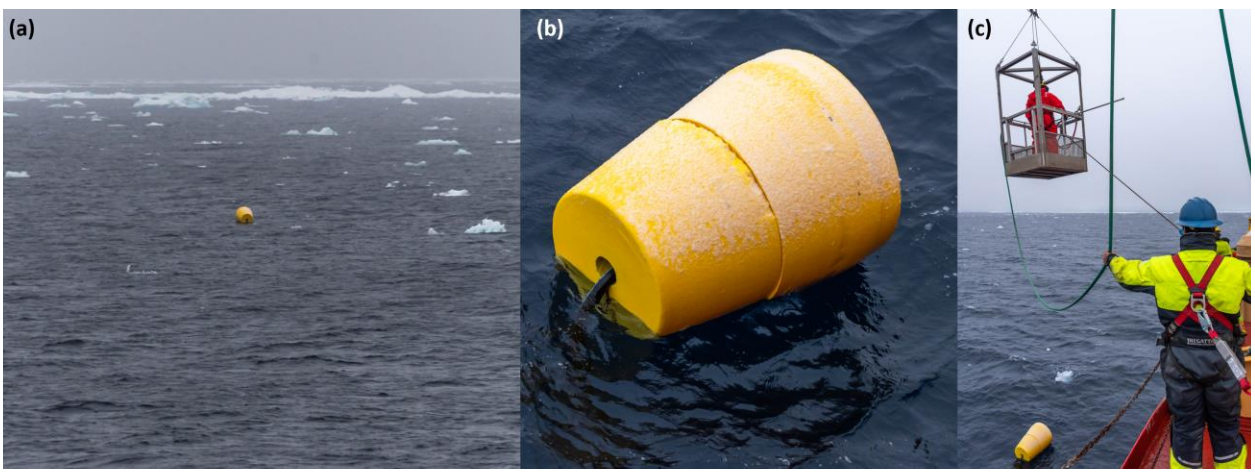


Figure 17. ITP 136 recovery: (a) The float is spotted in the distance; (b) The surface float had split down the middle; (c) Preparing to hook the surface package from the man-basket. *Photos by Gary Morgan, CCGS LSSL*.

<u>***# 2, OW 1, Sept. 6, 2024,** ~77N, 143W; air temp.: -0.5 ^oC, winds: 4 kn, o'cast w. light rain near end*</u>

TOPV13 open water deployment. This TOP samples velocity with the Nortek Signature 1000 current profiler (it has a fixed fin) and profiles to 300 m.

At 8:58 am, the fins and TOP profiling unit were clamped on, and weights attached under the A-frame, ready for deployment. At 9:03 the profiler was over the side and wire was out. The grounding pole was inserted at 9:38 and at 9:40 the system was released from the ship. The surface float bobbed upright with no listing, sitting around 12" into the water.

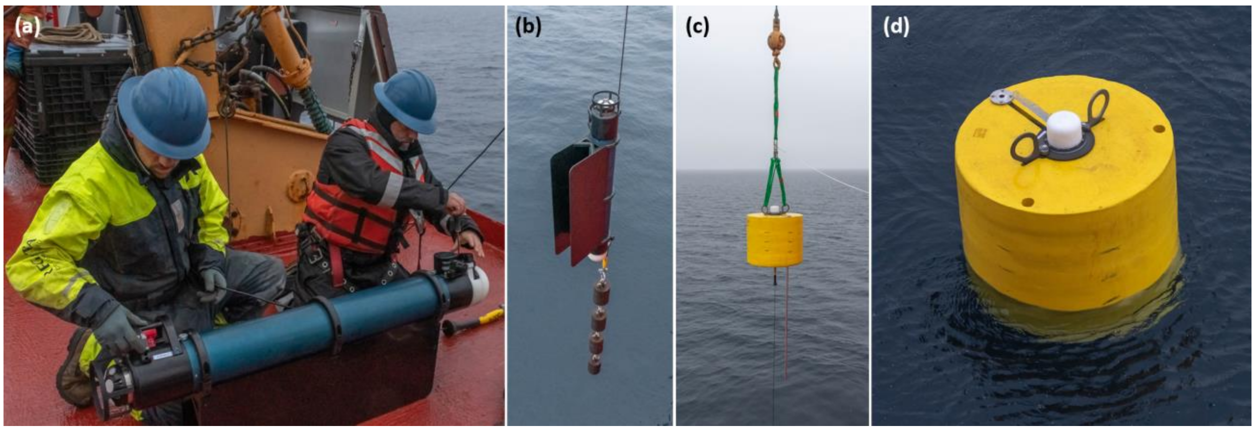


Figure 18. TOPV 13 deployment: (a) TOP profiling unit with velocity sensor (at left); (b) TOP profiling unit with fixed fin and weights suspended over the side of the LSSL during the open water deployment; (c) TOP surface float with grounding pole suspended over the side; (d) TOP surface float after release from the ship. *Photos by Gary Morgan, CCGS LSSL.*

<u>***# 3, IBO 1, Sept. 7, 2024,** near 78.5 N, 144.5 W; air temperature: -4.5^{o}C, winds: 15 knots*</u>

Three buoys were deployed on a single floe: TOP 14, SIMB 2024 # 6, OMB (plus MetBuoy in o/w)

A possible floe was identified on RADARSAT the previous day and targeted for the ice station. At 7:30 am the decision was made to do helicopter recon. A suitable floe was located from the helicopter at 10:23 am and the helicopter returned to the ship. On route by ship to the floe, we settled on a different suitable floe and nestled into it to work off the starboard side. Jeff O'Brien and Mary-Louise Timmermans went over in the basket to do the survey and found the ice to be about 50 – 90 cm thick, settling on a point about 35 m from the ship for the TOP (90 cm ice thickness). For the IBO deployment, the gangway was not used; gear was craned off and personnel were put on the ice with the basket. By 2:10 pm, all personnel and gear were on the ice for the TOP deployment

(Kazu Tateyama and group plus IOS personnel were on ice for deployment of the OMB and the SIMB). The deployment of TOP 14 (starting with tripod set up) began at 2:30 pm local and the installation was complete at 3:50 pm. Personnel and gear were all back on deck by 4:40, and the LSSL was backing out of the floe at 4:46 pm. A MetBuoy was deployed by Paul Macoun in open water adjacent to the floe as the ship left the area.

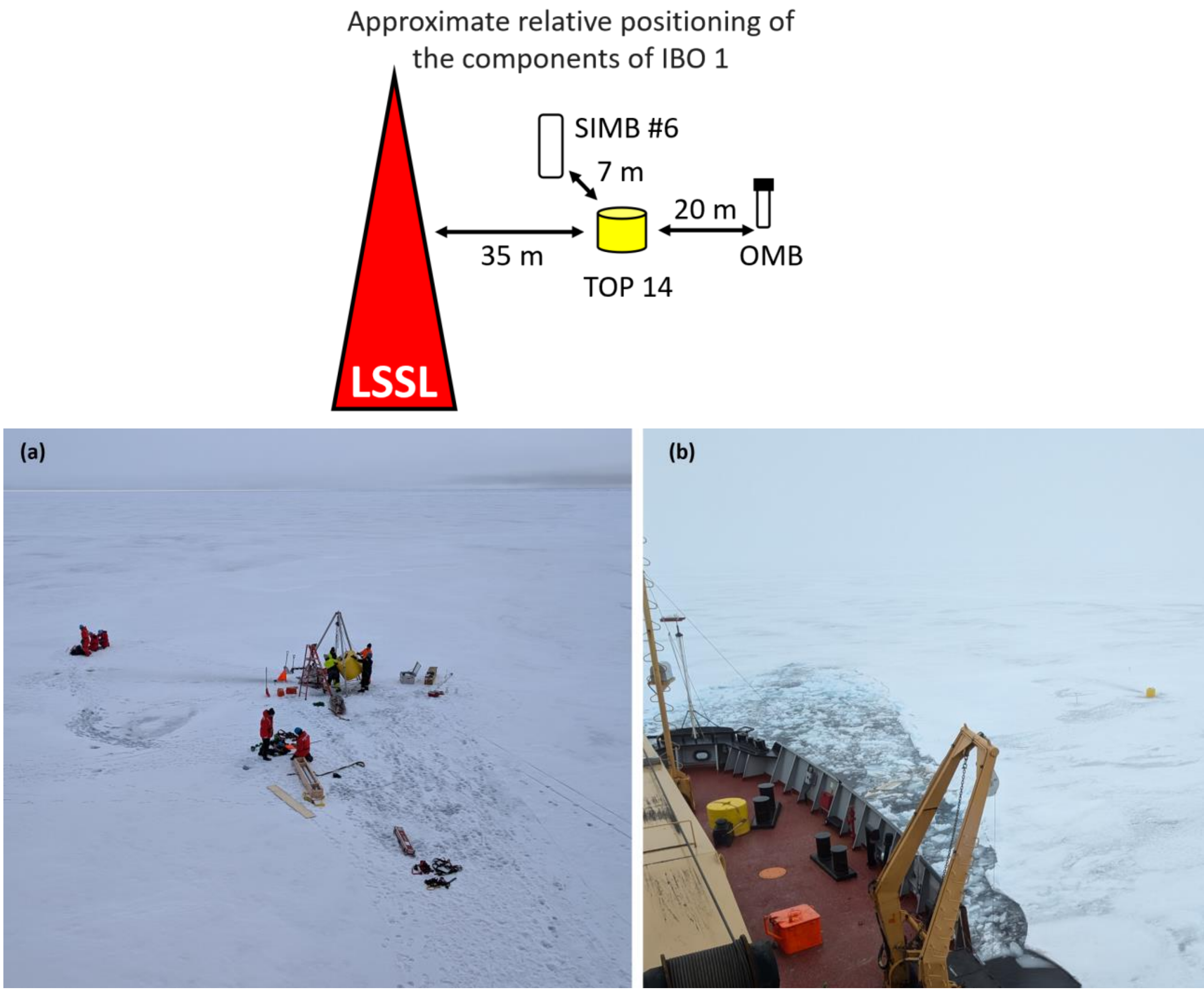


Figure 19. IBO 1 deployment: (a) Deployment of buoys underway; (b) TOP 14 and other buoys off the starboard bow of the LSSL as the ship backed away after the TOP was installed.

<u># 4, IBO 2, Sept. 8, 2024, near 78.7N, 150.7W; air temperature: -5ºC, winds: 13 knots, clear</u>

Six buoys were deployed on a single floe: ITP 142, TOPV 12, AOFB 49, SIMB 2024 #7, an OMB and a MetBuoy.

The LSSL arrived at a large egg-shaped pan of ice (about 8 km across) at around 6:50 am; we had selected the floe via RADARSAT two days previously. We nestled into part of the pan around 7:44 am with a clear working area (free of ice rubble) to place the gangway off the starboard side. The floe was free of large ridges and populated with frozen melt ponds visible as grey patches under the snow covering.

At 9:12 am Jeff O'Brien and Mary-Louise Timmermans were lowered over the starboard side in the basket to survey. The ice was about 50 to 60 cm thick along a ~130 m line running perpendicular from the ship's starboard side. TOPV 12 was to be installed closest to the ship (about 15 m away from the hull), with ITP 142 situated for deployment at the far end of the line (about 110 m from the TOP), and AOFB 49 and SIMB 2024 #7 between. The survey was completed, and the ice team was back on deck at 9:39 am.

After the ice survey, the starboard gangway was deployed and the crane was used to sling gear over. The ship's ATV was used to shuttle gear via sled to the buoy sites. By 11:37 am, all gear was on the ice and a 14" hole was drilled for the AOFB. The AOFB was mostly assembled and placed in the hole first, then the TOPV (a 14" hole was required for this system which had two retractable fins), followed by the ITP. Working conditions were ideal all day, with sunshine and only light winds.

A Go-Pro camera on a 20-foot selfie stick was used to acquire under-ice video of the TOPV being deployed. Its fins (retracted for the deployment) were observed in the video to unfold as expected.

All buoys were deployed and gear plus personnel were back on deck at 5:24 pm. An OMB (not pictured in the schematic below) was deployed at the end of an ice survey line running 200 m perpendicular from the ship's starboard bow.

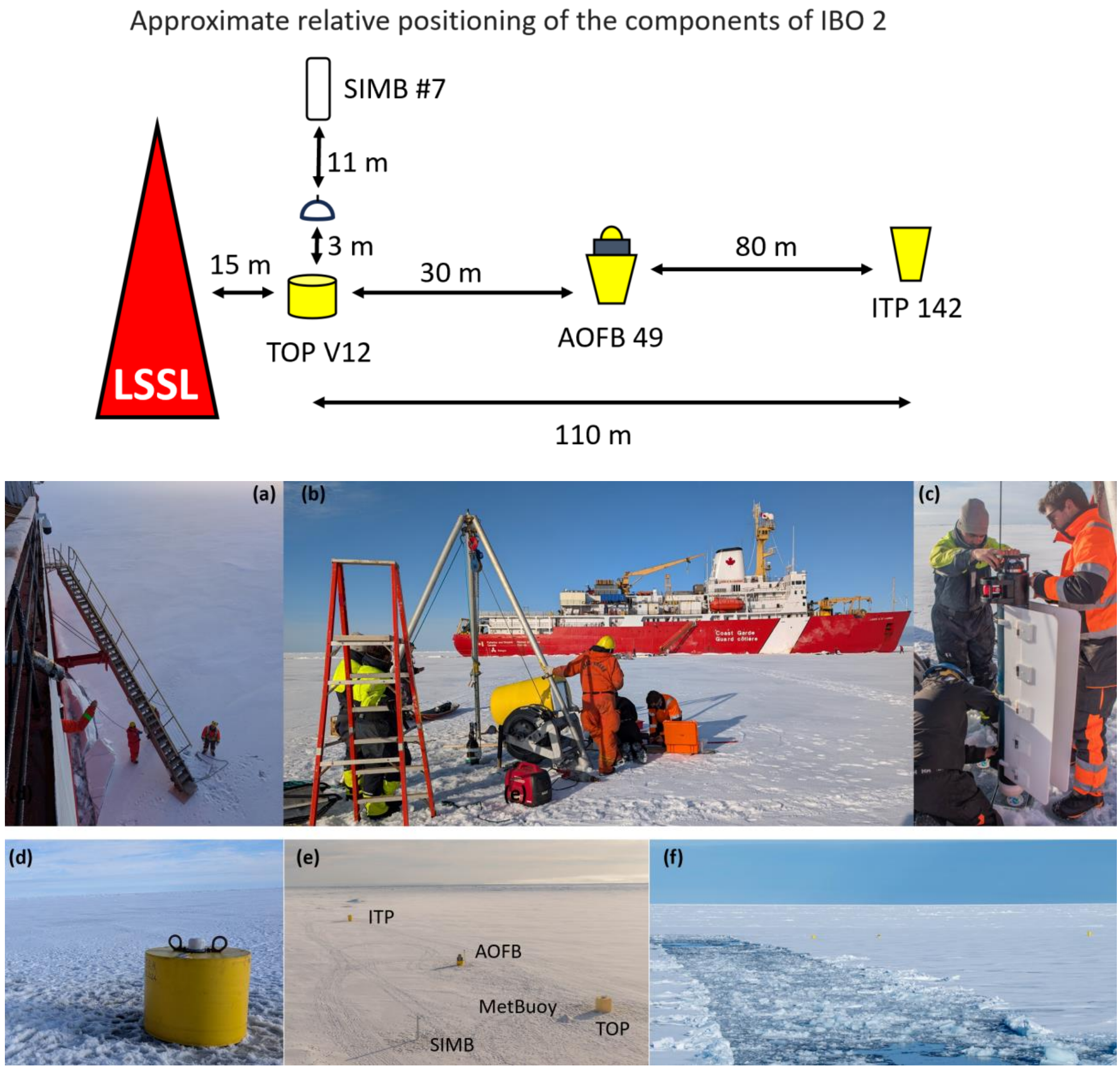


Figure 20. IBO 2 deployment: (a) The gangway is placed over the starboard side of the ship; (b) Assembling components for the ITP deployment; (c) The TOP profiling unit with white fins unfolded; fins were retracted just prior to putting the profiling unit through the hole, and unfolded in water once the profiler was through the hole; (d) Surface float of the installed TOP; (e) All components of the installed IBO; (f) The LSSL backs away from the floe at the end of the deployment.

 # 5, OW 2, Sept. 9, 2024, ~ 77.7N, 150W; air temp.: 2.7°C, winds: 10 knots southeast; 0% ice

TOP 15 (with T-chain and 760 m tether) open water deployment. Some small ice floes were in the vicinity, light snow, flat seas and no new freeze-up.

At ~5:15 pm, the winch was brought out of the forward hold and the WHOI team began preparing the gear on the deck for the open-water TOP deployment. The profiling unit and weights were in the water at 5:34 pm, and wire payout was complete by 5:43 pm. The surface float sat upright, floating around 15" into the water (deeper than the typical 12" seen for a shallower-tether TOP).

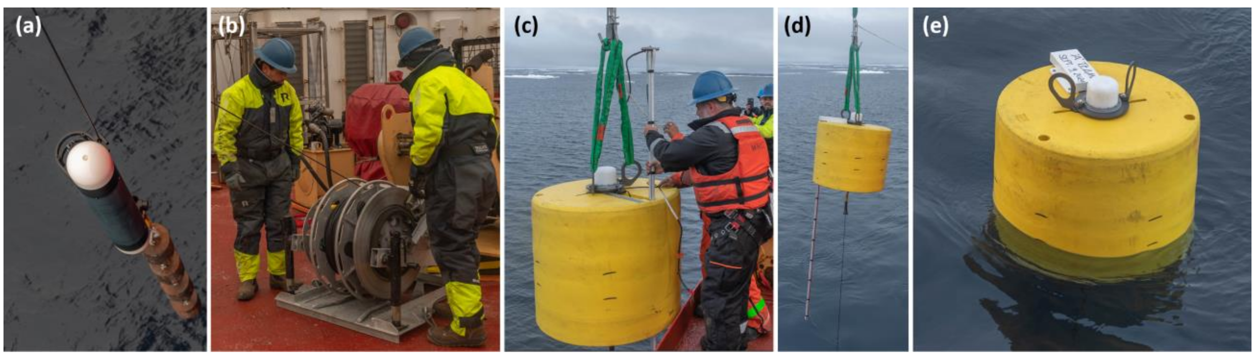


Figure 21. TOP 15 deployment: (a) TOP 15 profiling unit and weights suspended over the side of the LSSL near the beginning of the deployment; (b) Nico Llanos and Eric Trotto operate the ITP winch; (c) Jeff O'Brien inserts the grounding pole with thermistor chain into the float; (d) the surface portion of the TOP system suspended just before release of the system from the ship; (e) the deployed TOP system floats about 15" into the water. *Photos by Gary Morgan, CCGS LSSL.*

 # 6, OW 3, Sept. 12, 2024, 77.5N, 150W; air temperature: -4°C, winds: 12 knots, o'cast

ITP 143 (w. O2 optode sensor plus SAMI at 5m) open water deployment.

At 3:00 pm, the LSSL stopped in a broad swath of open water. At 3:08 pm the anchors and profiler were over the side to begin wire payout. Communication with the surface package (the final step of deployment) took about 10 minutes. The system was released at 3:59 pm and the surface float listed somewhat when it was floating free.

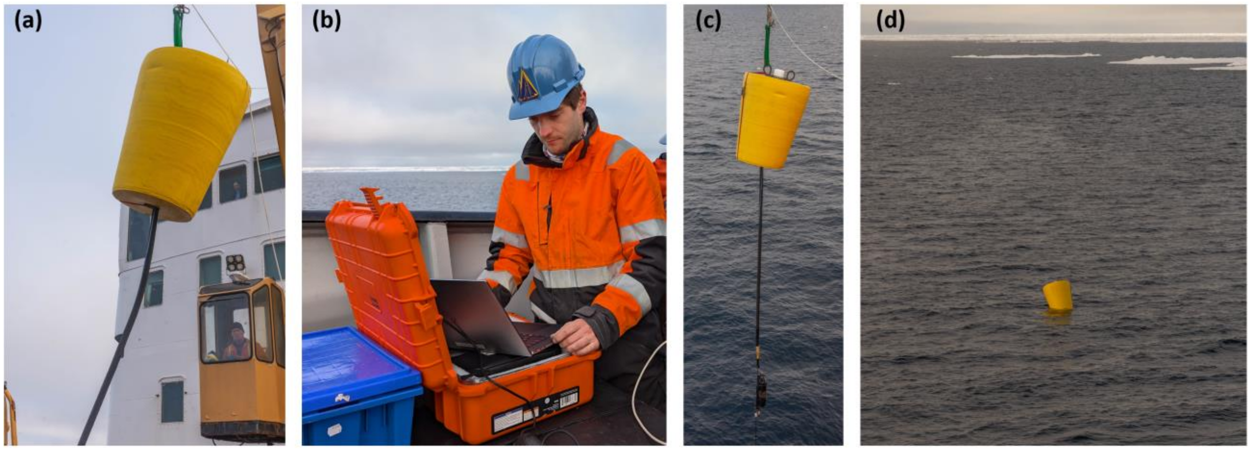


Figure 22. ITP 143 deployment: (a) ITP surface float suspended from the crane before deployment; (b) Tim McDonough performs a final communications check with the ITP prior to the open water deployment; (c) ITP surface float and SAMI sensors suspended over the side; (d) ITP surface float after release from the ship, listing slightly.

 # 7, Recovery 2, Sept. 14, 2024, *75.6N, 150.2W; air temp.: -1.8 ºC, winds: 10 kt, 0% ice*

TOP6 recovery. TOP 6 was deployed on a 1.10 m ice floe in the Beaufort Sea on September 24, 2022. It had expended its battery after 2 full years of acquiring temperature and salinity profiles between the ice-ocean interface and 200-m depth. The system was deployed on the same ice floe as ITP 137, but the buoys had separated in July 2024, and TOP 6 was drifting such that the LSSL only had to make a 4 nm deviation from the 150W line to locate it for recovery. The TOP was configured to report GPS positions every hour, so locating the buoy was easy, and it was spotted floating at 3:55 pm. The surface float was upright and submerged by an amount consistent with the entire system being intact. The basket was deployed to hook the top ring on the surface package at 4:05 pm. Recovery of the full system (including 200 m of wire, the profiling unit and weights) was complete by 4:36 pm.

Components were in excellent condition and will be refurbished and redeployed during a future expedition. The grounding pole had sheared off at about 30 cm below the base of the buoy at its joint. As expected, the white flotation cap at the top of the profiler unit was significantly dented, a result of repeated contact with ice.

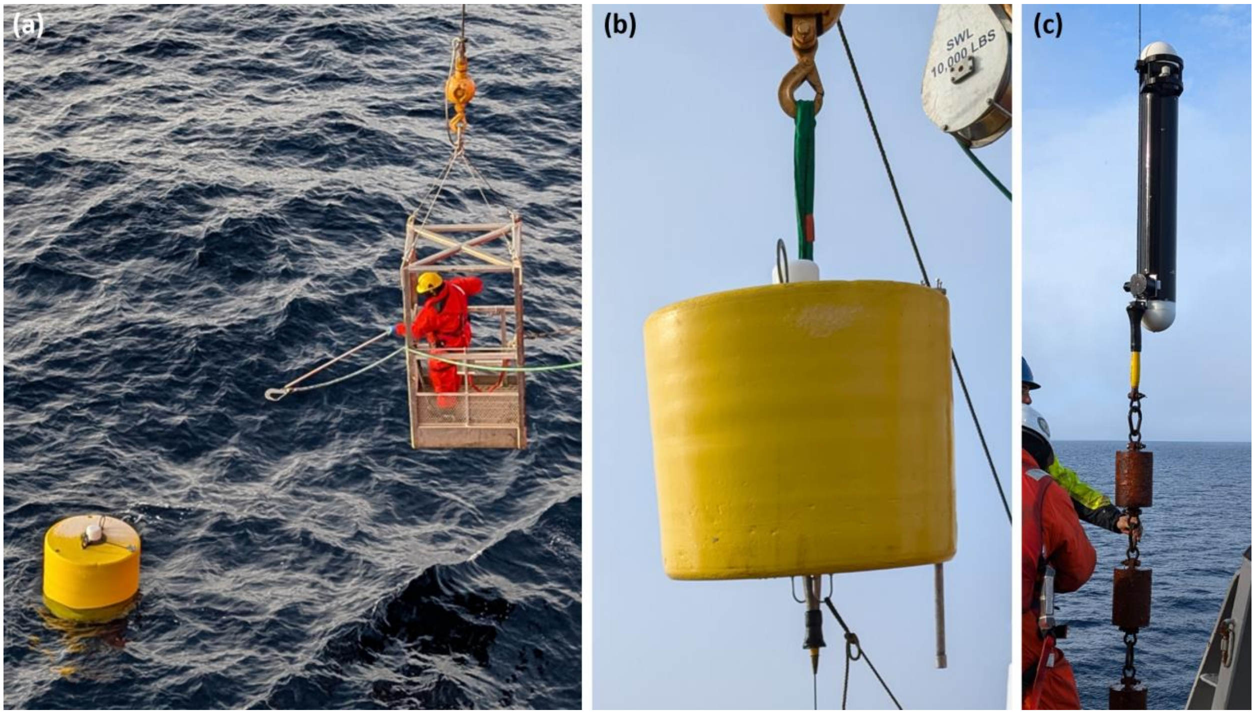


Figure 23. TOP 6 recovery: (a) TOP surface package just before it was hooked from the basket; (b) TOP surface float with only part of the grounding pole (lower right), which had sheared off at the joint; (c) TOP profiling unit and anchor weights are recovered, all in excellent condition.

3.3.3 Sea surface pCO_2, pH, and dissolved O_2

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

Overview: U.S. National Science Foundation Project: An Arctic Ocean sea surface observing network for the partial pressure of carbon dioxide (pCO_2), acidity (pH), and dissolved oxygen (DO)

This project is a collaboration between the University of Montana, Woods Hole Oceanographic Institution (Jeff O'Brien, Isabela Le Bras and John Toole) and Yale University (Mary-Louise Timmermans). The primary objectives are to 1) quantify the air-sea flux of CO_2 in the Canada Basin region of the Arctic Ocean using high temporal resolution sensor data and 2) use these data to help understand the mechanisms that control the Arctic Ocean carbon cycle.

As part of this project sensors for measurement of the partial pressure of CO_2 ($p$$CO_2$), dissolved oxygen (DO), temperature and photosynthetically active radiation (PAR) are deployed each year on WHOI ice-tethered profilers (ITPs) (Figure 1). The sensors are placed on the ITP cable just under the ice and send their data via satellite using the WHOI ITP interface. We have also been adding DO sensors to the ITP profiler for the past few years (Figure 1, left). In addition, CO_2 and pH sensors equipped with DO, PAR and temperature sensors are deployed at a depth of approximately 34 meters on each of the three WHOI BGOS moorings (Figure 1). We also measure sea surface pCO_2 in seawater coming into the ship's lab (intake at 9 m) (Figure 2).

Figure 24. A dissolved O_2 sensor (blue housing) on the profiler (ITP142). SAMI CO_2 being deployed on an ITP142 (center) and CO_2 and pH sensors after recovery on Mooring D (right). A fluorometer, deployed in 2023 in collaboration with Céline Guéguen (University of Sherbrooke), is also shown (right photo, upper left).

Cruise Accomplishments

We deployed SAMI-CO_2 sensors equipped with dissolved O_2 and PAR sensors on two ITPs (ITP142 and ITP143). ITP142 was deployed at the second ice station while ITP143 was deployed in open water. An oxygen optode was also deployed on both profilers (Figure 1, left). IOS collaborators manually sampled at the ice stations for inorganic carbon, alkalinity, and DO for sensor quality control. Quality control samples were also collected with the rosette near the deployment locations.

We also recovered and deployed SAMI-CO_2/SAMI-pH pairs on the BGOS-A, BGOS-B and BGOS-D moorings. Each pair included sensors for DO and PAR. The data coverage for moorings deployed in 2023 and the new ITPS are summarized in Table 1 below. Quality control samples were also collected with the rosette near the deployment locations and at the depth of the sensors (~34 m).

Lastly, we collected underway pCO_2 data using an infrared equilibrator-based system (SUPER-CO2, Sunburst Sensors) nearly continuously over the 27-day cruise. The instrument was connected to the Louis seawater line manifold located in the main lab (Figure 2). Quality control samples were collected approximately daily by manually sampling the seawater line (also known as the "loop").

Table 9. Days of data obtained from sensors for moorings deployed in 2023 and for ITPs deployed on this cruise (September 2024).

	CO2	pH	O2	PAR	Temperature
BGOS-A Mooring	100	158	347	347	347
BGOS-B Mooring	300	87	347	347	347
BGOS-D Mooring	186	320	0	349	349
ITP-142**	14	14	14	14	14
ITP-143**	11	11	11	11	11
underway pCO2	~25	x	x	x	~25

****as of Sep. 23, 2024**

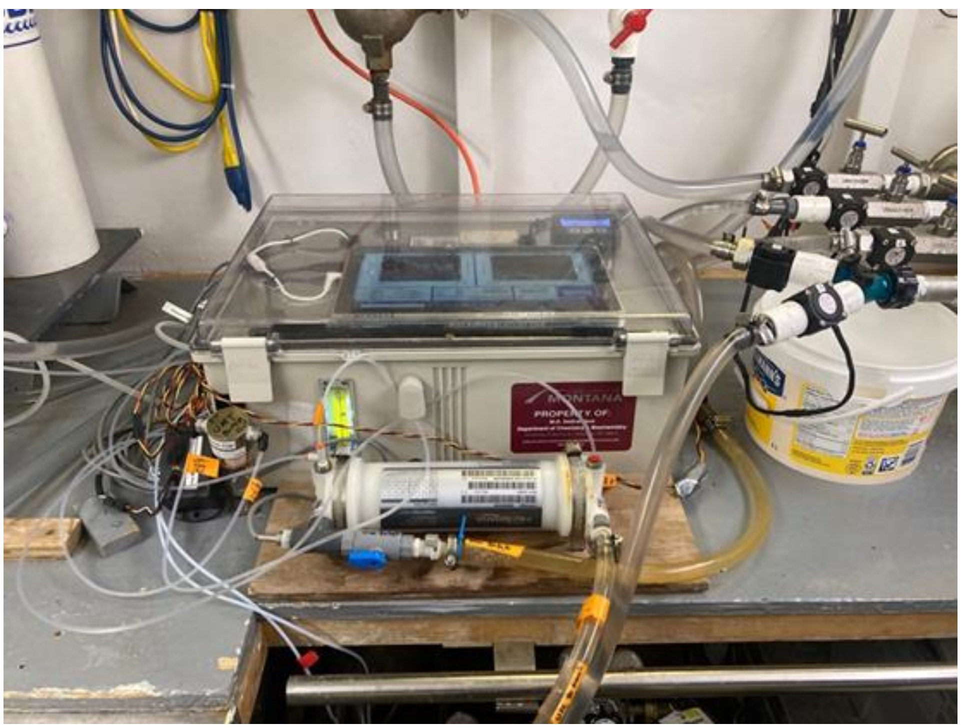


Figure 25. Shipboard underway pCO2 environmental monitor (SUPER) system connected to the ship's seawater line (at right).

3.4 XCTD Cruise Report

Kazu Tateyama, Yusuke Kohama (KIT) and Koh Izumiyama (HU)
PIs: Bill Williams (DFO-IOS), Motoyo Itoh (JAMSTEC), Andrey Proshutinsky, Isabel Le Bras (WHOI), Mary-Louise Timmermans (Yale)

Overview

Profiles of temperature and salinity were measured using expendable probes capable of being deployed while the ship was underway. Profiles were collected at 41 locations along the ship's track between the CTD stations.

Procedure

Expendable CTD probes (Tsurumi-Seiki Co., Ltd) were deployed from a hand-held launcher LM-3A (Lockheed Martin Sippican, Inc.) from the ship's stern. The data were communicated from the probe back to the launcher by a fine wire which breaks when the probe reaches its maximum depth. The launcher was connected to the Lockheed Martin Sippican MK-21 Ethernet deck unit and data were logged using the WinMK-21 software installed on the IOS's laptop "Arrow". The MK21 firmware and software were updated in 2022 to ensure compatibility with the new XCTD-1N probe.
Connection between the laptop and the deck unit was via an Ethernet switch. The switch was also connected to the science network. The ship's GPS stream was provided by science server over the network via GPSGate. Water depth from the sounder was displayed on the laptop in a terminal window. Data were automatically written by the WinMK-21 software to the local drive on the laptop. At the end of the cast the operator filled in the log sheet and manually transferred the new files to the science server.

Operational Notes

The Tsurumi-Seiki XCTD-1N probe was used exclusively in 2024.

Table 10. XCTD probe operational parameters.

Probe Type	Number Used	Filename Convention	Max Depth (m)	Max Ship Speed (Kts)
XCTD-1N	42	"C3_"	1000	12

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD-1N probe are summarized below in Table 27.

Table 11. XCTD-1N probe operational specifications.

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)

Of the 41 XCTD-1N probes, 39 successfully reached maximum depth (1,000 m) or bottom depth (618 m). Table A-1, A-2 and Figure 1 show a summary and the locations of the all deployments. Of the 2 probes failed to deploy due to no response from probe. The cause has not been identified.

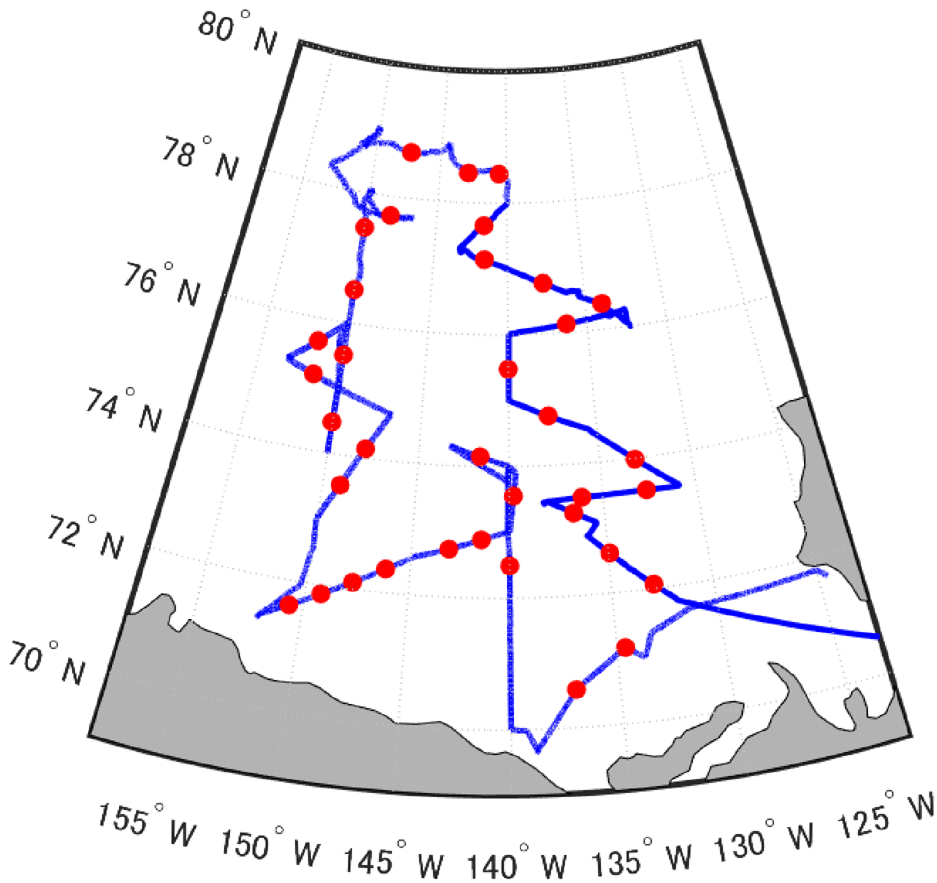


Figure 26. The locations of the all XCTD deployments. Table A-1. XCTD cast deployment locations. File name starting with C3 indicates the probe type was XCTD-1N.

Please see the Appendix for list of deployment times and locations.

3.5 Zooplankton Vertical Net Tows

Seth Fleming-Alho, Mike Dempsey (DFO-IOS)
P.I.: John Nelson (DFO-IOS)

Sampling

Zooplankton sampling and preservation were conducted on board by Seth Fleming-Alho of the day and Mike Dempsey of the night watch. A standard bongo net system was used with a fitted 150µm net on both sides as well as a calibrated TSK flowmeter installed to measure the amount of water flowing through the nets. In addition, an RBR pressure recorder was mounted on the gimble rod to record the actual depth of each net cast.
Net Events 1 to 17 used RBR Virtuoso SN 52917 however there was trouble with the data logging and a replacement RBR Solo SN 233282 was used for Net Events16 (overlap with the Virtuoso) to the end of the program.

A total of 45 bongo vertical net hauls were completed. 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 a single 100m bongo vertical net haul was completed. A total of two samples were collected at each station one from each side of the bongo net.
At CB9 there was an opportunity for a second deep cast and a tow to 1000m was performed (Net Event 20).

Bongos were deployed on the foredeck using the forward starboard A-frame. Rinsing of the nets was accomplished by attaching a hose to the salt-water tap on the port side near the outer door near the lounge. Water was left running during the cast to prevent the hose from freezing. The hose was removed after every station, emptied of water, coiled, and carried to the port foredeck sciences container to keep it warm.

The bongo was fitted with two 150µm mesh nets. One side of the bongo was labeled E with TSK serial number 7085 and the other side was labeled F with TSK serial number 7303. For consistency samples collected from the net marked E was preserved in 95% ethanol and samples collected from the net marked F were preserved using formalin with final sample concentration 3.7%. The formalin samples will be examined for species identification and the ethanol samples for DNA sequence analysis coordinated by John Nelson.

UTC was used to log all times and dates in zooplankton log unless otherwise specified.

Issues and solutions

Net Event 4: It was noticed that one of the fins on TSK sn 7303 (Ethanol side) was missing. It used for the rest of the program running with just 3 blades.

It was noticed that occasional the wind would catch and spin the TSK flowmeters while on deck and add false flow.

On occasion the flowmeter would return with a value less than the its value at the start of the cast. Errors from reading the flowmeter incorrectly have been ruled out. It is possible that if the gears inside the TKS did not mesh perfectly that they could slip and wind backwards. Unit should be inspected before being used again.

Some stations with loose flowing ice were challenging for the bridge to maintain an ice free pond for both the bongo and rosette at the same time. For several stations, the nets were held at the bottom of the cast for extra time while the bubblers pushed back ice then the haul was resumed right after the bubblers turned off. This is preferable way to manage fast ice.

Zooplankton operations take place on the starboard side and the saltwater supply for rinsing is drawn further aft on the port side. It would be helpful to have a saltwater source on the starboard side to reduce the length of hose needed to reach the A-frame.

The Zooplankton nets could benefit from more weight. Currently they have 50lbs on them. Mounting more would allow for smoother descents, less affected by wind and currents. A happy medium would have to be found where it is enough weight to weight down the nets but still a manageable amount for deploying and recovering.

Please see Appendix for time and location of bongo net hauls.

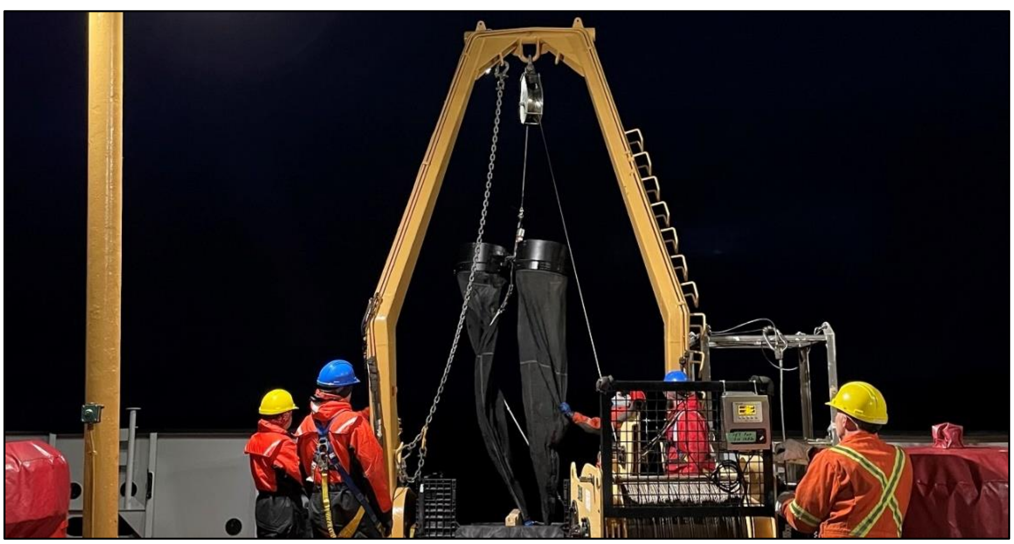


Figure 27. Bongo nets being deployed from the foredeck in 2023 (similar for 2024).

3.6 ARGO

Paul Macoun (DFO-IOS)
PI: Tetjana Ross (DFO-IOS)

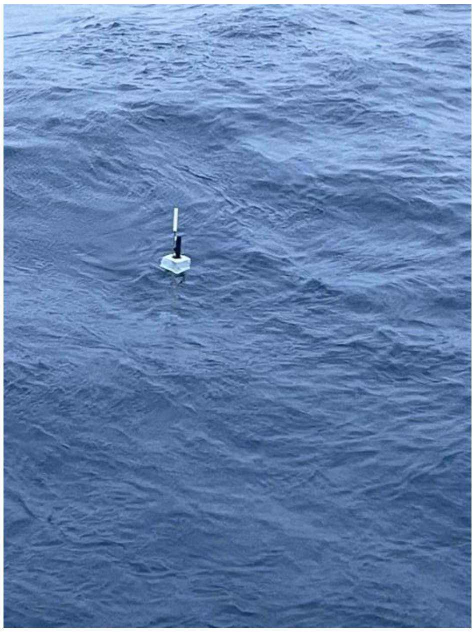
Fisheries & Oceans Canada provided 2 NKE Instrumentation ARGO floats for deployment during the JOIS 2024 program.

Table 12: Float Information

Manufacturer	Type	Serial #	@ BT	IMEI
NKE Instrumentation	ARVOR I NAOS	AI2600-21CA006	C200107-0196	300534060213390
NKE Instrumentation	ARVOR I RBR	AI3500-21CA003	C200107-0162	300534061174520

Table 13: Deployment Information

Serial Number	JOIS Station	Lat (N)	Long (W)	Date	Time (UTC)
AI2600-21CA006	STN-A	72.6	144.7	Sept. 18, 2024	1530
AI3500-21CA003	CB-27	73	140	Sept. 19, 2024	0237



AI2600-21CA006

AI3500-21CA003

Figure 28: Deployment photos

At the time of writing this report, the ARVOR I NAOS float with Serial Number AI2600-21CA006 had not communicated with the shore station. It is possible the buoy submerged prior to establishing a satellite link, and operators are monitoring the situation. The second float is operating normally.

3.7 Underway Surface Sea-water Measurements

Sarah Zimmermann and Paul Macoun(DFO-IOS)
Céline Guéguen, Magali Pucet, Margot de Mecquenem (USherbrooke)
Mike DeGrandpre (UMontana), Tianyu Zhou (University of Delaware)
P.I.s: Bill Williams, Celine Gueguen (USherbrooke), Mike DeGrandpre (UMontana), Wei-Jun Cai (University of Delaware)

3.7.1 Overview

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 lab off the main science lab. The lab is configured with an integrated Seabird SBE21 thermosalinograph (TSG), Seapoint Chl-a fluorometer and Wetlabs FDOM fluorometer. Recording independently, a second Wetlabs FDOM fluorometer, a Sunburst SUPER pCO2 system and an O2/Argon system were connected to the wetlab manifold.

Measurements were made for:

a. Surface temperature (inlet and lab), salinity, and fluorescence for Chlorophyll-a and FDOM.

b. Water samples were drawn for

    - Salinity, Dissolved Inorganic Carbon, Alkalinity, Chlorophyll, Oxygen, and a limited number of Nutrients (IOS/DFO)

    - Fluorescent Dissolved Organic Matter (*Celine Gueguen, USherbrooke*)

    - Tritium and Deuterium (*Elizabeth Priebe, CNL*)

c. Partial pressure of carbon dioxide (pCO_2) using a SunBurst SUPER instrument (Mike DeGrandpre, UMontana). See section on Sea surface pCO2, pH and dissolved O2.

d. New in 2023: The ratio of oxygen and argon concentrations (Zhangxian Ouyang and Wei-Jun Cai, University of Delaware). See following section on Underway measurement of O2/Ar ratio

Issues with the TSG:

> At the start of the program the Salinity from the SBE21 TSG was showing similar inconsistencies as in 2023. The TSG was quickly swapped out for a spare system. The salinity was quite low and there was concern the spare TSG also had a problem. The salinity was verified with a CTD reading and the spare system reinstalled.

Details of the set-up, operation, instruments' make, model, serial numbers, calibration, and performance are given in the Appendix.

3.7.2 Underway measurements of O2/Ar ratio

Tianyu Zhou (University of Delaware)

P.I.: Wei-Jun Cai (University of Delaware) and Yun Li (University of Delaware)

Overview

Sea ice loss in the Arctic has profound effects on surface net community production (NCP), as sea-ice state is a crucial factor to regulate light availability, water column stability and nutrient availability. In addition, sea ice provides habitat for numerous autotrophs in polar regions. It is of great interest to examine how sea ice loss in the Canada Basin and Beaufort Sea affects NCP in a late growing season.

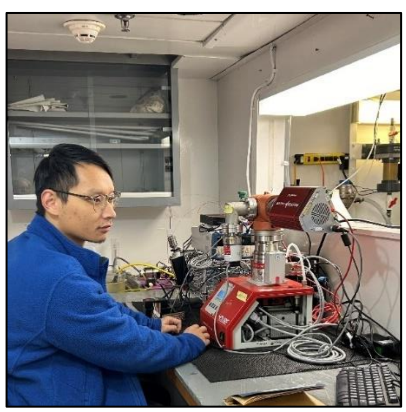


Figure 29. EIMS system for analysing O2/Ar ratio.

Sampling, Data Processing, and NCP Calculation

The ratio of oxygen and argon concentrations (O_2/Ar) was continuously measured underway using an equilibrator inlet mass spectrometry (EIMS; Cassar et al., 2009). Underway water (~9 m below waterline) was pumped through the loop system at a flow rate of 2-4 L min^{-1} through one filter to remove particulates, then to a gas-permeable membrane contactor cartridge (MicroModule 0.75×1). The equilibrated gas in the headspace was sent to a quadrupole mass spectrometer (Pfeiffer Prisma model QMG 220) for measurement. The O_2/Ar ratio was recorded every 2 s, and then was averaged into 2 min intervals. This measurement was calibrated with ambient air every 3 hours. The precision of the EIMS system is better than ±0.3% (Cassar et al., 2009). We removed any measurements that reflected interference from the bubbler when the ship was breaking ice, but retained measurements collected when the ship was on station or tethered to ice (with less interference from the bubbler).

To quantify oxygen status as influenced by both physical and biological processes in the mixed layer, oxygen saturation percentage (O_2%) was measured every 30 s underway using an Aanderaa optode (model 4531A). The optode was calibrated before each cruise with 0% and 100% O_2-saturated water according to manufacturer's instructions. Discrete DO samples collected from both the loop pipeline and CTD Niskin bottles (surface samples) were used to check and validate the optode measurements. Note that O_2% results are only used to demonstrate the total O_2 state in the mixed layer, not for NCP calculation.

The processed O_2/Ar measurements will be converted to NCP following Ouyang et al. (2021). We will apply an exponentially-weighted scheme to estimate NCP, which more accurately reflects an average state of NCP over the past few weeks by taking the impacts of both wind and sea ice histories into account (Teeter et al., 2018; Ouyang et al., 2021).

References

Garcia, H., & Gordon, L. (1992). Oxygen solubility in seawater: Better fitting equations. Limnology and Oceanography, 37(6), 1307-1312. doi:10.4319/lo.1992.37.6.1307

Cassar, N., Barnett, B., Bender, M., Kaiser, J., Hamme, R., & Tilbrook, B. (2009). Continuous high-frequency dissolved o2/ar measurements by equilibrator inlet mass spectrometry. Analytical Chemistry, 81(5), 1855-64. doi:10.1021/ac802300u

Teeter, L., Hamme, R., Ianson, D., & Bianucci, L. (2018). Accurate estimation of net community production from O_2/Ar measurements. Global Biogeochemical Cycles, 32(8), 1163-1181. doi:10.1029/2017GB005874

Ouyang, Z., Qi, D., Zhong, W., Chen, L., Gao, Z., Lin, H., Sun, H., Li, T. and Cai, W.J., 2021. Summertime evolution of net community production and CO_2 flux in the western Arctic Ocean. Global Biogeochemical Cycles, p.e2020GB006651.

3.8 Underway data logging using SCS

Paul Macoun, Sarah Zimmermann (DFO-IOS)
P.I.s: Bill Williams

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:

1. GPS from the ship's Furuno GPS, using NMEA strings $GPGGA and $GPRMC. These sentences, available on the science VLAN, were used by CTD, XCTD, TSG and mapping programs.

2. AVOS weather observations of air temperature, humidity, wind speed and direction, and barometric pressure ($AVRTE)

3. Sounder depth and the applied ship's draft and sound speed

4. Surface Photosynthetically Active Radiation (PAR)

5. Thermosalinograph (TSG), and the inlet sea surface temperature from the SBE38 that is also given in the TSG data stream.

6. Heading from the ship's Gyro ($HEHDT)

7. Data from the FDOM fluorometer in the seawater loop (FDOM)

8. Derived true wind speed calculated in SCS

Note the AVOS, TSG (and SBE38), PAR and FDOM data are also logged through their own software programs which may be more complete than the SCS record.
In particular, the TSG files will have updated calibration and processing through the SeaBird software. On the otherhand, computer feeds (ex. navigation feed to TSG computer) can mean the TSG file is incomplete and the SCS data server as a great backup.

Also note, the timestamp that precedes all the SCS strings is very useful for combining records. This timestamp comes from a computer clock that can drift. However, new for 2023 and continued for 2024, a time-server was used to keep the science server and other data computers (CTD, TSG, XCTD) up to date. If in doubt, check against the GPS time from the GGA or RMC record for the correct time.

The SCS system on a shipboard computer called the “NOAA server” collects *RAW files. The files are periodically restarted and contain up to a weeks’ worth of data.

More information on *.RAW files, string definitions, equipment and instruments, and performance issues are given in the Appendix.

3.9 Ice Observations

Overview

As in previous years, the ice observations recorded during the JOIS2024 cruise will provide detailed information for the interpretation of satellite imagery of the sea ice distribution. The sea ice extent for 2024 was the third lowest on record (4.09 x 10^6 km^2) as of September 11 as shown in Fig. 1(a). Fig. 1(b) shows the cruise track and averaged sea ice concentration during the ice observation period (September 1– 14) obtained from the GCOM-W AMSR2.

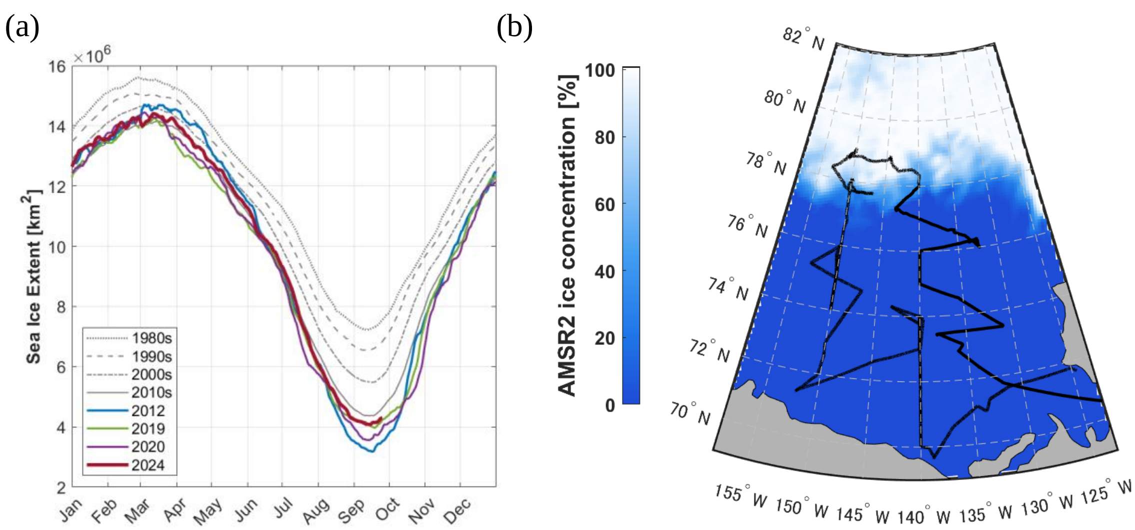


Figure 30. (a) Sea Ice Extent for all years and a comparison of 2012 and 2024 from Arctic Data archive System (https://ads.nipr.ac.jp/).
(b) Averaged AMSR2 sea ice concentration and ship truck during the ice observation.

3.9.1 Observations from the Bridge

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

While the ship was in the ice pack, ice conditions and supporting weather information were recorded every hour within 1nm about the ship when visibility allowed along the ships track. The combined 8-hour Ice and XCTD watch were carried out by the three ice observers, to cover the full 24 hours.

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

Observation has started on 5th September and ended on 13th September. 89 hourly data were recorded. Figure 2 show (a) total ice concentration, (b) primary ice concentration, (c) secondary ice concentration, (d) primary ice thickness, (e) secondary ice thickness. The thick old ice such as multi-year more than 300cm and second-year ice around 100-250 cm were observed as primary (thickest) ice.

.

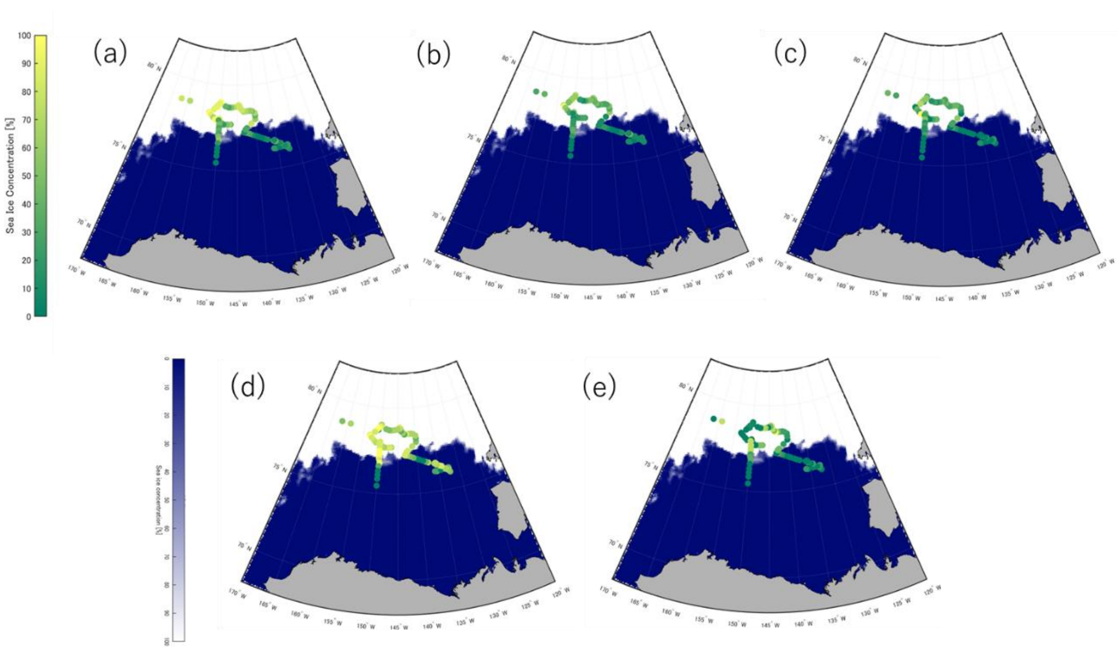


Figure 31. AMSR2 Sea Ice Concentration and Visual Ice Observations (a) Total ice concentration, (b) Primary ice concentration, (c) Secondary ice concentration (d) Primary ice thickness, (e) Secondary ice thickness

3.9.2 Ice Camera

Kazu Tateyama, Yusuke Kohama (KIT) and Yuki Ishiyama (UTokyo)
P.I.: Kazu Tateyama (KIT), Jennifer Hutchings (OSU)

A new camera called Shipborne Sea Ice Condition Recorder (SSICR) that captures both forward and downward views with a single camera and equipped with a GNSS receiver and 9-axis inertial sensor was installed. The camera was mounted on the starboard forward window frame of the bridge and connected to the science network by adding a hub to the network port for the CTD winch monitoring PC as shown in Fig. 3. Images were taken once every three minutes and stored on an internal 1 TB SSD, allowing the user to view real-time images and download stored image data via FTP from a web browser through the science network.

Observations were conducted from August 25 to September 22, and 20,964 images (26.8GB) and GNSS, 9-axis inertial data were recorded. Figure 4 shows examples of images taken with the front and side lenses.

The ortho-corrected images will be used to automatically determine concentration and thickness of sea ice, snow depth, melt pond fraction, ice floe size, cloud amount, and so on.

Figure 32. Location of SSICR with forward and side looking lenses on the starboard side of the bridge.

Table 14. Specifications of the SSICR.

Sensor	Specifications	
Camera	Number of pixels	8 mega pixels
	Image Size	3264 x 2488 pixels
	Interval	3min
9-axis inertial	Acceleration	g
	Gyro	dps
	Geomagnetism	gauss

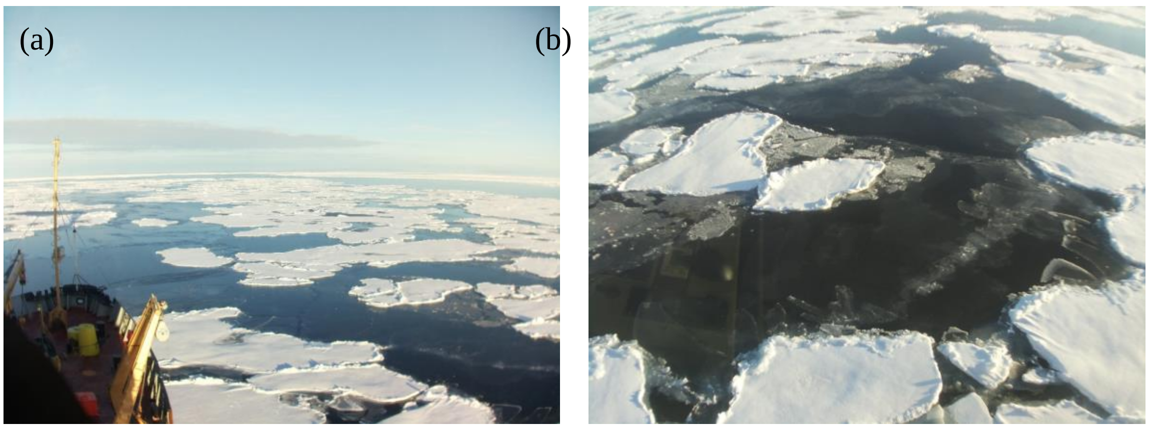


Figure 33. Examples of images taken by SSICR.

3.9.3 Sea-Ice imagery from GoPro mounted on bridge.

Sarah Zimmermann (DFO-IOS)
P.I.: Kazu Tateyama (KIT), Jennifer Hutchings (OSU)

This year a new system was set up on the bridge. See Kazu Tateyama's report describing his forward-looking and side-looking cameras mounted inside the bridge on the starboard side, taking pictures w/ data combined with GPS and 9-axis inertial sensor information. The network cameras (Netcams) that had been used from 2007 to 2023 were not installed this year. They had been installed above the bridge with views forward and side-looking, taking pictures every 1 minute or more frequent depending on the year.
We did continue with the forward looking GOPro (started in 2019) from inside the bridge taking pictures at 1 minute intervals. The self-recording GoPro camera was installed pointing forward looking over the bow from inside the bridge. Being inside, looking through the protected bridge window, the view was typically free of ice/rain/snow issues. The camera recorded images every 1 minute using 7M image size and Regular width.

The GoPro camera memory card was downloaded as needed (~5days)

- The GoPro camera took images from Sep 5th to 25th with an unfortunate gap from Sep 9th to 13th.
- The GoPro file and folder names cycle after downloading so each download was written to a unique folder.

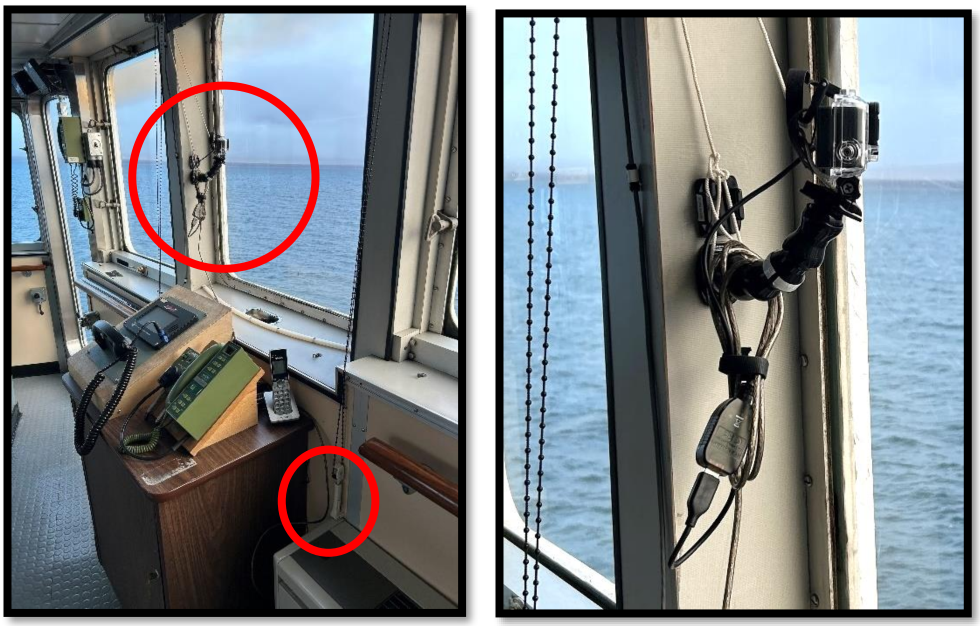


Figure 34. Location of forward looking GoPro camera on the port side of the bridge. Power outlet below the window is circled (left). Close up of GOPro, no back on camera case (right). Images from 2024.

Photo Log. Time and Date below are UTC.

The GOPro time and date were set to UTC. File date is UTC.

Laptop for at-sea photo download was *TP2017-03-Cod*. Files were copied to: C:\Users\science\Documents\SeaIce Photos GoPro

2024-09-05 04:52 First recording began. Mounted Go-Pro, putting new stick plate on ship's window frame, next to mount from last year. No ice leading up to this so only installed GoPro now as we are just entering ice edge toward station PP7.
Settings: med image, not wide, 1 minute photos, UTC Time and date set on GoPro.
GoPro: "Arc1GPRO" IOSArctic1; w/ small bat "1"; w/ big battery "BigBatt2"

2024-09-08 02:00 Downloaded files to Batch1 on laptop TP2017-03 Cod
Batch1 2024-09-05 04:52 to 2024-09-08 01:39 All good

2024-09-13 02:00 Downloaded files to Batch2 on laptop TP2017-03 Cod
Batch2 2024-09-08 02:15 to 2024-09-09 00:00 All good but stopped recording early for unknown reasons. The GoPro was set on "movie" when I came to download today (Sep 13th). Time and date still seem to be fine: Sep 13 19:43.

2024-09-26 01:00 Downloaded files to Batch3 on laptop TP2017-03 Cod
Batch3 2024-09-13 19:45 to 2024-09-25 15:03 All good

Equipment and settings were constant through the trip.

Equipment:

GOPro Hero3+ camera labeled with both: "Arc1GPRO" "IOSArctic1"
Large battery labeled "BigBatt2"
Case with back removed and on flexi arm. Back removed to allow continuous power. Buttons also removed (mid-2023) as they were accidently pressing the camera during ship motion. A USB cable with a power outlet adapter was used to supply continuous power to the camer.
64Gb SIM card

Settings:

7Mregular
60sec time lapse
Date and time set to UTC on 5 Sep 2024 04:30.

3.9.4 Shipborne EM observation

Kazu Tateyama, Yusuke Kohama (KIT) and Yuki Ishiyama (UTokyo)
P.I.: Kazu Tateyama (KIT), Jennifer Hutchings (OSU)

An Electro-Magnetic induction device EM31/ICE (EM) and a laser altimeter LD90-3100HS were used for indirect sea-ice thickness measurement continuously, installed at foredeck's crane on the portside. EM and laser instruments were covered by a yellow-orange color waterproof fiber reinforced plastic case and should be hanged at 4.5m height above sea surface and in more than 7m separation from ship due to avoid hitting ice and the effect from ship hull.

A new boom for SEM was introduced from the last cruise as shown Fig.5. The new boom was stable enough under strong winds and was easier to handle. Advantages such as easier calibration of the SEM were obtained.

In addition, the SEM data loggers were connected to the ship's network using LAN cables. It is now possible to monitor raw data in real time and download hourly recorded data via FTP. However, converting the raw data to sea ice thickness in real time remains an issue for the future.

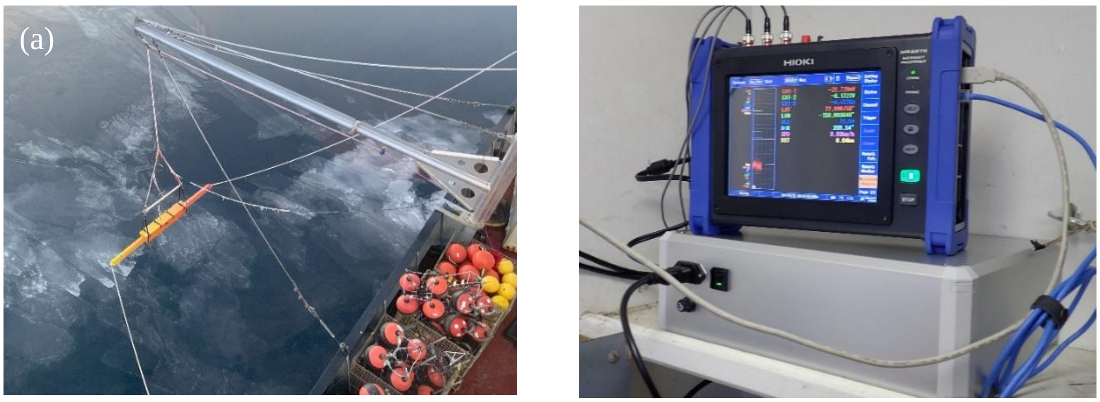


Figure 35. Phots of (a) shipborne EM and a new boom (b) data logger and power unit.

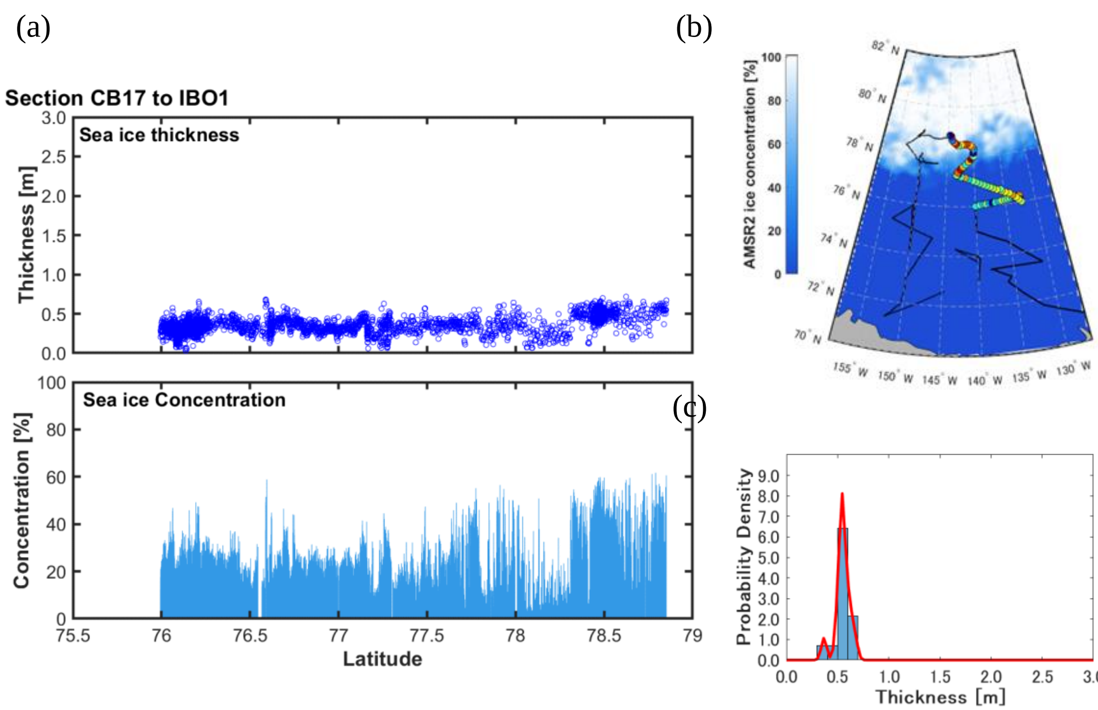


Figure 36. (a) Distribution of total ice thickness and sea ice concentration, (b) map of total ice thickness distribution, (c) Histograms and Probability Density Functions in the CB17 to IBO1 section.

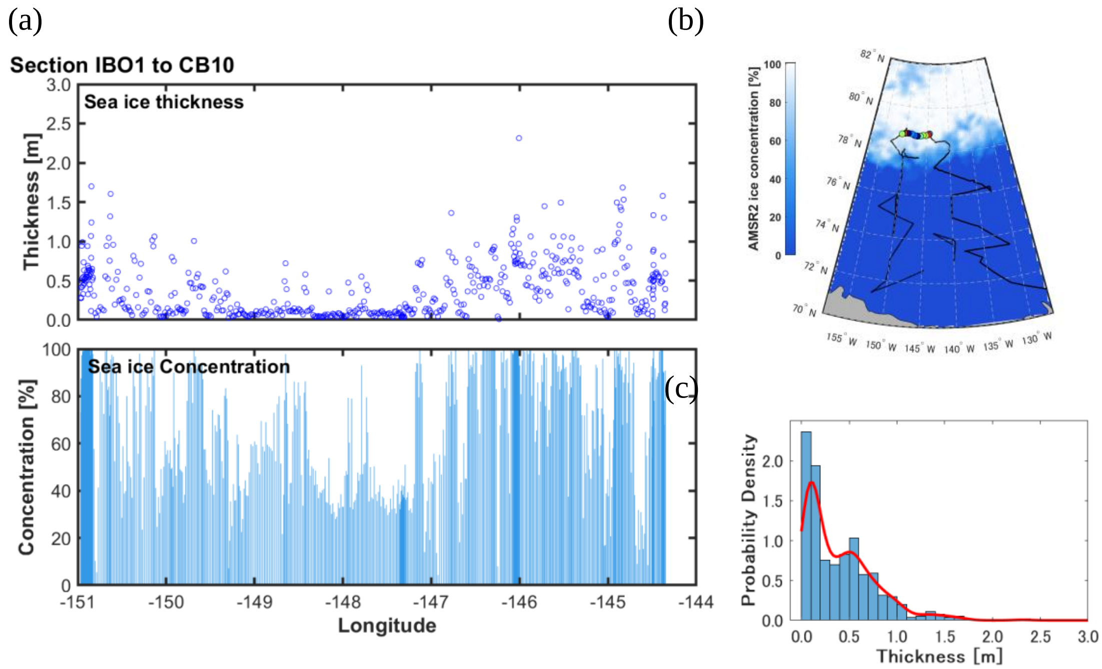


Figure 37. (a) Distribution of total ice thickness and sea ice concentration, (b) map of total ice thickness distribution, (c) Histograms and Probability Density Functions in the IBO1 to CB10 section.

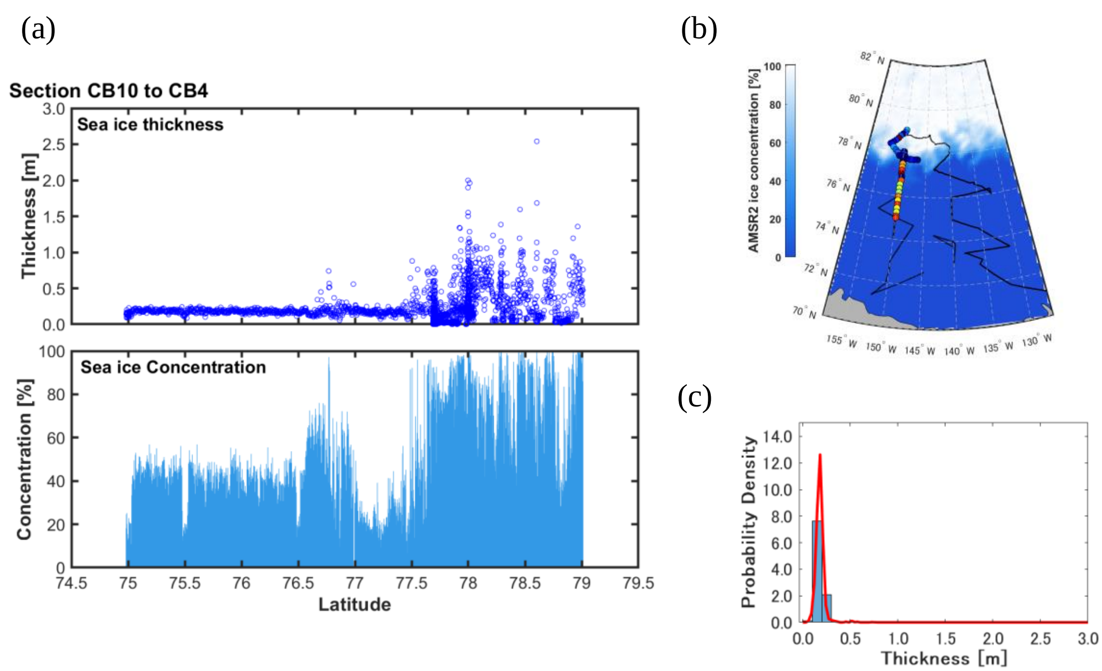


Figure 38. (a) Distribution of total ice thickness and sea ice concentration, (b) map of total ice thickness distribution, (c) Histograms and Probability Density Functions in the CB10 to CB4 section.

3.9.5 Ship Performance

Yuki Ishiyama (UTokyo)
P.I.: Takuji Waseda(UTokyo)

LSSL's performance data has been collected since 2023. This year, propeller shaft revolutions, power (No.1–No.3 propulsion motors, No.1–No.5 generators), and fuel consumption were provided by CCG engineers. Ship speed is collected from RMC_*.Raw files on the science server.

The propeller shaft RPM and the power of the motors and generators were provided in CSV format. Although the data acquisition frequency is not completely consistent, data is obtained approximately once per minute. Additionally, the time of data acquisition is included in CSV files. The motors and generators are numbered as 1, 2, 3… from the port side. The maximum output for each motor is 6,714 kW. Daily fuel consumption is recorded once a day in Engineer Log Book at motor control room, covering the 24-hour period from 00:00 to 24:00 on ship's local time (UTC-6 in JOIS2024).

Performance data collection was made in open water as well as in ice-covered conditions. Fig. 9 The propeller shaft RPM and the power of the motors and generators were provided in CSV format. Although the data acquisition frequency is not completely consistent, data is obtained approximately once per minute. Additionally, the time of data acquisition is included in CSV files. The motors and generators are numbered as 1, 2, 3… from the port side. The maximum output for each motor is 6,714 kW. Fuel consumption is recorded once a day in Engineer Log Book at motor control room, covering the 24-hour period from 00:00 to 24:00 according to the ship's local time (UTC-6 in JOIS2024). Fuel consumption is calculated by reading the fuel tank level and measuring the difference.

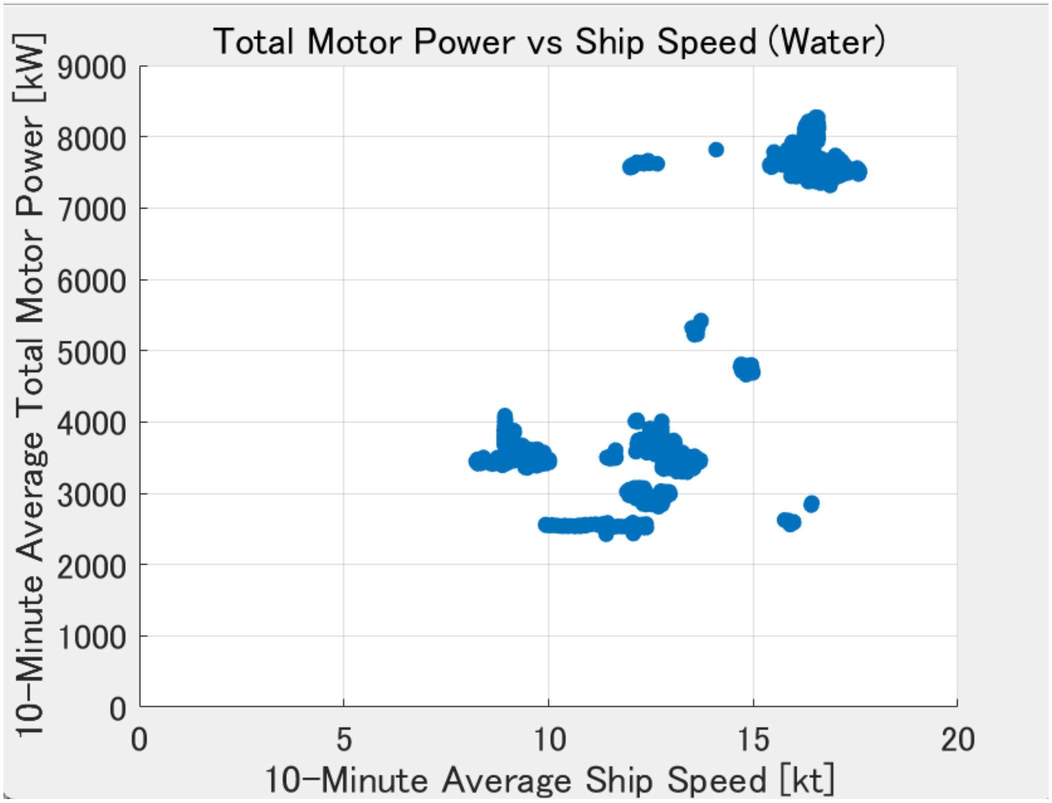


Figure 39. Total propulsion power vs ship speed in open water.

Figure 39 presents data collected in ice. Again, total propulsion power is plotted against ship speed. The color of the plot represents the sea ice concentration obtained from visual sea ice observations. From the figure, even with the same total motor power, lower sea ice concentration plots (blue plots) tend to have higher ship speeds compared to higher sea ice concentration plots (red plots). For example, when a total motor power around 3500 kW, the ship speed is 14 kt at 0% sea ice concentration, whereas the speed is 8 kt when the sea ice concentration is 100%. It should be noted that this figure focuses only on sea ice concentration and does not take ice thickness into consideration.

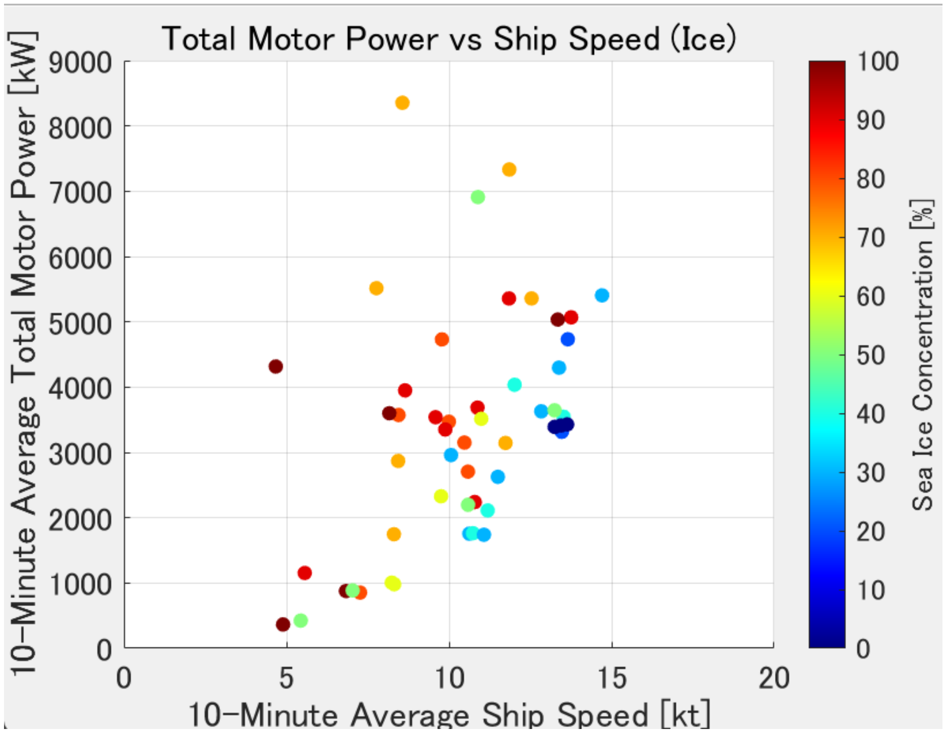


Figure 40. Total propulsion power vs ship speed in ice.

Figure 41. Example of icebreaking navigation.

3.9.6 Passive Microwave Radiometer observation

Kazu Tateyama, Yusuke Kohama (KIT)
P.I.: Kazu Tateyama (KIT)

Observation of passive microwave radiation from sea-ice or sea water were conducted using a portable Passive Microwave Radiometer (PMR) which is developed by Mitubishi Electric Tokki Systems Co., Ltd., Japan. A Microwave/Miliwave Radiometer Systems (MMRS2B) was used for two frequencies and polarizations: 18GHz with vertical and horizontal polarization. A radiation thermometer and a visible camera also provide surface temperature in Kelvin and its visible image. SEM thickness and PMRs were collected sea-ice thickness and its microwave radiometric properties in order to validate and improve the algorithm for estimation of the Arctic snow/sea-ice total thickness by using the AMSR2 [Krishfield et al., 2014].

The brightness temperatures of 18 GHz-V and -H and IR observations were carried out while the vessel was on station in sea ice and open water during September 10 to 13 as shown in Fig.12. The results are summarized in Table 2.

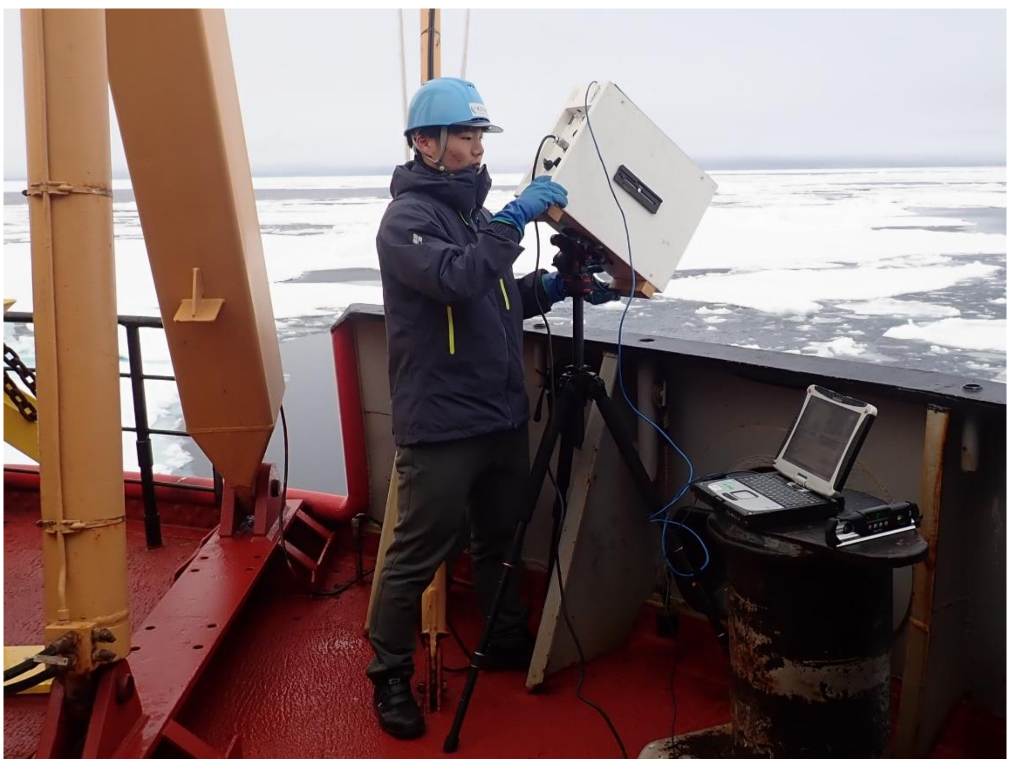


Figure 42. Photo of PMR observation.

Table 15. Results of passive microwave observation.

Date	Observation Type (Incident angle)	18GHz V-pol (K)				18GHz H-pol (K)			
		Brightness Temperature		Infrared Temperature		Brightness Temperature		Infrared Temperature	
		Ave	Std	Ave	Std	Ave	Std	Ave	Std
9/10	Calibration	277.2	1.2	288.5	0.3	-	-	-	-
9/10	Sea ice (Moving) (35°)	219.2	10.5	284.5	0.4	-	-	-	-
9/11	Calibration	273.8	0.2	279.9	0.1	-	-	-	-
9/11	Open Water (35°)	181.3	0.3	278.8	0.1	98.8	0.2	279.9	0.1
9/12	Calibration	276.2	0.4	282.6	0.4				
9/12	Open Water (35°)	190.7	0.2	277.4	0.1	108.1	0.3	277.0	0.1
9/12	Open Water (35°)	189.3	0.2	277.3	0.1	107.2	0.2	276.7	0.1
9/12	Open Water (35°)	189.9	0.2	277.2	0.1	108.7	0.3	276.5	0.1
9/12	Open Water (35°)	187.1	0.2	278.9	0.1	-	-	-	-
9/12	Open Water (45°)	163.0	0.2	279.4	0.1	-	-	-	-
9/12	Open Water (45°)	166.8	0.2	280.4	0.1	-	-	-	-
9/12	Second year ice (35°)	230.8	0.2	279.1	0.1	184.9	0.2	279.0	0.1
9/12	Second year ice (35°)	236.3	0.2	278.4	0.1	184.1	0.2	278.8	0.1
9/12	Second year ice (35°)	231.5	0.3	278.3	0.1	189.1	0.3	278.7	0.1
9/12	Second year ice (35°)	220.5	0.2	279.9	0.1	-	-	-	-
9/13	Calibration	269.3	0.2	278.1	0.2	268.4	0.3	279.6	0.2
9/13	Open Water (35°)	179.8	0.3	280.4	0.1	103.9	0.7	280.5	0.2
9/13	Sky	21.2	0.2	275.8	0.2	19.7	0.2	276.6	0.1

3.9.7 Thermal camera observation

Yuki Ishiyama (UTokyo)
P.I.: Takuji Waseda(UTokyo)

From this year, thermal camera observations were newly conducted. This camera can distinguish the surface temperature difference by measuring Infrared ray. The purpose of this observation is to investigate the temperature difference between sea ice and open water.

From September 5 to September 18, thermal camera images and visual images were simultaneously taken. The images were taken on the port side, starboard side, and aft of the ship.

Thermal camera images were obtained for nilas, first-year ice, multi-year ice, brash ice, and open water. Figure 7 shows the example of the captured thermal camera image. Figure 8 is a histogram of the temperature distribution measured by the thermal camera. It shows that there are two peaks in temperature distribution. The left one is sea ice and the right one is open water.

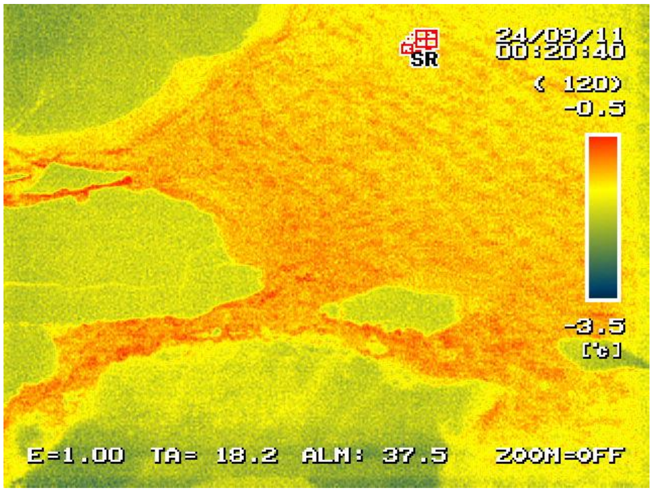


Figure 43. Example of the captured thermal camera image

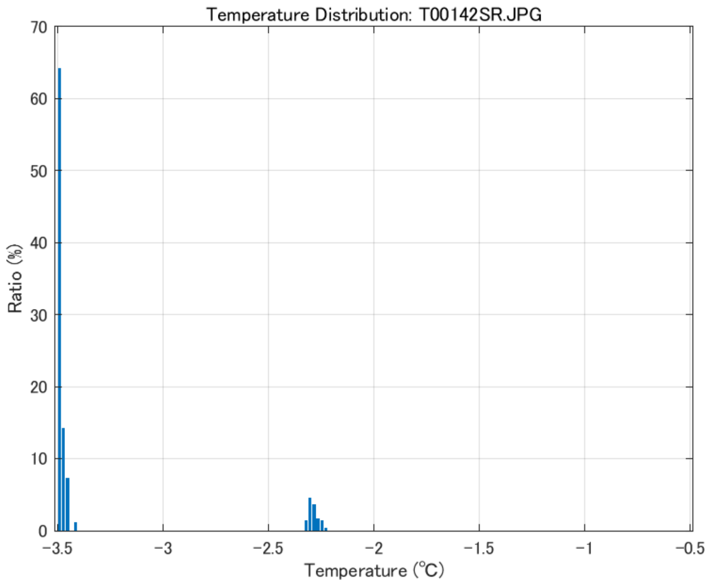


Figure 44. Temperature distribution of thermal camera image

3.9.8 Ice Station Ice Observations

Kazu Tateyama(KIT), Yusuke Kohama (KIT), Yukihide Ishiyama(UTokyo), Tianyu Zhou(UDelware), Magali Pucet(USherbrooke), Margot de Mecqunem(USherbrooke), Michiyo Yamamoto- Kawai(TUMSAT), Mark Belton(DFO-IOS), Mackenzie Mueller(DFO-IOS), Seth Felming-Alho(DFO-IOS), Paige Hagel(DFO-IOS), Jeniffer Kosty(Yale)
P.I.: Jennifer Hutchings (OSU), Kazu Tateyama (KIT)

Ice thickness transects were taken at 2 ice stations to characterize the sea-ice floe where WHOI's ITPs were deployed. In parallel, ice cores and snow sample were taken for temperature, salinity and density profiles.

Ice and snow measurements were conducted by following the standard JOIS protocol at each ice station.

1. Establishing 100m-long or 200m-long transect line by using tape measure and flags
2. Collecting snow depth, ice thickness and freeboard data along transects at every 10m by using an electrical-powered ice auger with a generator.
3. Collecting ice cores at 0m, 50m, 100m by using an ice corer with an engine.
4. Measuring snow pit at 0m, 50m, 100m

Overview of ice stations

<u>Ice Station 1</u>
Coring: Kazu Tateyama, Yusuke Kohama, Yuki Ishiyama
Snow pit: Kazu Tateyama

Ice was accessed using man basket of starboard side. Only one ice core was collected due to short stay.

<u>Ice Station 2</u>
Drilling: Yusuke Kohama, Mark Belton, Margot de Mecqunem
Coring: Yukihide Ishiyama, Tianyu Zhou, Magali Pucet, Michiyo Yamamoto- Kawai, Mackenzie Mueller, Seth Felming-Alho, Paige Hagel, Jeniffer Kosty
Snow pit: Kazu Tateyama

Ice was accessed from gangway of port side. A 200m-long transect was set as shown in Fig.9. Ice cores were collected at four sites along the transect line. The average thickness of snow and ice along the transect line was 0.044m and 0.56m for line 1, and 0.046m and 0.47m for line 2, respectively.

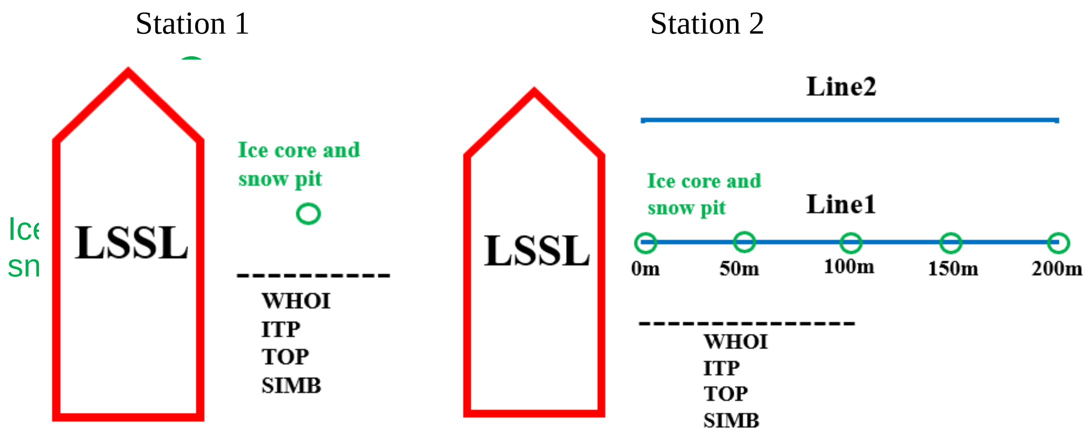


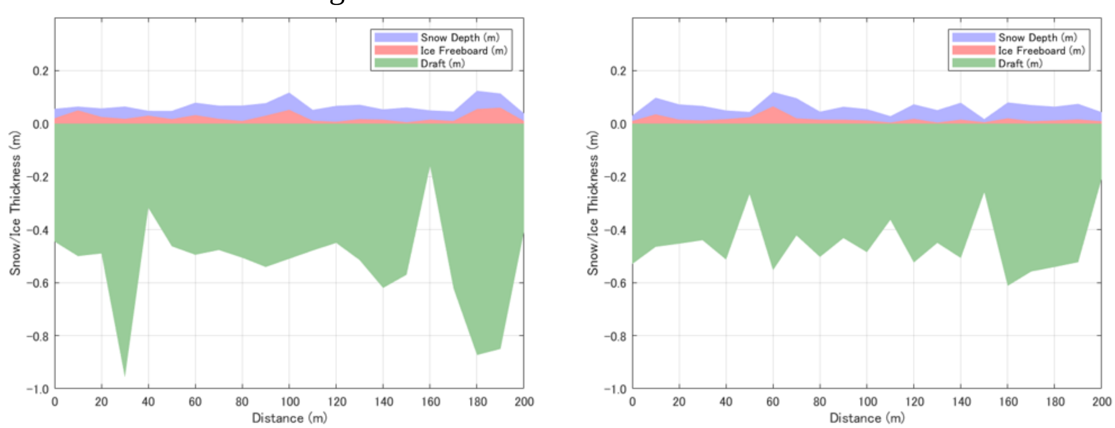
Figure 45. Schematics of point and transects on each ice stations.

Ice thickness transects

At ice station 2, we conducted two 200 m transects measuring snow depth, ice thickness and ice freeboard every 10 m along the transect lines.

A 2” ice auger and electric drill were used to make a hole in the sea-ice. Ice thickness and freeboard were measured with using a tape measure with a weighted end (“dongle”). Snow depth was measured with a plastic ruler.

The results are shown in Fig.10.



Ice transect line1 Ice transect line2

Figure 46. Thickness of snow and ice, freeboard measurements at line1 and line2 of ice station2.

Ice core

Table 3 shows the summary of collected ice core samples. 6 physics cores in total were taken from station 1 and 2.

Cores were collected using a 1m-long 4” diameter corer using a new electric powered auger head. Immediately after collecting the core, the temperature was measured at 10cm intervals starting at 5cm. The core was then sectioned into 5cm chunks, measured for density, bagged and melted back on board for salinity measurements. Salinity was measured using a hand held salinity probe.

Table 16. Summary of collected ice core samples and snow pit observation.

Station	Transect #, Distance	Core - Property	Snow Pit
1		Temperature, Salinity, Density	Yes
2	Transect 1, 0m Transect 1, 50m Transect 1, 100m Transect 1, 150m Transect 1, 200m	Temperature, Salinity, Density	Yes Yes Yes

Station#1 core A 176cm

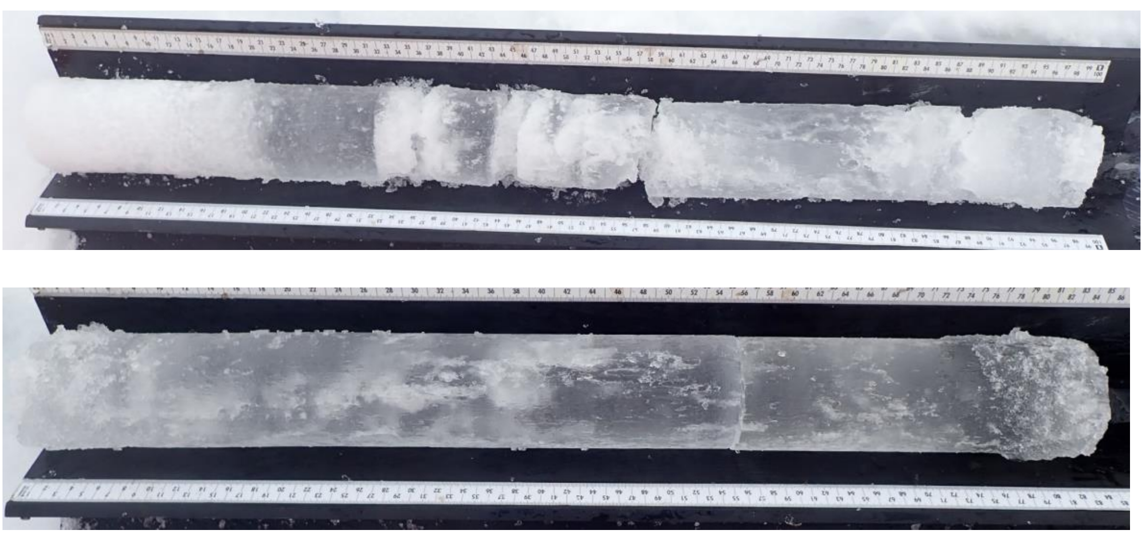
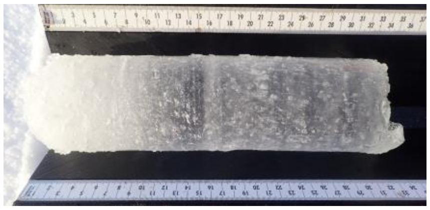


Figure 47. Photos of ice core samples from station 1.

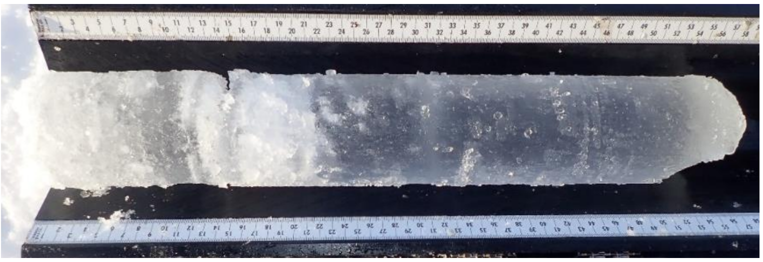
Station#2-T0m core A 32cm



Station#2-T50m core A 35cm

Station#2-T100m core A 60cm

Station#2-T150m core A 56cm



Station#2-T200m core A 35cm

Figure 48. Photos of ice core samples from station 2.

Temperature, Salinity and Density Profiles

Temperature, salinity and density profiles were measured at each core site. Figure 49 shows temperature, salinity and density profiles of ice.

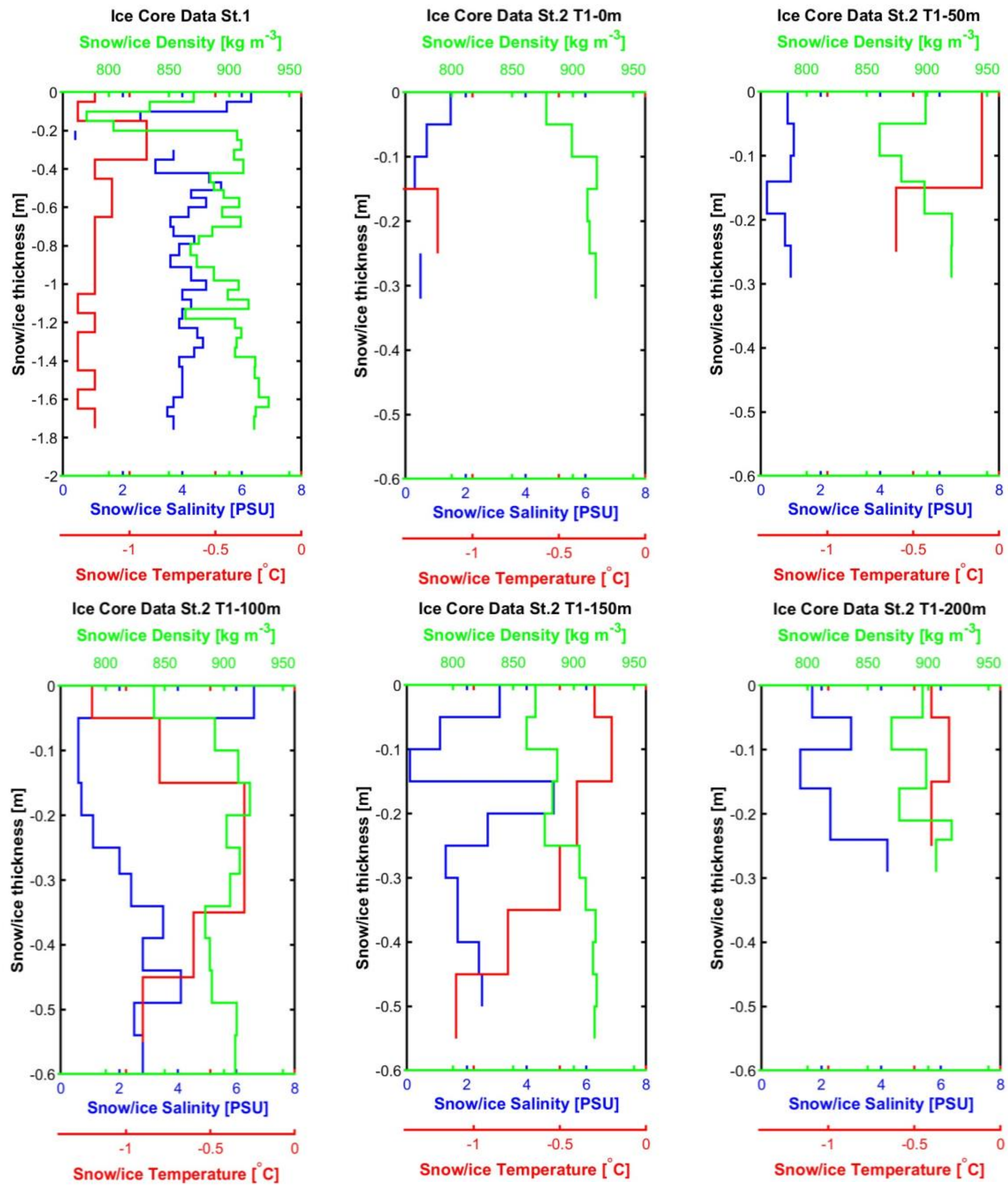


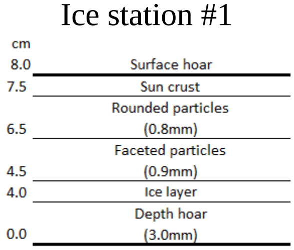
Figure 49. Temperature, salinity and density profiles of ice core samples from Ice station 1 and 2.

Snow pits

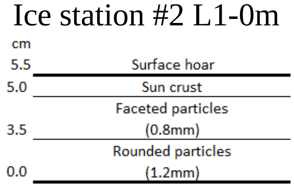
Figure 50 and 51 show an example of t snow cross-section and the snow layer structure and photographs of observed snow crystal types.

Figure 50. Results

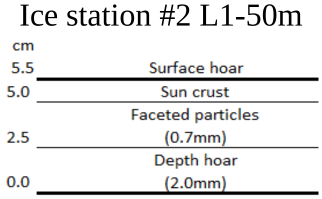
Ice station #1



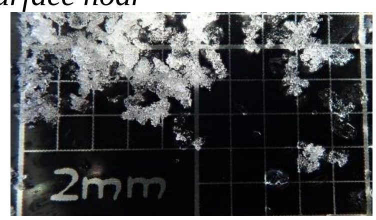
Ice station #2 L1-0m



Ice station #2 L1-50m

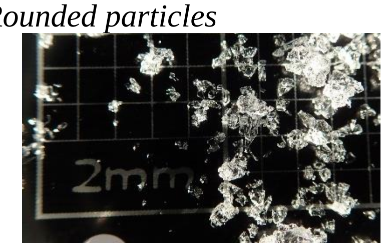


Surface hoar



Sun Crust

Rounded particles



Faceted particles

Figure 51. Results of snow layer structures and photographs of representative snow crystals obtained from snow pit observations.

Wave buoy

Yuki Ishiyama (UTokyo)
P.I.: Takuji Waseda(UTokyo)

Wave buoy is a newly introduced observation instrument from this year. At each ice station, one wave buoy was installed. Total of 2 wave buoys were deployed. The purpose of this buoy is to measure waves propagating under the sea ice. The buoy is equipped with an IMU and an Iridium antenna, and the collected wave data and buoy's GPS position are transmitted to land via the Iridium satellite. Table 4 shows the date, location and Ice thickness information for each buoy.

Table 17. Wave buoy deployment Summary

Event	Date (UTC)	Location	Ice thickness (m)
Wave buoy St.1	Sept. 7, 2024 21:20	78° 49.6392' N, 144°27.8815' W	1.76
Wave buoy St.2	Sept. 8, 2024 19:00	78° 42.9344' N, 150°46.0521' W	0.35

3.9.9 Ice Observation Data

lsloaa::sciencenet/2024-011-JOIS/Data/

- /JOIS2024_Icestation_Transect_Core/
  JOIS2024_Ice_Stations_Summery.xlsx
  JOIS2024_IceStation_IceCore.xlsx
  JOIS2024_IceStation_Transect.xlsx
  JOIS2024_IceStation_SnowPit.xlsx
    /Ice_station#1/ and /Ice_station#3/
    /Ice Core Photos/
    /Snow pit photos/

- /Ice_Watch/
  JOIS2024_ice_watch.xlsx
  /Ice_Watch_Photos/

- /Shipborne_EM/
  Not ready

3.9.10 Ice Observation References

Hutchings, JK, Heil, P, Lecomte, O, Stevens, R, Steer, A and Lieser, JL. (2015). Comparing methods of measuring sea-ice density in the East Antarctic. *Ann. Glaciol*., 56(69): 77-82 (*doi.org/10.3189/2015AoG69A814).*

Krishfield, RA, Proshutinsky, A, Tateyama, K, Williams, WJ, Carmack, EC, McLaughlin, FA and Timmermans, M-L. (2014). Deterioration of perennial sea ice in the Beaufort Gyre from 2003 to 2012 and its impact on the oceanic freshwater cycle. *J. of Geophys. Res.: Oceans*. 119(2): 1271-1305.

Tateyama, K, Inoue, J, Hoshino, S, Sasaki, S and Tanaka, Y. (2018). Development of a new algorithm to estimate Arctic sea-ice thickness based on Advanced Microwave Scanning Radiometer 2 data. *Okhotsk Sea and Polar Oceans Research*, 2:13-18.

3.10 Meteorological Buoys (ECCC)

Paul Macoun (DFO-IOS)
Puneet Jaswal (ECCC)

Environment and Climate Change Canada (ECCC) shipped 7 MetOcean buoys to the CCGS Louis S. St-Laurent in July for deployment during the JOIS 2024 program.

The models of the 7 buoys are as follows:

- 2 X SVP-I-BXGSA-L-AD
- 1 X SVP-I-BDGS
- 4 X SVP-I-BXGS-LP

The 2 SVP-I-BXGSA-L-AD buoys are designed to be dropped from a low flying aircraft and had an added harness for that purpose. These harnesses were removed. The single SVP-I-BDGS buoy is outfitted with a drogue for open water deployment. The remaining

4 SVP-I-BXGS-LP floats are configured for deployment in open water, amongst ice or even on the ice.

As of the time of this report, one buoy has stopped reporting data. Buoy #4, Model SVP-I-BXGS-LP, Serial Number J1HUZI, deployed at 9:02 UTC on September 9th is not communicating. It is possible the buoy has been covered by ice, or its antenna is no longer facing skyward.

Table 18: Buoy & Activation Information (magnet removal)

#	Model	Serial Number	IMEI Number	Date	Time (UTC)
1	SVP-I-BXGS-LP	J1HUXZ	300534062591760	4-Sep-24	15:50
2	SVP-I-BXGS-LP	J1HUZF	300534062598760	4-Sep-24	15:51
3	SVP-I-BXGS-LP	J1HVDO	300534062497970	4-Sep-24	15:51
4	SVP-I-BXGS-LP	J1HUZI	300534062594760	4-Sep-24	15:51
5	SVP-I-BXGSA-L-AD	J06UJ1	300234063511510	4-Sep-24	15:52
6	SVP-I-BXGSA-L-AD	J05HW5	300234062552760	4-Sep-24	15:52
7	SVP-I-BDGS	J1HTDN	300534062593800	5-Sep-24	16:27

Table 19: Deployment Information

#	Date	Time (UTC)	Lat (N)	Long (W)	Photo	Site Description
1	7-Sep-24	2:00	78.00	140.00	Yes	CB16, floes and open water
2	8-Sep-24	4:30	78.84	144.51	Yes	IB01, floes, thin layer ice, water
3	8-Sep-24	22:45	78.77	151.00	Yes	IB02, on ice floe 6 X 4 nm
4	9-Sep-24	9:02	79.00	150.00	**No**	CB11, dark
5	9-Sep-24	17:30	78.30	153.21	Yes	CB10, floes, thin layer ice, water
6	10-Sep-24	7:21	77.70	146.70	**No**	CB12, dark
7	13-Sep-24	3:51	77.00	150.00	Yes	CB8, open water, limited ice

Model: SVP-I-BXGS-LP Serial Number: J1HUXZ

Model: SVP-I-BXGS-LP Serial Number: J1HUZF

Model: SVP-I-BXGS-LP Serial Number: J1HVDO

Model: SVP-I-BXGSA-L-AD Serial Number: J06UJ1

Model: SVP-I-BDGS Serial Number: J1HTDN

Buoys on back deck after activation

Figure 52: Deployment Photos

3.11 Slocum Glider

Seth Fleming-Alho (DFO-IOS)

PI: Stephanie Waterman (UBC)

Table 20. Glider deployment and recovery details

Date	Time (UTC)	Lat (N)	Long (W)	
2-Sep	19:49	73.429	138.181	Deployment
20-Sep	20:30	73.764	139.958	Recovery

0n on the Louis St Laurent the Slocum Glider Mike was deployed on September 2nd 19:49 UTC at 72.996 N -140.195 E. The glider spent 15 days measuring temperature, backscatter, dissolved oxygen, salinity, chlorophyll and CDOM. The glider appears to have caught some form of debris on the 7th of September which leads to the glider being nose heavy for the rest of the mission duration. Further evidence to something being caught on the glider is visible in the backscatter plot seen below.

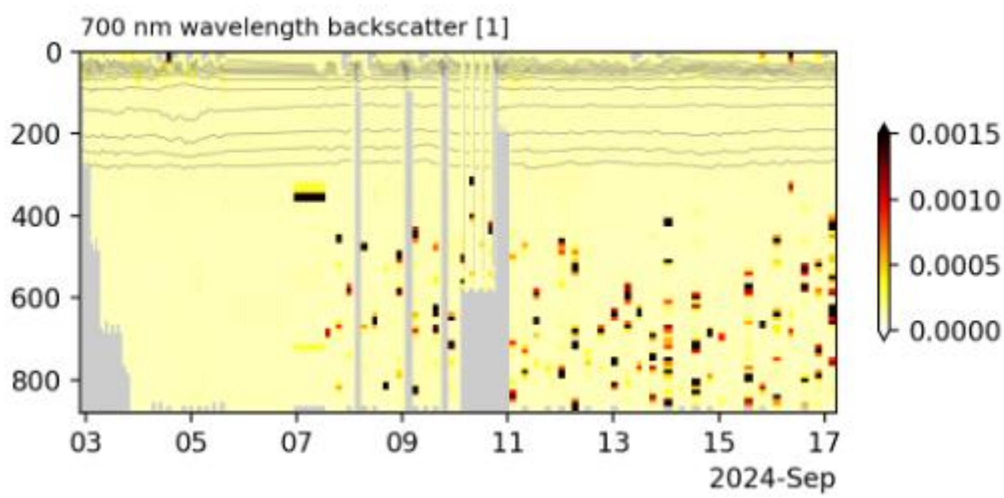


Figure 53: Backscatter plot evidence for debris caught on glider

This debris lead the glider pilots to attempt maneuvers to dislodge the object but attempt proved unsuccessful.

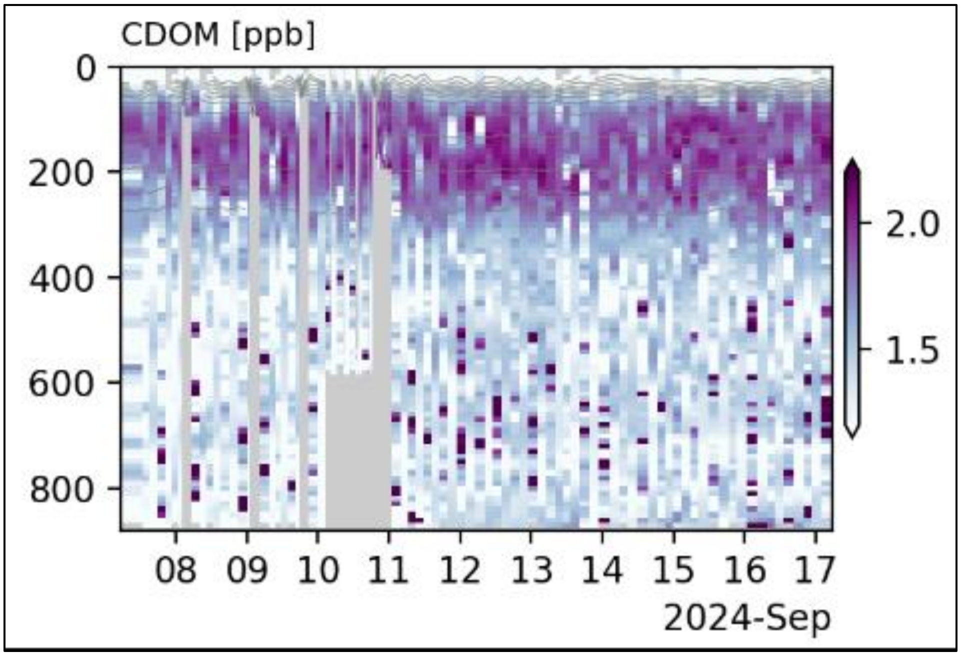


Figure 54: Further evidence for debris in the CDOM plot

The glider still managed to capture valuable cast data and it was able to maneuver to approximately 20km from the expected rendezvous pickup point. See below for the glider track.

Figure 55: Glider "Mike's" track

The glider did hit a science error during its last day and spent slightly less than a day adrift. During recovery the sea state was less than ideal leading to the loss of a wing. It was also noted during recovery upon approaching the glider it was missing its thruster. It has been theorized that during the glider`s surface drift the object dislodged itself and took the (magnetically coupled) thruster with it.

Full details for the glider mission can be found here
https://cproof.uvic.ca/gliderdata/deployments/dfo-mike579/dfo-mike579-20240902/

The glider has had its data downloaded and it's packed back into its crate for its return trip to UBC.

Figure 56. Glider going out for deployment.

3.12 Underway CTD (UCTD)

An OceanScience Underway CTD (UCTD) system was mounted on the stern of the ship with the goal of testing the set up and seeing if the UCTD could be used to measure the upper 50m without the effect of ship mixing due to prop-wash.
The UCTD free falls while the ship is underway, measuring pressure, temperature and conductivity (salinity) data.
All casts with UCTD probe SN 70200108.

The ship was slowed to 10knts and a few tests were performed:

uctd0001
Single drop with bobbin wound with 435m of line, free fall, ship at 10knt

uctd0002 TowYoTesting

Series of freewheel and reeling in without recovering sensor. Ship 10knt. Freewheel of 5, 10, 30 and 60 seconds.

uctd0003 TowYoAfterXCTD
One more 60 sec tow. Ship running at 10knt.

uctd0004 TowYo
Series of 20sec deployments. First set of 10 w/ probe starting about 30m behind the ship. Second set of 10 with probe starting ~130m behind ship. Could see probe was in ship's wake or just to the side. Final drop (21st) was after a combined payout of 80 sec. Probe was not visible before the start of the drop, likely underwater.

uctd0004 to uctd0013 Mackenzie Trough
Set of casts as ship transited over Mackenzie Trough

4 APPENDIX

4.1 Science Participants

Table A1. Onboard Science Participants

Number	Personnel	Institution	Role
1	Paul Macoun	DFO-IOS	Co-Chief Scientist, CCG Liaison
2	Sarah Zimmermann	DFO-IOS	Co-Chief Scientist, Data Specialist
3	Paige Hagel	DFO-IOS	Technician, Watchleader
4	Mike Dempsey	DFO-IOS	Technician (lead), Watchleader
5	Sarah Ann Quesnel	DFO-IOS	Nutrient Analyst (lead)
6	Marty Davelaar	DFO-IOS	DIC Analyst (lead)
7	MacKenzie Mueller	DFO-IOS	DIC/Salts Analyst
8	Mark Belton	DFO-IOS	Oxygen Analyst (lead)
9	Seth Fleming-Alho	DFO-IOS	CTD Operations/Analyst
10	Celine Guegen	USherbrooke	Scientist, CDOM (lead)
11	Magali Pucet	USherbrooke	CDOM Analyst, Student
12	Margot de Mecquenem	USherbrooke	CDOM Analyst, Student
13	Tianyu Zhou	UDelaware	O2/Argon Analyst
14	Mary-Louise Timmermans	Yale	BGOS Scientist (lead)
15	Ashley Arroyo	Yale	BGOS, Student
16	Jennifer Kosty	Yale	BGOS, Student
17	Jeff O'Brien	WHOI	Moorings & Buoys (lead)
18	Nico Llanos	WHOI	Moorings & Buoys Technician
19	Tim McDonough	WHOI	Moorings & Buoys Technician
20	Eric Trotto	WHOI	Moorings & Buoys Technician
21	Michael DeGrandpre	UMontana	Mooring & Buoys - pCO2
22	Kazu Tateyama	KIT	Scientist, Sea ice Observations (lead)
23	Yusuke Kohama	KIT	Sea ice Observations. Student
24	Yukihide Ishiyama	KIT	Sea ice Observations. Student
25	Michiyo Yamamoto-Kawai	TUMSAT	Scientist, Alkalinity (lead)

Table A2. Principal Investigators Onshore

Name	Affiliation	Program
Bill Williams	DFO-IOS	DFO Program lead
Isabela LeBras	WHOI	Mooring and Buoy co-lead
Andrey Proshutinsky	WHOI	Moorings and ITP program lead / CTD/Rosette / XCTD
Richard Krishfield	WHOI	Moorings and ITP / CTD/Rosette / XCTD
John Toole	WHOI	ITP Buoys
Motoyo Itoh	JAMSTEC	CTD/Rosette / XCTD
Shigeto Nishino	JAMSTEC	CTD/Rosette
Takashi Kikuchi	JAMSTEC	CTD/Rosette
Don Perovich	CRREL	Ice Mass-Balance Buoy
David Walsh	ConcordiaU	CTD/Rosette / Microbial Diversity
John Nelson	DFO-IOS	Zooplankton
John Smith	DFO-BIO	CTD / Rosette / ^{129}I $\cancel{/ ^{236}U}$
Nuria Casacuberta Arola	ETH Zurich	CTD / Rosette / ^{129}I $\cancel{/ ^{236}U / ^{39}Ar / ^{14}C;}$
Jennifer Hutchings	OSU	Ice Observations
Wei-Jun Cai	UDelaware	$\delta^{13}C$-DIC
Zhangxian Ouyang	UDelaware	O2/Ar from Underway Seawater Loop
Tetjana Ross	DFO-IOS	Argo Floats
Chris Gordon	DFO-BIO	Argo Floats
Stephanie Waterman	UBC	Glider
Alexander Zucconi	ECCC	Met SVP Buoys
Puneet Jaswal	ECCC	Met SVP Buoys
Ignatius Rigor	UW, IABP	IMB Buoy
Andrew Ross	DFO-IOS	BioToxins (CTD/Rosette)
Elizabeth Priebe	CNL	Tritium water samples (ship of opportunity)

Table A3. Affiliation Abbreviations.

Abbreviation	Definition
APL	Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
BIO	Bedford Institute of Oceanography, DFO, Dartmouth, NS, Canada
ConcordiaU	Concordia University, Montreal, Qc, Canada
CNL	Canada's Nuclear Laboratory
CRREL	Cold Regions Research Laboratory, New Hampshire, USA
DFO	Department of Fisheries and Oceans, Canada
ETH Zurich	ETH Zurich, Switzerland
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
NPS	Naval Postgraduate School, Monterey, California, USA
OSU	Oregon State University, Corvallis, Oregon, USA
TUMSAT	Tokyo University of Marine Science and Technology, Tokyo, Japan
UDeleware	University of Delaware, Newark, Delaware, USA
UMontana	University of Montana, Missoula, Montana, USA
USherbrooke	University of Sherbrooke, Quebec, Canada
WHOI	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
YaleU	Yale University, New Haven, Connecticut, USA

Table A4. Project website URLs.

Project	Website Address
Beaufort Gyre Observing System	https://www2.whoi.edu/site/beaufortgyre/
Beaufort Gyre Observing System dispatches	https://www2.whoi.edu/site/beaufortgyre/expeditions/
Ice-Tethered Profiler buoys	https://www2.whoi.edu/site/itp/
Ice Mass Balance buoys	https://imb-crrel-dartmouth.org/simb3/
Arctic Ocean Flux Buoy	www.oc.nps.edu/~stanton/fluxbuoy/
Glider	https://www.oceangliderscanada.ca/groups/72/ and https://cproof.uvic.ca/ Zoom map out to see arctic deployment.
ARGO Floats	https://www.aoml.noaa.gov/argo/ and https://argo.ucsd.edu/data/
Arctic Mooring Locations (research community not just ours)	Maritime Operations | Arctic Watch (scroll down to current conditions)

4.2 Location of Science Stations

The scientific crew boarded the *CCGS Louis S. St-Laurent* icebreaker in Cambridge Bay, NU, on 29 August, 2024 and departed Cambridge Bay, NU on 26 September, 2024.

Locations of CTD/Rosette, XCTD, zooplankton vertical net, as well as the mooring and buoy recovery and deployments are listed in the tables below.

4.2.1 CTD/Rosette

Table A5. CTD/Rosette cast locations

CTD Cast #	Station Name	CAST START DATE and Time (UTC)	Latitude (°N)	Longitute (°W)	Water Depth (m) Knudsen 12kHz Sounder	**Cast Depth (m)** (Max CTD depth)	Sample Numbers	Ice Coverage (tenths) (Rough Estimate by CTD Operator)	Comment for Cruise Report
1	AG5	9/1/2024 0:34	70.5503	122.8982	646	630	1-24	0/10	Combined Geochem and Productivity ("DNA/RNA" cast)
2	CB1	9/1/2024 18:13	71.7797	131.8873	1122	1114	25-48	0/10	
3	CB31b	9/2/2024 0:29	72.3468	134.0083	2040	2053	49-72	0/10	
4	CB23A	9/2/2024 7:13	72.8977	135.9937	2759	2735	73-96	0/10	
5	CB22	9/2/2024 14:51	73.4477	137.9878	3121	3111		0/10	No samples. Niskin vents open so retook cast.
6	CB22	9/2/2024 23:11	73.4502	138.0003	3122	1007	97-120	0/10	
7	CB50	9/3/2024 6:43	73.5010	134.2470	2888	2875	121-144	0/10	
8	CB51	9/3/2024 14:12	73.4980	130.8957	2494	2485	145-168	0/10	
9	CB40	9/4/2024 0:21	74.4975	135.4215	3236	3241	169-192	0/10	
10	CB18	9/4/2024 9:25	75.0013	140.0008	3624	3620	193-216	0/10	
11	CB17	9/4/2024 18:35	76.0013	140.0070	3696	3687	217-240	0/10	
12	PP6	9/5/2024 9:45	76.2607	132.5278	3100	3043	241-264	1/10	
13	PP7	9/5/2024 20:20	76.5462	135.4300	3560	3558	265-288	1/10	
14	CB15	9/6/2024 7:12	76.9995	139.9927	3724	3717	289-312	0/10	
15	CB13	9/6/2024 16:45	77.3007	143.2963	3778	3772	313-336		Replaced transmissometer CSTAR1050DR with CSTAR10520R; Jelly caught on rosette frame.
16	CB16	9/7/2024 1:13	77.9970	139.9747	3749	3740	337-360	5/10	Transmissometer CSTAR1052DR removed and CSTAR1050DR put back in.
17	IBO2 test	9/8/2024 0:05	78.8162	144.4912	3802	101	-		CTD sensor test cast to 100m. Fluorometer is dummied off to see how transmissometer responds.
18	IBO2-DNA	9/8/2024 0:21	78.8175	144.4868	3806	251	361-368	8/10	Productivity cast; new ice forming (less than 1cm)
19	IBO-2 Geo	9/8/2024 1:39	78.8220	144.4512	3806	3797	369-392	9/10	Geochemistry cast
20	IBO-1	9/9/2024 0:55	78.7265	150.8978	3829	800	393-416	9/10	ITP/TOP/SAMI calibration cast and high res lower halocline sampling; Small jelly seen in water moving near the wire; On-

									ice sample (#9001) at 3m was also taken for SAMI calibration. Its in it own chemistry spreadsheet.
21	CB11	9/9/2024 6:02	79.0012	149.9790	3827	3807	417-440	7/10	
22	CB10	9/9/2024 15:33	78.3035	153.2200	2334	2349	441-464	6/10	Niskin 14 (#454) did not close properly due to pair of pliers left in bottle and lip stayed open.
23	TOP15	9/10/2024 0:31	77.7178	149.4822	3790	801	-		TOP15 calibration cast - no bottles
24	CB12	9/10/2024 4:33	77.6993	146.6893	3811	3802	465-488	5/10	
25	CB9-DNA	9/10/2024 19:43	78.0042	149.9172	3827	602	489-504	4/10	Productivity cast
26	CB-9 Geochen	9/11/2024 0:08	78.0307	149.8450	3834	3811	505-528		'Geochemistry cast. On upcast at 1666m the winch was stopped due poor wire-wraps on winch. CTD raised to 1600m then back down to fix wrap. Niskins 1-3 (Samples #505, 506, 507) may be questionable due to the CTD being re-lowered Leaky spigot on Niskin 2, probably due to the wire incident.
27	CB-9DeepW	9/11/2024 7:22	78.0107	149.8968	3824	3812	529-552	5/10	CB9 Deep Water cast. More winch adjustments: on downcast at 1800m the spooling was adjusted. The fairlead rollers appeared to be lagging wire on forward drumcheek. The fairlead diamond screw follower was advanced 4mm. Cast spooled OK. After cast, pylon trigger #452 removed and cleaned trigger #498 put on.
28	CB9-CO2	9/12/2024 5:06	78.0010	149.9888	3827	250	553-559	5/10	BGOS-B SAMI calibration cast (CB9). Niskin 5 empty, closed at surface.
29	CB8	9/13/2024 1:01	76.9972	149.9822	3826	3815	560-583	2/10	Seal seen swimming with its head popping up during downcast.
30	CB3	9/14/2024 0:01	74.0000	150.0015	3826	3813	584-607	0/10	
31	CB4 DNA	9/14/2024 7:45	75.0002	149.9958	3826	1003	608-630	0/10	
32	CB4 Geochem	9/14/2024 9:56	75.0008	150.0037	3826	3816	631-654	0/10	
33	CB7	9/15/2024 0:23	76.0000	149.9995	3832	3819	655-678	0/10	Niskin 3 didn't close - trigger locked.
34	CB5	9/15/2024 8:11	75.3035	153.2893	3846	3831	679-702	0/10	Styrafoam cup cast for souveneirs. Bags of cups attached to rosette frame.
35	CB6	9/15/2024 19:53	74.7017	146.7152	3700	3771	703-726	0/10	Water seen draining over the side of the ship (from salt lab) during 3 min soak at 10m at the start of the cast. Check first few meters of downcast for poor data.
36	CB2	9/16/2024 7:51	73.0037	150.0005	3730	3738	727-750	0/10	
37	CB2a	9/16/2024 14:10	72.5003	150.0035	3727	3712	751-774	0/10	Jelly strand noticed on rosette after cast.
38	BL8	9/16/2024 19:33	71.9552	150.2935	3000	2946	775-798	0/10	
39	BL7	9/16/2024 23:43	71.8197	150.7590	2582	2561	-		
40	BL6	9/17/2024 2:58	71.6822	151.1362	2095	2076	799-822	0/10	
41	BL-5	9/17/2024 6:26	71.5952	151.3580	1583	1569	-		

42	BL4	9/17/2024 8:35	71.5237	151.5822	1157	1129	823-843		Jelly tentacle in CTD plumbing of primary salinity sensor. Target depth based on primary salinity is off due to this. The secondary CTD salinity is fine.
43	BL3	9/17/2024 11:39	71.4692	151.8077	568	507	844-861	0/10	Discharge in water, cleaned w/ bubblers; jelly fish seen at surface tentacles all over rosette especially Niskin 10
44	BL2	9/17/2024 14:39	71.3945	151.9498	168	160	862-873	0/10	
45	BL1	9/17/2024 16:29	71.3607	152.0817	82	79	874-881	0/10	
46	STAA	9/18/2024 12:50	72.6007	144.6970	3437	3418	882-905	0/10	
47	CB27	9/19/2024 0:10	73.0028	140.0073	3228	3205	906-929	0/10	Niskin 3 did not close; A second Niskin closed at surface.
48	CB21DNA	9/19/2024 9:07	74.0007	139.9808	3508	301	930-953	0/10	DNA Cast
49	CB21Geo	9/19/2024 10:44	74.0007	139.9760	3508	3496	954-977	0/10	Geochemistry Cast
50	CB19	9/20/2024 3:25	74.3005	143.3003	3697	3687	978-1001	0/10	Winch stopped at 388m to fix noise.
51	CB21DeepW	9/20/2024 11:41	74.0005	140.0022	3515	3103	1002-1025	0/10	Deep water study cast. On downcast winch stopped @ 2050 m to winch fix noise; switched to low gear; stopped at 3102m, not bottom.
52	CB29	9/21/2024 6:21	72.0008	140.0040	2686	2673	1026-1049	0/10	
53	MK6	9/21/2024 10:51	71.5715	140.0015	2481	2462	1050-1073	0/10	
54	CB28b	9/21/2024 16:03	71.0012	140.0042	2086	2071	1074-1097	0/10	
55	MK4	9/21/2024 19:21	70.8115	140.0040	1530	1489	1098-1121	0/10	
56	MK3'	9/21/2024 22:13	70.6493	140.0010	1040	1001	-		CTD only, no samples. Due to sounder issues only went to 1000m. On upcast, working sounder indicated bottom was ~1260m.
57	MK3	9/22/2024 0:08	70.5700	139.9980	10	762	1122-1144	0/10	
58	MK2	9/22/2024 3:06	70.4007	139.9997	510	490	1145-1163	0/10	
59	MK1	9/22/2024 6:35	70.2318	139.9993	245	248	1164-1177	0/10	
60	CB28aa	9/22/2024 9:17	70.0015	140.0005	60	53	1178-1184	0/10	
61	HI	9/22/2024 16:07	69.6535	138.9145	39	38	1185-1187	0/10	

4.2.2 XCTD

Table A6. XCTD cast deployment locations. File name starting with C3 indicates the probe type was XCTD-1N.

Filename	CAST START DATE and Time (UTC)	Latitude (°N)	Longitude (°W)	Probe Serial Number	Probe Type	Cast Depth (m)	Comment
C3_00004.edf	9/1/2024 21:59	72.0634727	132.912446	22072684	XCTD-01N	1000.03	launched successfully, no Ice, 12knots
C3_00008.edf	9/2/2024 4:38	72.6082075	134.925528	22072683	XCTD-01N	1000.03	launched successfully, no Ice, 12knots
C3_00009.edf	9/2/2024 12:26	73.2569763	136.616577	22072687	XCTD-01N	1000.03	launched successfully, no Ice, 12knots
C3_00010.edf	9/3/2024 2:46	73.4877818	136.127859	22072682	XCTD-01N	1000.03	launched successfully, no Ice, 12knots
C3_00011.edf	9/3/2024 11:00	73.5016938	132.655554	22072685	XCTD-01N	1000.03	launched successfully, no Ice, 10knots
C3_00013.edf	9/3/2024 20:04	73.9847988	133.066792	22072686	XCTD-01N	1000.03	launched successfully, no Ice, 10knots
C3_00014.edf	9/4/2024 5:53	74.7526865	137.710647	22072690	XCTD-01N	1000.03	launched successfully, no Ice, 10knots
C3_00015.edf	9/4/2024 14:58	75.4776942	140.002074	22072689	XCTD-01N	1000.03	launched successfully, no Ice, 10knots
C3_00019.edf	9/5/2024 2:49	76.129953	136.285811	22072753	XCTD-01N	1000.03	1 miss, launched again. 2nd launch was successful. No ice. 10knots.
C3_00020.edf	9/5/2024 18:02	76.3941993	133.92295	22072752	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:2, 10knots
C3_00021.edf	9/6/2024 3:39	76.7685915	137.649551	22072751	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:2, 10knots
C3_00022.edf	9/6/2024 11:41	77.1411538	141.551129	22072756	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:2, 10knots
C3_00023.edf	9/6/2024 22:13	77.6561615	141.629232	22072755	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:6, 10knots
C3_00024.edf	9/7/2024 6:57	78.4409002	140.561358	22072759	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:5, 3knots
C3_00025.edf	9/7/2024 10:23	78.4501715	142.867369	22072754	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:7, 3knots
C3_00026.edf	9/8/2024 8:32	78.695307	147.322794	22072758	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:7, 3knots
C3_00027.edf	9/9/2024 12:21	78.6014053	151.607085	22072757	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:9, 3knots
C3_00029.edf	9/9/2024 20:33	77.987534	151.485772	22072762	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:10, 3knots
C3_00030.edf	9/10/2024 9:23	77.7047773	148.288034	22072761	XCTD-01N	1000.03	launched successfully, Sea Ice Concentration:6, 10knots
C3_00032.edf	9/12/2024 21:23	77.4707103	149.967955	23118240	XCTD-01N	1000.03	1st failed connection, 2nd launched successfully, Sea Ice Concentration:4, 0knots
C3_00033.edf	9/13/2024 6:08	76.5092667	149.995677	23118239	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00034.edf	9/13/2024 10:43	75.5075807	149.998654	23118241	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00035.edf	9/13/2024 21:26	74.4746572	150.036769	23118236	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00036.edf	9/15/2024 5:29	75.6530347	151.661294	23118237	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00038.edf	9/15/2024 13:15	75.1458103	151.578022	23118238	XCTD-01N	1000.03	launched successfully, Open water, 10knots

C3_00039.edf	9/15/2024 17:24	74.8514518	148.35899	23118233	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00040.edf	9/16/2024 1:43	74.1406848	147.968145	23118234	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00041.edf	9/16/2024 4:54	73.5459393	149.066352	23118235	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00042.edf	9/18/2024 0:14	71.6270508	150.669979	23118232	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00043.edf	9/18/2024 3:08	71.8664522	149.238676	23118231	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00044.edf	9/18/2024 6:14	72.1057495	147.771465	23118230	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00045.edf	9/18/2024 9:27	72.3595777	146.208926	23118218	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00046.edf	9/18/2024 18:27	72.7295493	143.093419	23118219	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00047.edf	9/18/2024 21:27	72.884402	141.450766	23118220	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00052.edf	9/19/2024 5:58	73.5492817	139.769903	23118221	XCTD-01N	1000.03	Ethernet had a problem. Launched successfully, Open water, 10knots
C3_00053.edf	9/20/2024 8:54	74.1460338	141.589836	23118222	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00054.edf	9/21/2024 3:40	72.4916497	140.006075	23118223	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00055.edf	9/23/2024 2:01	70.5790218	137.009765	23118224	XCTD-01N	1000.03	launched successfully, Open water, 10knots
C3_00059.edf	9/23/2024 10:51	71.1574667	134.606817	23118225	XCTD-01N	657.8655	launched successfully, Open water, 10knots

Table A7. Placeholder - XCTD cast deployment locations for CCGS Sir Wilfrid Laurier in support of the JOIS/BGOS program (Cruise ID ####-### DFO-IOS).

No XCTDs launched from Sir Wilfrid Laurier this year (did not sail to Arctic)

4.2.3 Zooplankton – Vertical Bongo Net Hauls

Summary of samples taken at each station. At each station 2 samples were collected using the same net mesh size 150µm. One net's samples were preserved in 95% ethanol, the other in buffered formalin.

Table A8. Zooplankton vertical bongo net hauls.

Date Time (UTC) GPS	Station	Net Event	CTD Event	Positional Information		Wire Out	Wire Angle	Sounder Depth(m)	Comments
				Latitute	Longitude				
01-09-2024 19:19:12	CB-1	1	2	71 47.157 N	131 52.327 W	100	0	1114	TSK's spun while going from ship to surface. Likely impacted TSK reading
01-09-2024 19:19:12	CB-1	1	2	71 47.157 N	131 52.327 W	100	0	1114	TSK's spun while going from ship to surface. Likely impacted TSK reading
02-09-2024 00:55:49	CB-31b	2	3	72 20.736 N	134 0.808 W	100	0	2050	SFA
02-09-2024 00:55:49	CB-31b	2	3	72 20.736 N	134 0.808 W	100	0	2050	SFA
02-09-2024 08:09:21	CB-23a	3	4	72 53.903 N	135 58.444 W	100	0	2748	MD
02-09-2024 08:09:21	CB-23a	3	4	72 53.903 N	135 58.444 W	100	0	2748	MD
9/2/2024 15:18	CB-22	4	5	73 26.881 N	137 58.550 W	100	10	3125	MD TSK on Ethanol side, sn7303, is missing a blade. Only has 3 of the 4 blades.
9/2/2024 15:18	CB-22	4	5	73 26.881 N	137 58.550 W	100	10	3125	MD
03-09-2024 07:18:14	CB-50	5	7	73 29.938 N	134 14.443 W	100	5	2888	MD
03-09-2024 07:18:14	CB-50	5	7	73 29.938 N	134 14.443 W	100	5	2888	MD
03-09-2024 15:25:27	CB-51	6	8	73 30.084 N	130 54.781 W	100		2483	MD
03-09-2024 15:25:27	CB-51	6	8	73 30.084 N	130 54.781 W	100		2483	MD
04-09-2024 00:48:03	CB-40	7	9	74 30.018 N	135 25.253 W	100	15	3250	SFA
04-09-2024 00:48:03	CB-40	7	9	74 30.018 N	135 25.253 W	100	15	3250	SFA. Readings on flowmeters went backwards.
04-09-2024 10:03:16	CB-18	8	10	75 0.017 N	139 59.88 W	100		3626	MD
04-09-2024 10:03:16	CB-18	8	10	75 0.017 N	139 59.88 W	100		3626	MD

04-09-2024 18:56:02	CB-17	9	11	76 0.046 N	140 0.152 W	100	0	3696	SFA
04-09-2024 18:56:02	CB-17	9	11	76 0.046 N	140 0.152 W	100	0	3696	SFA
05-09-2024 10:10:47	PP-6	10	12	76 15.793 N	132 32.137 W	100	3	3061	MD
05-09-2024 10:10:47	PP-6	10	12	76 15.793 N	132 32.137 W	100	3	3061	MD
05-09-2024 20:43:39	PP-7	11	13	76 32.972 N	135 25.856 W	100	0	3559	SFA
05-09-2024 20:43:39	PP-7	11	13	76 32.972 N	135 25.856 W	100	0	3559	SFA
06-09-2024 07:39:07	CB-15	12	14	77 0.014 N	139 59.932 W	100	3	3725	MD
06-09-2024 07:39:07	CB-15	12	14	77 0.014 N	139 59.932 W	100	3	3725	MD
06-09-2024 17:13:29	CB-13	13	15	77 18.144 N	143 17.609 W	100	0	3779	
06-09-2024 17:13:29	CB-13	13	15	77 18.144 N	143 17.609 W	100	0	3779	
07-09-2024 01:33:09	CB-16	14	16	77 59.953 N	139 58.668 W	100	0	3749	SFA
07-09-2024 01:33:09	CB-16	14	16	77 59.953 N	139 58.668 W	100	0	3749	SFA
08-09-2024 02:17:08	IBO2	15	19	78 49.395 N	144 26.012 W	100	20	3780	SFA - Paused at 46m on upcast to clear ice.
08-09-2024 02:17:08	IBO2	15	19	78 49.395 N	144 26.012 W	100	20	3780	SFA - Paused at 46m on upcast to clear ice.
09-09-2024 07:03:47	CB-11	16	21	79 0.207 N	149 57.938 W	100	1	3827	
09-09-2024 07:03:47	CB-11	16	21	79 0.207 N	149 57.938 W	100	1	3827	
09-09-2024 15:57:47	CB-10	17	22	78 18.29 N	153 13.221 W	100	1	2330	
09-09-2024 15:57:47	CB-10	17	22	78 18.29 N	153 13.221 W	100	1	2330	
10-09-2024 05:05:21	CB12	18	24	77 41.987 N	146 40.998 W	100	5	3811	
10-09-2024 05:05:21	CB12	18	24	77 41.987 N	146 40.998 W	100	5	3811	
11-09-2024 00:44:20	CB-9	19	26	78 1.848 N	149 50.349 W	100	0	3826	SFA
11-09-2024 00:44:20	CB-9	19	26	78 1.848 N	149 50.349 W	100	0	3826	SFA: something is very wrong with the flowmeter . Have pictures of the dials not sitting where they should and numbers running backwards.
12-09-2024 07:47:14	CB-9CO2	20	28	78 0.428 N	149 59.071 W	1000	2	3818	
12-09-2024 07:47:14	CB-9CO2	20	28	78 0.428 N	149 59.071 W	1000	2	3818	
13-09-2024 01:22:03	CB8	21	29	76 59.749 N	149 58.687 W	100	15	3826	SFA
13-09-2024 01:22:03	CB8	21	29	76 59.749 N	149 58.687 W	100	15	3826	SFA

14-09-2024 00:22:09	CB3	22	30	74 0.032 N	150 0.303 W	100	0	3824	2 comb jellies! Not sure which net they were in.
14-09-2024 00:22:09	CB3	22	30	74 0.032 N	150 0.303 W	100	0	3824	
14-09-2024 10:26:08	CB-4 Geochem	23	32	75 0.075 N	150 0.07 W	100	2	3828	
14-09-2024 10:26:08	CB-4 Geochem	23	32	75 0.075 N	150 0.07 W	100	2	3828	
15-09-2024 00:44:32	CB7	24	33	76 0.111 N	149 59.987 W	100	20	3830	SFA did second bongo because this one had a yoyo at surface
15-09-2024 00:44:32	CB7	24	33	76 0.111 N	149 59.987 W	100	20	3830	SFA did second bongo because this one had a yoyo at surface
15-09-2024 01:06:18	CB7	25	33	76 0.130 N	149 59.792 W	100	0	3830	SFA
15-09-2024 01:06:18	CB7	25	33	76 0.130 N	149 59.792 W	100	0	3830	SFA. TSK shows backward flow?
15-09-2024 08:39:33	CB5	26	34	75 18.129 N	153 17.885 W	100	3	3846	MD
15-09-2024 08:39:33	CB5	26	34	75 18.129 N	153 17.885 W	100	3	3846	MD.
16-09-2024 08:21:05	CB-2	27	36	73 0.112 N	150 0.152 W	100	4	3815	MD
16-09-2024 08:21:05	CB-2	27	36	73 0.112 N	150 0.152 W	100	4	3815	MD. Winds at 20knt. Broke lanyard on cod end.
16-09-2024 14:33:55	CB-2a	28	37	72 30.035 N	150 0.479 W	100	1	3727	MD
16-09-2024 14:33:55	CB-2a	28	37	72 30.035 N	150 0.479 W	100	1	3727	MD
16-09-2024 20:37:58	BL-8	29	38	71 56.998 N	150 17.647 W	100		2969	SFA
16-09-2024 20:37:58	BL-8	29	38	71 56.998 N	150 17.647 W	100		2969	SFA
17-09-2024 03:16:10	BL-6	30	40	71 40.859 N	151 8.248 W	100		2083	SFA
17-09-2024 03:16:10	BL-6	30	40	71 40.859 N	151 8.248 W	100		2083	SFA
17-09-2024 09:09:55	BL-4	31	42	71 31.189 N	151 35.168 W	100	4	1155	MD Put into 2 x 125mL jars.
17-09-2024 09:09:55	BL-4	31	42	71 31.189 N	151 35.168 W	100	4	1155	MD
17-09-2024 14:25:22	BL-2	33	44	71 23.736 N	151 56.566 W	100	0	175	MD
17-09-2024 14:25:22	BL-2	33	44	71 23.736 N	151 56.566 W	100	0	175	MD
18-09-2024 13:10:41	STA-A	34	46	72 35.969 N	144 42.113 W	100	2	3434	MD counter not reset so went 110 m out
18-09-2024 13:10:41	STA-A	34	46	72 35.969 N	144 42.113 W	100	2	3434	MD
19-09-2024 00:41:35	CB-27	35	47	73 0.137 N	139 59.913 W	100	0	3226	SFA

19-09-2024 00:41:35	CB-27	35	47	73 0.137 N	139 59.913 W	100	0	3226	SFA
19-09-2024 11:12:12	CB-21	36	49	74 0.024 N	139 58.575 W	100	1	3512	MD. Net sitting at 100m for 2 minutes.
19-09-2024 11:12:12	CB-21	36	49	74 0.038 N	139 58.547 W	100	1	3512	MD. Net sitting at 100m for 2 minutes.
20-09-2024 03:59:58	CB-19	37	50	74 18.009 N	143 17.899 W	100	0	3697	SFA
20-09-2024 03:59:58	CB-19	37	50	74 18.009 N	143 17.899 W	100	0	3697	SFA
21-09-2024 06:50:25	CB-29	38	52	72 0.012 N	140 0.399 W	100	1	2690	MDM. TSK adjusted.
21-09-2024 06:50:25	CB-29	38	52	72 0.012 N	140 0.399 W	100	1	2690	MDM
21-09-2024 11:18:31	MK-6	39	53	71 34.256 N	140 0.264 W	100	2	2483	MDM
21-09-2024 11:18:31	MK-6	39	53	71 34.256 N	140 0.264 W	100	2	2483	MDM
21-09-2024 16:24:06	CB-28b	40	54	71 0.098 N	140 0.208 W	100	1	2085	MDM. Counters are spinning freely in the wind.
21-09-2024 16:24:06	CB-28b	40	54	71 0.098 N	140 0.208 W	100	1	2085	MDM. Counters are spinning freely in the wind.
21-09-2024 19:44:46	MK4	41	55	70 48.611 N	140 0.511 W	100	5	1474	SFA
21-09-2024 19:44:46	MK4	41	55	70 48.611 N	140 0.511 W	100	5	1474	SFA
22-09-2024 00:21:03	MK-3	42	57	70 34.181 N	139 59.981 W	100	20	778	SFA paused 2min at 27m on upcast
22-09-2024 00:21:03	MK-3	42	57	70 34.181 N	139 59.981 W	100	20	778	SFA paused 2min at 27m on upcast
22-09-2024 03:22:00	MK-2	43	58	70 23.997 N	140 0.071 W	100	5	501	SFA
22-09-2024 03:22:00	MK-2	43	58	70 23.997 N	140 0.071 W	100	5	501	SFA
22-09-2024 06:16:33	MK-1	44	59	70 13.895 N	139 59.961 W	100	0	250	MDM
22-09-2024 06:16:33	MK-1	44	59	70 13.895 N	139 59.961 W	100	0	250	MDM
22-09-2024 09:02:59	CB-28aa	45	60	70 0.144 N	140 0.034 W	50	2	60	MDM
22-09-2024 09:02:59	CB-28aa	45	60	70 0.144 N	140 0.034 W	50	2	60	MDM

4.2.4 Mooring and Buoy Operations

The mooring anchor was ranged on in the pre-recovery survey, but it was deemed not necessary to range on the acoustic pinger near the top of the mooring because all mooring recovery and deployments were in completely open water.

Table A9. BGOS mooring recoveries and deployments from CCGS Louis S. St-Laurent 2024.

Mooring	Surveyed location (anchor*)	2024 Recovery	2024 Deployment	2024 Location (drop posn.)	Deploy bottom depth (m)
A	74 59.946 N 149 59.550 W *42 m from 2023 drop location	13 Sept. 13:50 UTC	14 Sept. 18:33 UTC	75 00.000 N 149 59.970 W	3825
B	77 59.999 N 150 00.034 W *10 m from drop	10 Sept. 14:55 UTC	12 Sept. 18:10 UTC	78 00.071 N 149 59.900 W	3828
D	73 59.989 N 140 02.853 W *24 m from drop	19 Sept. 14:49 UTC	20 Sept. 19:02 UTC	73 59.999 N 140 02.890 W	3527

Table A10. BGOS ice and open-water deployments/recoveries from CCGS Louis S. St-Laurent 2024.

IBO: Ice-Based Observatory; OW = Open Water deployment , ITP: Ice-tethered Profiler; TOP: Tethered Ocean Profiler; SIMB: Seasonal Ice Mass Balance Buoy, AOFB: Arctic Ocean Flux Buoy, SAMI: pCO2 system, MetBuoy: MetOcean's buoys from ECCC measuring atmospheric pressure and temperature, OMB: OpenMetBuoy from University of Tokyo measuring waves in ice.

Event	Buoy system	Date (2024) and local time	Location	Ice thickness (m)

		(local +6hrs = UTC)		
#1 Recovery 1	ITP 136	Sept. 5 09:10	76.025 N 132.34 W	N/A
#2 OW 1	TOPV 13	Sept. 6 09:40	77.23 N 143.17 W	N/A (open water)
#3 IBO 1	TOP 14 w. T-chain, SIMB 2024 #6, OMB + nearby o/w MetBuoy	Sept. 7 16:13	78 31.56 N 144 32.07 W	0.50 – 0.90
#4 IBO 2	TOPV 12, AOFB 49, ITP 142 w. O2 optode + SAMI, SIMB 2024 #7, OMB, MetBuoy	Sept. 8 17:24	78 43.55 N 150 43.47 W	0.50-0.60
#5 OW 2	TOP 15 w. T-chain	Sept. 9 18:17	77 43.90 N 150 00.00 W	N/A (open water)
#6 OW 3	ITP 143 w. O2 optode + SAMI	Sept. 12 15:59	77 28.16 N 149 56.85 W	N/A
#7 Recovery 2	TOP 6	Sept. 14 16:36	75 44.12 N 150 24.25 W	N/A

Ice thicknesses (cm) at specific buoys: TOP014 = 90; SIMB #6 = 90; TOPV12 = 55; ITP 142 = 55; AOFB 49 = 50; SIMB #7 = 55 cm

Table A11. DeGrandpre group sensor data collection summary. Days of data obtained from sensors for moorings deployed in 2023 and for ITPs deployed on this cruise (September 2024).

In addition we collected underway $p\mathrm{CO_2}$ data using an infrared equilibrator-based system (SUPER-CO2, Sunburst Sensors) continuously over the cruise. The instrument was connected to the ship's seawater line manifold located in the main lab.

Mooring / ITP	CO_2	pH	O_2	PAR	Temperature
BGOS-A Mooring	100	158	347	347	347
BGOS-B Mooring	300	87	347	347	347
BGOS-D Mooring	186	320	0	349	349
ITP-142**	14	14	14	14	14
ITP-143**	11	11	11	11	11
underway pCO_2	~25	x	x	x	~25

**as of Sep. 23, 2024

Environment and Climate Change Canada (ECCC) sent 7 MetOcean buoys for deployment during the JOIS 2024 program. These buoys aid the ECCC's weather measurements and forecasting.

Table A12. Meteorological Buoys – Deployment information for all ECCC MetOcean buoys.

#	Model	Serial Number	IMEI Number	Date	Time (UTC)	Lat (N)	Long (W)	Photo	Site Description
1	SVP-I-BXGS-LP	J1HUXZ	300534062591760	7-Sep-24	2:00	78.00	140.00	Yes	CB16, floes and open water
2	SVP-I-BXGS-LP	J1HUZF	300534062598760	8-Sep-24	4:30	78.84	144.51	Yes	IB01, floes, thin layer ice, water
3	SVP-I-BXGS-LP	J1HVDO	300534062497970	8-Sep-24	22:45	78.77	151.00	Yes	IB02, on ice floe 6 X 4 nm
4	SVP-I-BXGS-LP	J1HUZI	300534062594760	9-Sep-24	9:02	79.00	150.00	No	CB11, dark

5	SVP-I-BXGSA-L-AD	J06UJ1	300234063511510	9-Sep-24	17:30	78.30	153.21	Yes	CB10, floes, thin layer ice, water
6	SVP-I-BXGSA-L-AD	J05HW5	300234062552760	10-Sep-24	7:21	77.70	146.70	No	CB12, dark
7	SVP-I-BDGS	J1HTDN	300534062593800	13-Sep-24	3:51	77.00	150.00	Yes	CB8, open water, limited ice

4.2.5 ARGO Floats

Fisheries & Oceans Canada provided 2 NKE Instrumentation ARGO floats for deployment during the JOIS 2024 program. These were deployed at CTD/Rosette stations to provide initial deployment comparison.

Table A13. Meteorological Buoys – Deployment information for DFO ARGO floats.

Date	Time (UTC)	JOIS Station	Lat (N)	Long (W)	Manufacturer	Type	Serial Number	@ BT	IMEI
Sept. 18	15:30	STN-A	72.6	144.7	NKE Instrumentation	ARVOR I NAOS	AI2600-21CA006	C200107-0196	300534060213390
Sept. 19	02:37	CB-27	73.0	140.0	NKE Instrumentation	ARVOR I RBR	AI3500-21CA003	C200107-0162	300534061174520

4.2.6 Glider Deployment and Recovery Locations

Table A14. Glider deployment and recovery

Date	Time (UTC)	Lat (N)	Long (W)	
2-Sep	19:49	73.429	138.181	Deployment
20-Sep	20:30	73.764	139.958	Recovery

4.3 CTD/Rosette Sensor Configuration

ROS 1 to 61 (all casts)

V0 = chlorophyll fluorometer
V1= transmissometer
V2 = dissolved oxygen
V3 = altimeter
V4 = CDOM fluorometer
V5 = free
V6 = Cosine PAR
V7 = Rinko III (UserPolynomial)

CTD

CTD#	Make	Model	Serial#	Used with Rosette?	Casts Used
Primary	SeaBird	911+	1493	Yes	All casts
Secondary	SeaBird	911+	756		Not used; backup

	Calibration and Accuracy Information CTD #1493 PRIMARY						
Sensor		**Accuracy**	**Pre-Cruise**		**Post Cruise**		**Comment**
Name	**S/N**		**Date**	**Location**	**Date**	**Location**	
Pressure Sensor, Digiquartz with TC	1493	Nominal 1.2 m	10-Nov-2022	SeaBird Lab			
Temperature, SBE3plus	6726	Nominal ± 0.001 °C	07-Dec-2023	SeaBird Lab			
Conductivity, SBE4C	6137	Nominal 0.003 mS/cm	12-Dec-2023	SeaBird Lab			
Pump, SBE5T	05-11218		New:2022				
Secondary Temp., SBE3plus	6727	Nominal ± 0.001 °C	06-Dec-2023	SeaBird Lab			
Secondary Cond., SBE4C	6139	Nominal 0.003 mS/cm	12-Dec-2023	SeaBird Lab			
Secondary Pump, SBE5T	05-11219		New:2022				

Calibration and Accuracy Information, External Sensors							
Sensor		**Accuracy**	**Pre-Cruise**		**Post Cruise**		**Comment**
Name	**S/N**		**Date**	**Location**	**Date**	**Location**	
SBE 43 Dissolved Oxygen sensor	2599		04-Jan-2024	SeaBird Lab			CTD Voltage Channel 2 On Primary pump;
Altimeter, Valeport VA500	80262		8 Feb 2022	Valeport			CTD Voltage Channel 3 Scale factor 15, Range limit 100m
Seapoint Fluorometer (Chl-a)	3741		16-Jul-2014; 2 pt check at IOS: 21-Feb-2024	Seapoint; 2 pt check at IOS			CTD Voltage Channel 0 On Secondary Pump;

Wetlabs C-Star Transmissometer	CST-1050DR		23-Jun-2024	IOS (In-house light/dark test)			CTD Voltage Channel 1
WETLabs ECO CDOM	6677		New: 3-Apr-2021	WETLabs			CTD Voltage Channel 4
Satlantic Cosine Log PAR	517		2014-Jun-25	Satlantic			CTD Voltage Channel 6
Biospherical Surface PAR QSR2200	20498		4 Apr 2016	Biospherical			
Biospherical PAR QSR2150 (Continuous)	50228		21 Jun 2016	Biospherical			External to CTD data
Alec Rinko III dissolved oxygen sensor	0259, Film B		14-Feb-2024 12-Sep 2024 14-Sep-2024 28-Sep-2024	IOS; On board			Cast 1 to 61; V7

Deck Units

Type	Make	Model	Serial #	Comment
Deck Unit	Seabird	11plus	1281	2024: Either 680 or 1281 used all cruise, not sure which.
Deck Unit	Seabird	11plus	680	2024: Either 680 or 1281 used all cruise, not sure which.

Rosette Pylons

Type	Make	Model	Serial #	Comment
Water Sampler Carousel	Seabird	32	1231 w/ Trigger 452	Pylon used for all casts; trigger swapped throughout

Water Sampler Carousel	Seabird	32	498	Pylon as backup; trigger swapped in throughout

Seabird specifications on sensors:

SBE 3plus temperature sensor
Range -5.0 to +35 °C
Resolution 0.0003 °C at 24 samples per second
Initial Accuracy2 ± 0.001 °C
Response Time3 [sec.] 0.065 ± 0.010 (1.0 m/s water velocity)
Self-heating Error < 0.5 sec. to within 0.001 °C

SBE4c conductivity sensor
Measurement Range 0.0 to 7.0 Siemens/meter (S/m)
Settling Time 0.7 seconds to within 0.0001 S/m
Initial Accuracy 0.0003 S/m
Stability 0.0003 S/m/month
Time Response 0.060 seconds (pumped)

Digiquartz pressure sensor
Measurement Range Pressure 0 to 6800m (10,000 psi)
Accuracy 0.018% of full scale
Resolution (at 24 Hz) Pressure 0.001% of full scale
Time Response Pressure 0.015 second

4.4 Seawater Loop Measurements

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

4.4.1 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.

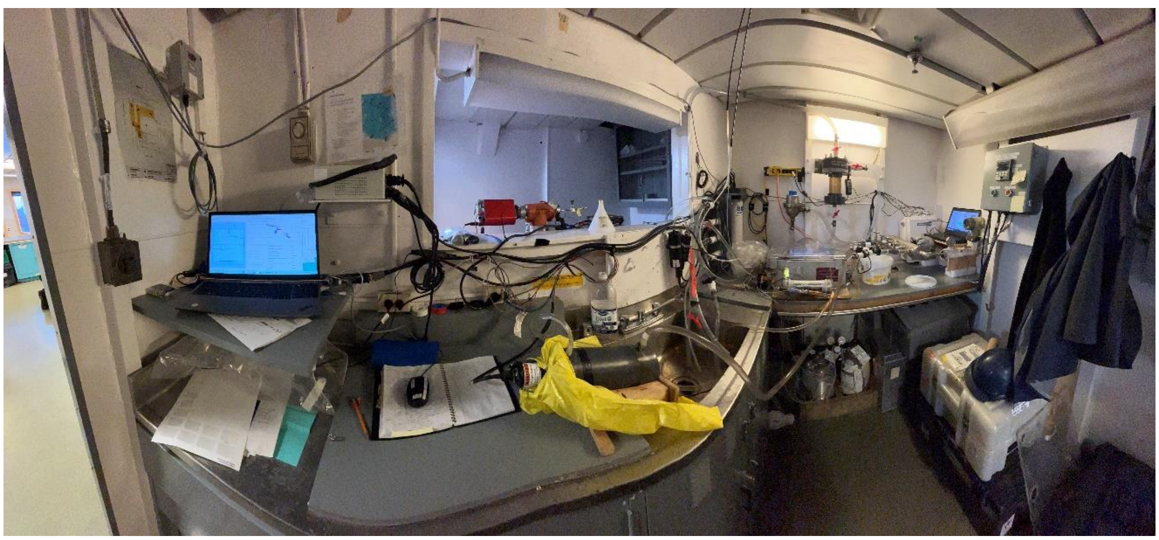


Figure A1. Seawater loop system w/ Chl-a and FDOM sensors attached to left wall, the second FDOM sensor in wood cradle next to sink. The pCO2 system sits on the center of the back bench. The manifold's new needle valves, flowmeters, data logger in white box and laptop are on the right side of the room. The O2/Ar system was installed on the other side of the passthrough. The seawater loop provides uncontaminated seawater from 9m depth to the science lab for underway measurements (photo 2024).

New for 2023 were calibrated flow valves that displayed and logged flowrate in real time. This was done using a Campbell Scientific interface box and software. In addition, the plastic ball valves were replaced with metal needle valves giving much finer control over the flowrate.

Figure A2. TSG manifold, flow meters, data logger and laptop (photo 2023).

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 A3. Honeywell controller for the pump, located in the TSG lab.

Figure A4. Seawater passes through a filter (in front of engineer) before going to the pump (on orange platform). 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. Photos are from previous years, but is the same strainer configuration for 2024.

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 seawater temperature measured by the SBE21 in the TSG lab).

Figure A5. SBE38 temperature sensor in the engine room (2023**). NOTE THE RED HANDLE AT BOTTOM OF PHOTO. THIS VALVE IS IN THE CLOSED POSITION DURING OPERATION.** This handle is hidden from view when open, but needs to be closed to force flow past the temperature sensor to get accurate seawater measurements

On the first manifold arm is a Kate's mechanical flow rate controller followed by a vortex de-bubbler, installed inline to remove bubbles in the supply to the SBE-21 thermosalinograph (TSG). This is the only system that had a de-bubbler.

A second manifold arm had a Y branch with the TSG's Chl-a fluorometer and FDOM sensor off one branch and the U de Sherbrooke FDOM sensor off the other branch.

A third arm of the manifold went to an automated system for measurements of pCO2. Measurements were made with an infrared equilibrator-based system (SUPER-CO2, Sunburst Sensors) by Cory Beatty, and Mike DeGrandpre (UMontana). Data were recorded through the cruise with discreet DIC, Alkalinity water samples drawn for comparison. For more information please see his report (*Sea surface pCO2, pH, and dissolved O2*).

A fourth arm of the manifold went to an automated measurement of oxygen to argon ratio. On this branch, O_2/Ar measurements were made with a quadrupole mass spectrometer and O_2% saturation using an Aanderaa optode (model 4531A). Oxygen water samples were taken for oxygen comparison. The O_2/Ar measurements were made by Tianyu Zhou, Wei-Jun Cai and Yun Li (University of Delaware). Please see their report for more information (*Underway measurement of O2/Ar ratio*).

The TSG data were collected through SeaBird's Seasave acquisition program v Seasave V 7.26.7.107 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 GPSgate software and the ship's science LAN to shuttle data: bring in the ship's GPS, bring in the SBE38 (inlet temperature) data from the engine room to the TSG instrument, and to pass out the TSG and SBE38 data to the ship's data collection system (SCS). The software program GPSgate provided the conversion between USB, TCP/IP, and virtual and real communication ports.

4.4.2 Issues, Settings, Instruments

The Seawater Manifold is configured with four outlet arms:

- Arm 1: Valve 1 to de-bubbler and then TSG
- Arm 2: Valve 2 to the O2/Ar setup (EIMS)
- Arm 3: Valve 3 to the pCO2 system
- Arm 4 with Y
    - Valve 4 to Fluorometer 1: Seapoint Chl-a Fluorometer w/ 30x gain and then to Wetlab FDOM fluorometer
    - Valve 5 to Fluorometer2: USherbrooke's Wetlab FDOM sensor

Pump Settings and Flow Rate

Flow rate varied often due to sea-ice clogging the strainer at the ship's sea-water inlet, or pump malfunction. Sometimes the flow stopped altogether due to clogging and the pump would be turned off until conditions improved (less ice). The TSG data acquisition was typically left running however the periods of bad data will need to be identified and removed.

Typical flow rates

Instrument	Flowmeter L/min		Measured L/min
	Goal,	Typical	
TSG	15 to 25	20	11
O2/Ar Systme (EIMS)	2 to 5	4	4
pCO2	1.5 to 2.0	1.8	1.8
Fluorometer pair	1.6 to 2.4	2.4	2.0
FDOM single (UdeS)	5.2 to 5.5	5.2	5.45

Water Pressure at manifold: Pressure set to 30psi, it had been 50psi (Sep 8th, but Sr Eng Travis said this was too high and creating banging in pipes).

Water samples

Discrete water samples for Salinity, FDOM, DIC, Alkalinity, Chlorophyll, and Oxygen 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.

Issues with Sea Water Pump and TSG data

TSG changed

SN 3297 was reading unusually fresh surface water (22.5 PSU in Coronation Gulf, Aug 31st and 3PSU fresher than CTD at Stn AG5 in Amundsen Gulf) so TSG was swapped out.

SN 3274 set up Sep 1st. Surface water reading very fresh still so a SBE 19+ SN 4560 was added to the TSG system Sep 2nd . It also read very fresh surface water and both the SBE21 and SBE19+agreed with CTD at CB31b. With this confirmation, the SBE21 sn3274 was left in place to use as the TSG.
First good file with NMEA started 2 Sep 03:56 UTC however configuration file needed correcting in post processing (chl setting was incorrect).

Flow meters

- Flow meter on Valve 4 (Chl and CDOM) not working. Replaced the flowmeter "4" with flowmeter "6", and the Y-valve at the same time (4 Sep 20:11 UTC). This new flowmeter also stopped reporting. We're not sure if this is due to not working well with low flow or the connection back at the Campbell Scientific box.

- For low-flow, the flowmeter appears to get stuck, unclear if this is the valve (real reduction of flow) or just the flowmeter. Turning the valve up and then back to original spot tends to fix this issue.
- Calibration of flowmeters has drifted/or is not necessarily correct. It is very useful to show stability, but flow checks are needed.

Pump Transducer and Honeywell Control Box

The LED panel of the Honeywell Control Box has faded to the extent that its only readable when the lab lights are turned off. In effort to set the Honeywell controller to a higher process variable, the pressure transducer needed setting to a new range. The transducer couldn't be reset – unclear if it was a transducer problem or missing the external keypad for the transducer. It may be fixable, or a new transducer should be installed. Without this, the pump would need to be set to run at a fixed frequency.

4.4.3 TSG Configuration

TSG Seabird SBE21 SN 3297

Calibration and Accuracy Information, TSG							
Sensor		Accuracy	Pre-Cruise		Post Cruise		Comment
Name	S/N		Date	Location	Date	Location	
Seabird TSG SBE21	3297	Conductivity was intermittently bad in 2023 so system was checked by Seabird Feb 2024. No cause found.	28-Feb-24	SeaBird Lab	No post cruise cal		Installed initially and then replaced with SN3274.
Seabird TSG SBE21	3274		28 Jan 2024	SeaBird Lab	In progress	SeaBird Lab	System collecting data 2 Sep 03:56 UTC
Seabird Temperatrue SBE-38 (Intake temperature)	0870		28 Jan 2023	SeaBird Lab	No post cruise cal		
Seapoint Chlorophyll Fluorometer	SCF2841 30x gain		Jun 2014	Seapoint 2pt health check at IOS (20 Feb 2023)			30x gain cable (0 to 5V = 0 to 5mg/mL)
Wetlabs ECO CDOM Fluorometer	WSCD-1281		17 Jun 2015	Wetlabs			
Computer: laptop TP2023-02							Receives updates from timeserver

- In SEABIRD acquisition software: NMEA option has “Time Added” box checked
- SBE38 via internet sent out from computer using real Com # assigned by the USB to serial converter, then null modem to cable to TSG housing.
- New for 2023, continued for 2024: Computer has time and date updated by timeserver.

4.5 Logging of Underway measurements with SCS

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This section gives the SCS string definitions, and lists the issues encountered this year.

These are the measurements taken at frequent regular intervals continuously throughout the cruise logged by NOAA's "Shipboard Computer System" (SCS) software running on the science server.

These measurements are:

1. GPS from the ship's Furuno GPS, using NMEA strings $GPGGA and $GPRMC. These are the same GPS sentences, available on the science VLAN, being used by CTD, XCTD, TSG and mapping programs.
2. AVOS weather observations of air temperature, humidity, wind speed and direction, and barometric pressure ($AVRTE).
3. Sounder depth and the applied ship's draft and sound speed.
4. Surface Photosynthetically Active Radiation (PAR).
5. Thermosalinograph (TSG), and the inlet sea surface temperature from the SBE38 that is also given in the TSG data stream.
6. Heading from the ship's Gyro ($HEHDT).
7. Data from the FDOM fluorometer in the seawater loop (FDOM).
8. Derived true wind speed calculated in SCS.

4.5.1 Issues with the underway system and data

4.5.2 SCS Data Strings Defined

This system takes data arriving via the ship's science network (a VLAN) in variable formats and time intervals and stores it in a uniform ASCII format that includes a time stamp.

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

The SCS system, running on a shipboard computer called the “NOAA server” or “science server” collects *.Raw files. The files are restarted periodically so they do not get too large. Each sentence logged in a .Raw file is also parsed for data fields of interest, and the values extracted, labelled and stored in the SCS database. The compress utility can be used on these extracted data to create files from a single data file for one sentence for the entire cruise.

The list of *.Raw files and fields within the data string are given below for 2020 but are similar for 2024:

<u>Position, Time, Date, Speed and Course over ground - $GPRMC</u>

File: RMC_*.Raw
Time interval 1 second

Description of *.Raw file string , example file: RMC_20200910-214857.Raw
09/10/2020,21:48:58.578,$GPRMC,214427.00,A,7238.52537,N,07151.97735,W,15.051,310.9,100920,999.9,E,D*10
09/10/2020,21:48:59.999,$GPRMC,214428.00,A,7238.52807,N,07151.98798,W,15.050,310.2,100920,999.9,E,D*13

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
“$GPRMC”
Time HHMMSS.SS
Status A= Active, V=Navigation receiver warning
Latitude DDMM.MMMM
Latitude N or S
Longitude DDDMM.MMM
Longitude E or W
Speed over ground in knots
Course over ground in degrees (True)
Date DDMMYY
Magnetic variation in degrees (999.9 = not valid)
Variation E or W
Mode indicator: A=Autonomous, D=Differential
No comma before this field – checksum starting with *

Extracted and stored in the Database:

RMC-Time UTC
RMC-Latitude
RMC-Longitude
RMC-SOG
RMC-COG
RMC-Date

Position - $GPGGA

File: GGA_*.Raw
Time interval 10 second

Description of *.Raw file string , example file: GGA_20200909-160350.Raw

09/09/2020,16:03:52.027,$GPGGA,155920.0,6642.04389,N,06103.44820,W,2,08,1.0,16.8,M,18.5,M,7.0,0138*50
09/09/2020,16:04:02.996,$GPGGA,155931.0,6642.08959,N,06103.44817,W,2,08,1.0,16.9,M,18.5,M,6.0,0138*5F

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
"$GPGGA"
Time HHMMSS.S
Latitude DDMM.MMM
Latitude N or S
Longitude DDDMM.MMM
Longitude E or W
Fix type: 0=invalid position, 1=autonomous GPS,2=DGPS
Number of satellites used
Horizontal dilution of precision
Height of the geoid
M (units of height)
Age of correction data for DGPS in seconds
Correction station ID number
No comma before this field – checksum starting with *

Extracted and stored in the Database:

GGA-Quality (#9 above)
GGA-Satellite Count
GGA-Age of data

Depth – “Sounder”

Depth is measured using the 3.5, 12 or 30kHz transducers using a new for 2018 Knudsen CHIRP 3260 Echosounder, labeled “Science”. The depth value has been increased by the ship’s draft for each transducer. The depth is calculated using a specified sound speed. Both the draft and nominal sound speed variables are set by the user in the Knudsen software. Nominal sound speed is the average of the water column sound speed. 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 depends on ping rate, but in practice is between 5 and 7 seconds.

It was determined in past years that if the ship’s “fish finder” is on, there is interference with the 12kHz system.

Sounder data are more problematic than other types collected by SCS. 0.0 values are reported when the sounder does not detect bottom. It will report values that to the eye judging the visual echogram are clearly incorrect; any values less than 35m or values that either double or halve those nearby should likely be discarded. In areas with steep bathymetry the sounder will often report incorrect values from side reflections of deeper or shallower water – these artefacts can be difficult to filter out.

File: Knudsen-Sounder_*.Raw

Description of *.Raw file string
Knudsen-Sounder_20200921-001000.Raw
09/21/2020,00:11:32.929,Sounder,21092020,001435,,,,12.0kHz,3750.71,9.00,,,,1479
09/21/2020,00:11:43.929,Sounder,21092020,001448,,,,12.0kHz,3750.84,9.00,,,,1479

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
“Sounder”
Date UTC: DDMMYYYY
Time UTC: hhmmss
Sounder frequency (3.5kHz)
Depth (3.5kHz)
Applied draft (3.5kHz)
Sounder frequency (12kHz)
Depth (12kHz)
Applied draft (12kHz)
Sounder frequency (30kHz)

Depth (30kHz)
Applied draft (30kHz)
Soundspeed m/s

Extracted and stored in the Database:

Knudsen-Sounder-3.5kHzDepth
Knudsen-Sounder-3.5kHzTD
Knudsen-Sounder-12kHzDepth
Knudsen-Sounder-12kHzTD
Knudsen-Sounder-30kHzDepth
Knudsen-Sounder-30kHzTD
Knudsen-Sounder-NominalSoundSpeed

<u>Meteorological data from AVOS (Automatic Voluntary Observing Ships System) - $AVRTE</u>

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).

Note that the ship's gyro feed is not connected to AVOS so the compass being used for relative to apparent calculation is the AVOS fluxgate compass and should thus be avoided if possible. SCS does a relative to true wind calculation, using the gyro heading and SOG and this is described below.

Barometer – not sure where this is mounted.

Time interval is 10 sec

File: AVOS-serial-AVRTE_*.Raw
Description of *.Raw file string
AVOS-serial-AVRTE_20200915-001000.Raw
09/15/2020,00:10:10.605,$AVRTE,200915,001014,00840,CGBN,24.9,322,181,,,,1018.60,,-1.9,60,,,,5.0,,,141.7,13.3*45
09/15/2020,00:10:21.199,$AVRTE,200915,001024,00840,CGBN,24.4,321,181,,,,1018.84,,-2.0,60,,,,24.7,,,140.8,13.4*75

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)

“$AVRTE”
Date UTC: YYMMDD
Time UTC: hhmmss
Region?
Ship’s Call Sign
Relative wind speed, knots
Apparent wind direction, degrees true north
Relative wind direction, degrees where ship’s bow is “North”
Space for 2nd wind sensor, not installed
Space for 2nd wind sensor, not installed
Space for 2nd wind sensor, not installed
Barometric pressure, Mbar (same as mmhg)
Space for 2nd barometer, not installed
Air temperature, degrees C
Relative Humidity, %
Space for 2nd temperature sensor
Space for 2nd humidity sensor
Space for Sea Surface Temperature, degrees C (this is NOT the same as the sea water loop TSG intake reading – different source)
Wind gusts, knots
Blank space for 2nd wind sensor gust
Heading ($HEHDT) direction, “Compass 1”, degrees (not active)
AVOS fluxgate compass direction, “Compass 2”, degrees
AVOS battery voltage
No comma before this field – checksum starting with *

Extracted and stored in the Database:

AVOS-serial-AVRTE-date
AVOS-serial-AVRTE-time
AVOS-serial-AVRTE-wind speed
AVOS-serial-AVRTE-apparent wind
AVOS-serial-AVRTE-relative wind
AVOS-serial-AVRTE-barometric pressure
AVOS-serial-AVRTE-air temperature
AVOS-serial-AVRTE-relative humidity

Seawater Loop (TSG)

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

File: TSG-serial-*.Raw

Description of *.Raw file string
TSG-serial-_20200911-193215.Raw
09/11/2020,19:32:33.321, 1.58 1.36 30.741 27.035 0.380
0.37973 0.07204 255.811262
09/11/2020,19:32:38.321, 1.57 1.36 30.736 27.027 0.369
0.36874 0.07082 255.811319

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
Sea Surface Temperature in lab, Deg C
Sea Surface Temperature at intake, Deg C
Sea Surface Salinity, PSU
Sea Surface Conductivity in lab, mS/cm
Sea Surface Fluorescence (Chlorophyll-a), ug/L
Sea Surface Fluorescence (Chlorophyll-a) voltage, V
Sea Surface Wetlabs ECO CDOM Fluorometer voltage, V
Julian Day

Extracted and stored in the Database:

TSG-serial--T1
TSG-serial--T2
TSG-serial—Salinity
TSG-serial—Conductivity
TSG-serial—ChlFuorescence
TSG-serial--V0
TSG-serial--V1
TSG-serial--JulianDay

<u>Seawater Intake Temperature (SBE38)</u>

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 separate report for description of TSG sensors.

File: SBE-38-serialport-*.Raw

Time interval is about 1 second.

Description of *.Raw file string
SBE-38-serialport-_20201005-001000.Raw
10/05/2020,00:10:03.877, 3.3221
10/05/2020,00:10:14.343, 3.3265

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
Sea Surface Temperature at intake, Deg C

Extracted and stored in the Database:

TSG-serial--T1

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 located 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).

Logging and transfer of the PAR data froze numerous times during the cruise; it was restarted whenever noticed.

File: ASCII-PAR-serialport-*.Raw
Time interval is 10 second.

Description of *.RAW file string
ASCII-PAR-serialport-_20200912-001000.Raw
09/12/2020,00:11:41.768,D|35.813,1.54,7.451
09/12/2020,00:11:52.143,D|35.439,1.54,7.43

Sentence fields:

Date MM/DD/YYY (timestamp from SCS)
Time HH:MM:SS.SSS (timestamp from SCS)
"D|" - not sure what this is, ignored

Surface PAR, uE/m2/sec (same as in CTD data)
Unknown
unknown

Extracted and stored in the Database:

ASCII-PAR-serialport-PAR