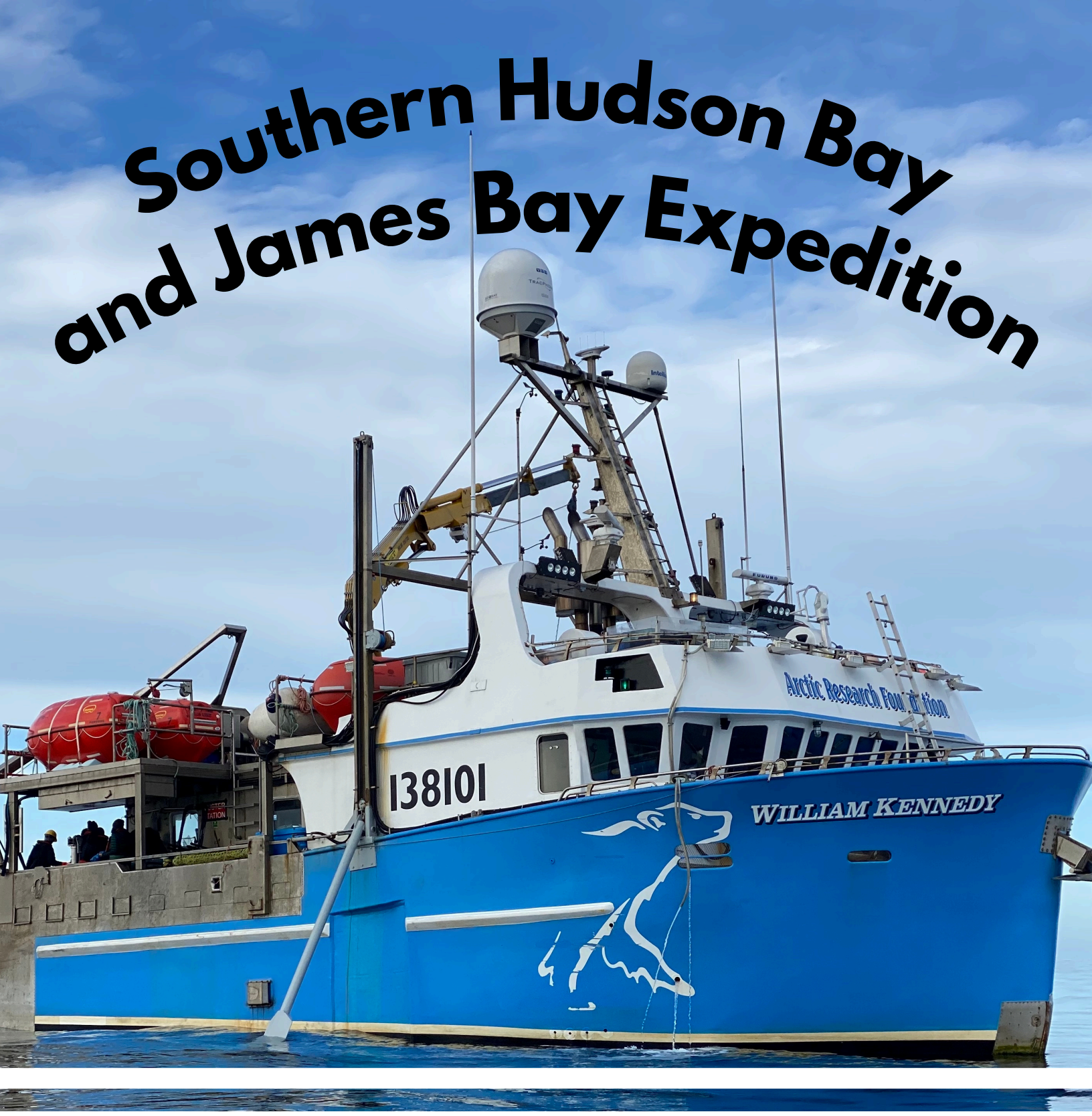
Southern Hudson Bay and James Bay Expedition



UM

Centre for Earth Observation Science

Cruise Report

July 31 - September 1, 2023

Executive Summary

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Under NSERC, CFI, Fisheries and Oceans Canada, and Parks Canada funding, an oceanographic research expedition to James Bay and the Belcher Islands occurred from July 31–September 1, 2023. This expedition represented the third annual oceanographic research cruise to James Bay (James Bay Expedition, JBE) and the second to the Belcher Islands aboard the *RV William Kennedy*. The goal of the cruise was to update our oceanographic understanding of the system, with a focus on tracking freshwater and nutrients and their impact on the marine ecosystem. All work in 2023 was carried out under the multiyear NRI License number, 03 010 23R-M.

In addition to the University of Manitoba, scientists from the Freshwater Institute, Fisheries and Oceans Canada (DFO), and the University of Alberta (UA) participated in the research program. The Arctic Eider Society and Sanikiluaq HTA, as well as the Cree Marine Research Needs Working Group chaired by Oceans North, provided regional support and advice, and consultations with Chiefs and Councils of coastal communities to help plan the cruise. Several community visits and outreach projects were conducted during the 2023 expedition, including visits to the communities of Sanikiluaq, the Cree Nation of Weenusk.

The research program was multidisciplinary and included sampling in support of physical oceanography, chemical oceanography, biogeochemistry (both organic and inorganic), biological oceanography (primary production), invertebrates and fish, environmental DNA (eDNA), and sediment geochemistry (box coring). Of the 5 oceanographic moorings deployed, we were able to recover 3, with 1 lost (CMO-A) and 1 planning to be recovered in 2024. We also deployed one annual mooring just south of the Belcher Islands and two seasonal moorings nearby the Moose and Winisk Rivers with support from Weenusk and Moose River First Nations. All moorings carry sensors for temperature, salinity, and current profiles, and selected moorings carry instruments for measuring ecologically significant properties (light, fluorescence of dissolved organic matter and Chlorophyll, pH) and collecting settling particulate matter (i.e., sediment traps). To improve understanding of the bay's physical oceanography, hydrographic sections were completed that included more than 169 conductivity-temperature-depth (CTD) casts to profile the water column. Near-continuous measurements of salinity and temperature were obtained from a flow-through system connected to the ship's thermosalinograph (TSG). The ship's zodiacs were used to extend sampling sections towards the coast and various river mouths.

In the lab aboard the RV William Kennedy, a benchtop Algae Online Analyser implemented on the flow-through system provided estimates of phytoplankton community abundance. Additionally, water sample collection was conducted at 21 partial stations in Southern Hudson Bay and James Bay and 12 full stations around the Belcher Islands. At stations, water samples were obtained from various depths and locations and processed by filtration and other means to allow subsequent analyses of various chemical and biological parameters. Nets were deployed to obtain samples that will be used to characterize the biodiversity and distribution of zooplankton and fish communities in James Bay and assess taxon-specific fatty acids and stable isotope

signatures of key forage species and benthic invertebrates. Sediment cores were also collected and sectioned for dating and geochemical analysis and additional surface sediment samples were obtained where the seabed was not amenable to subsurface core collection.

Overall, the research cruise represents a significant step towards obtaining new data that will update the understanding of the oceanography of Southeastern Hudson Bay and James Bay. The semi-synoptic measurements of water properties across the region obtained within an approximate 1-month time frame will allow preparation of maps and sectional plots showing the spatial distribution of important surface and subsurface ocean properties. These properties include salinity, temperature, water clarity, pH, and concentrations of coloured dissolved organic matter, dissolved organic carbon, nutrients, chlorophyll *a*, and suspended particulate matter.

During the coming months, the new observations will be used to improve our understanding of the oceanography of James Bay. The data will allow assessment of the contributions of freshwater sources in James Bay, the influence of freshwater on nutrient distributions, and their downstream effects on the Belcher Island marine system. The data will be used to describe the distribution and magnitude of phytoplankton production and characterize the vulnerability to ocean acidification. The continuous observations of properties obtained from the moored instruments will provide insight into the seasonal cycle in salinity, water temperature, and several biological and chemical parameters. Samples of pelagic and benthic organisms will allow detailed descriptions of fish and invertebrate community characteristics. Sediment cores will be analyzed and dated where possible with the goal of estimating sediment and carbon accumulation rates and seeking evidence of environmental change. The new knowledge will be shared through workshops, presentations, and distribution of community outreach materials as advised by the Arctic Eider Society, Sanikiluaq HTA, and the Cree Marine Research Needs Working Group and prepared for scientific presentations and publications.

Acknowledgments

We wish to thank the following people and organizations: Captain David McIsaac and the entire crew of RV William Kennedy for their hard work and long hours to support the research efforts of this cruise, while also ensuring researchers on board were safe, comfortable, and well fed; the Arctic Research Foundation for their support of the Kennedy's activities; Dr. Jennie Knopp and all members of the Cree Marine Research Needs Working Group for their dedication and guidance concerning the James Bay Expedition; Anna Baggio and Megan Chen of Wildlands League for coordination of community consultations and assistance with poster preparation; Alan Penn of the Cree Nation Government for helping prepare plain language background material; Vern Cheechoo and Lawrence Martin of Mushkegowuk Council for motivating the James Bay portion of the project and helping guide the research and outreach efforts for this cruise; Drs. Karen Richardson and Marlow Pellatt from the Office of the Chief Ecosystem Scientists, Parks Canada Agency, for input and coordination related to carbon cycling and biodiversity science in the region; Dr. Joel Heath, the Arctic Eider Society, and Sanikiluaq HTA for support of vessel operations around the Belcher Islands. Director Dr. Tim Papakyriakou and many members of CEOS were instrumental in making the cruise possible. Special thanks to Ashley Soloway for helping to manage equipment, shipping, and assisting with logistics; Dr. Sergei Kirillov assisting with mooring preparation; Stephen Ciastek for preparing other equipment and instruments; Alessia Guzzi for sampling protocol development and student training; and in particular, Yekaterina Yezhova was instrumental in preparing and packing for the cruise.

Financial support for the expedition (ship time) and operations onboard was provided by NSERC Alliance, Fisheries and Oceans Canada, Parks Canada Agency, and the CFI-funded University of Manitoba's Churchill Marine Observatory (CMO). Additional support was provided by University of Manitoba GETS program, Canadian Foundation for Innovation (CFI), and NSERC Discovery Grants and Research Tools and Instruments programs. Preparation of this report was led by C.J. Mundy and Yekaterina Yezhova.

Project Team

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Dr. Tim Papakyriakou, Co-Chief Scientist on Leg 1
Dr. Jens Ehn, not on board
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Kyle Hennebury, Second Mate
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Geraldine Harris, Bridge Watch
Tyson Arsenault, Bridge Watch
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Other collaborators, not on board
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Drs. Karen Richardson and Marlow Pellatt from the Office of the Chief Ecosystem Scientists, Parks Canada Agency

Most of the participants during Leg 1 of the 2023 James Bay and Belcher Islands Expedition aboard the Research Vessel William Kennedy. Photo credit: Nick Decker.

Most of the participants during Leg 2 of the 2023 James Bay and Belcher Islands Expedition aboard the Research Vessel William Kennedy. Photo credit: Jonathon Randall.

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1. Introduction

James Bay (Figure 1.1) remains one of the least studied water bodies in Canada despite its vast size (~68,000 km^2), resident beluga whale population, and rich coastal habitats that seasonally host hundreds of thousands of migratory birds (Steward & Lockhart, 2005). It is home to a large Cree First Nation population in nine coastal communities (Figure 1.1). The Belcher Islands are an Arctic archipelago located 120 km north of James Bay (Figure 1.1). The Inuit community of Sanikiluaq is located on the northern side of the islands, and the lands are part of Inuit Nunangat, or the homeland of the Inuit.

Situated at the southern margin of the Arctic, adjacent to Hudson Bay and with a vast watershed that includes the peatlands of the James Bay Lowlands, James Bay is uniquely positioned to respond to climate change. It is also a locus of freshwater river runoff, receiving more than 200 km^3/yr, which influences virtually all its properties. Because of its large freshwater inputs, James Bay exerts a strong influence on properties around the Belcher Islands within southeast Hudson Bay (Eastwood et al., 2020) and contributes to modifying Arctic Ocean outflow as it gets transported to the North Atlantic Ocean, ultimately influencing ocean properties and productivity in downstream areas as far away as the Labrador Sea.

The James Bay watershed hosts large industrial (hydroelectric) developments that have altered the timing and volume of river inflow to the bay. Throughout most of James Bay, our knowledge of basic ocean properties such as the saltiness (salinity) of the waters and the circulation patterns date back to the early 1970s. Based on observations (El-Sabhl & Koutitonsky, 1977; Peck, 1978; Prinsenberg, 1982) and recent modelling (Eastwood et al., 2020; Ridenour et al., 2019), James Bay may be considered a large estuary, connected to but oceanographically distinct from its neighbour, Hudson Bay. The early 1970s was the last time an offshore research vessel carried out a dedicated scientific mission in James Bay. Since then, we know James Bay has changed substantially, with Cree community members observing first-hand changes in river mouth morphology and in the plants and animals that comprise coastal ecosystems. Although a comprehensive coastal habitat research program got underway in Eeyou Istchee (east James Bay) in 2017 to study eelgrass habitat and its use by geese, the offshore areas of James Bay remained unstudied.

The Belcher Islands are of interest because the generally cyclonic (counterclockwise) surface circulation in Hudson Bay results in a strong influence of James Bay outflow around the southern part of the islands during winter (Eastwood et al., 2020) and possibly other times of the year (Macdonald & Kuzyk, 2011). In the summer, the surface waters surrounding the Belcher Islands show the lowest temperature relative to the surrounding Hudson Bay system, which may indicate water mixing and high productivity in the area (Department of Fisheries and Oceans, 2011; Galbraith & Larouche, 2011). Tidally generated internal waves (Petrusevich et al., 2018) and elevated surface Chlorophyll *a* concentrations (Anderson and Roff, 1980) also are documented in the Belcher Islands area. Indigenous-driven marine protection initiatives are being explored for both the Belcher Islands archipelago and James Bay.

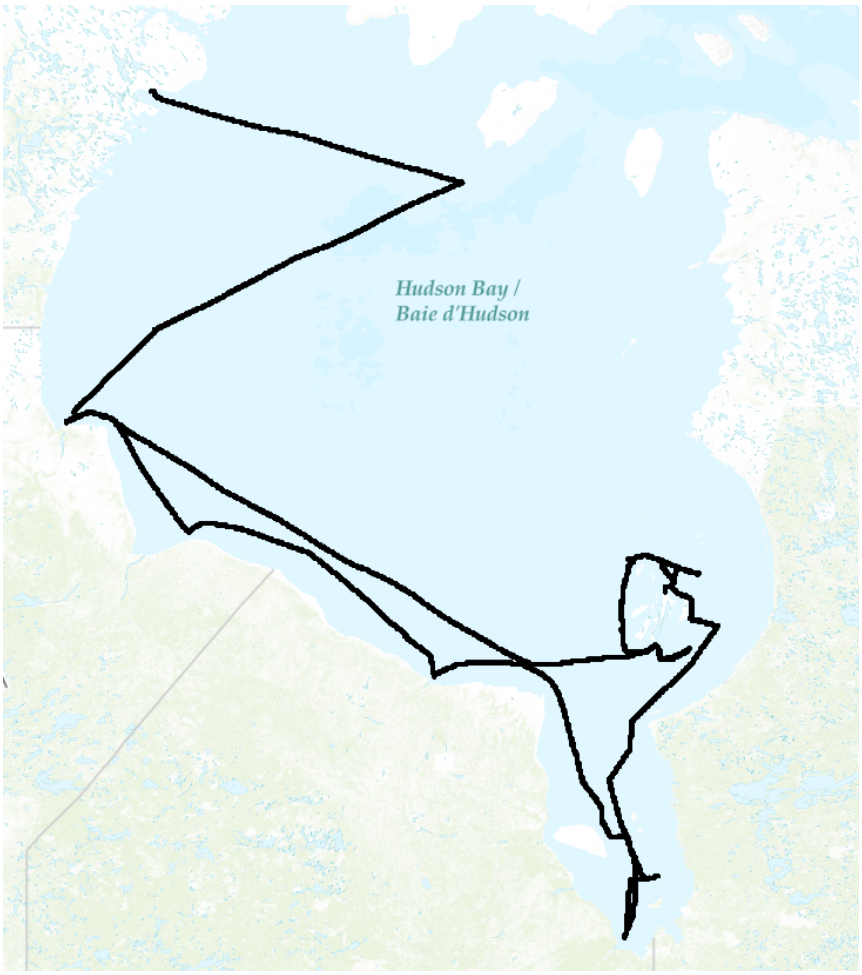

Figure 1.1. *Cruise track for the 2023 James Bay and Belcher Islands Expedition.*

The James Bay Expedition that took place in August 2021 through 2023 aimed to collect oceanographic data from southern Hudson Bay, the area surrounding the Belcher Islands, and the waters of James Bay to better understand these systems and the exchanges among the various subregions. The objective of the cruise in 2023 was to build on baseline oceanographic data collected in the region, including observations of physical, chemical, and biological features (e.g., salinity, temperature, currents, phytoplankton, zooplankton), with emphasis on offshore waters.

The southern Hudson Bay/James Bay/Belcher Islands cruise occurred between July 31 through September 1 and three legs (legs 0-2, Figure 1.1). Leg 0 started from Rankin Inlet, NU, and finished in Churchill, MB. There the ship refueled and loaded science gear and the leg 1 team, and then transited to the Winisk River, James Bay (where some science team got off), and then north to Sanikiluaq, NU. In Sanikiluaq, more science personnel exchanged to start leg 2, which circumnavigated the Belcher Islands. The ship then steamed back to Churchill to complete its Research cruise.

In each leg of the cruise, moorings deployed during the 2022 cruise were retrieved, and new oceanographic moorings were deployed. Within the James Bay-southern Hudson Bay study area, a full suite of water, sediment, and biota sampling was completed at 21 partial stations in Southern Hudson Bay and James Bay and 12 full stations around the Belcher Islands, with 169 CTD casts accomplished during the cruise. The zodiac was deployed to sample near the shore at a number of these stations. Additionally, surface water properties were monitored all along the ship's track using the ship's underway 'flow-through' system.

The intention is that the collected data will be completely accessible to all research partners. Data are first subjected to quality assurance/quality control screening and then curated onto the CEOS-based Canadian Watershed Information Network (CanWIN) (http://lwbi.cc.umanitoba.ca/). UM also will enter into a Data Sharing Agreement with Mushkegowuk Council and will post data, where appropriate, on SIKU.

2. Physical Oceanography and Mooring Operations

Cruise Participants: Kate Yezhova, Xander Bjornsson, Tim Papakyriakou (CEOS)
Principal Investigators: C.J. Mundy, Jens Ehn, Sergei Kirillov, Zou Zou Kuzyk, Tim Papakyriakou (CEOS), Dave Capelle, Andrea Niemi, and Marianne Marcoux (DFO)

Introduction

While the east coast of James Bay (Quebec) has been studied in relation to hydroelectric development and more recently eelgrass habitat (Ingram and Prinsenberg, 1987; Messier et al., 1989; Leblanc et al., 2022; Peck et al., 2022), the offshore and west coast (Ontario) has received little attention. Previous systematic hydrographic observations occurred in the 1970s and early 1980s (El-Sabh and Koutitonsky, 1977). Since the 1970s, James Bay has undergone significant change both in terms of the persistence of sea ice and sea surface temperatures (SST) (Kirillov et al., 2020). Prior to the 2021 James Bay Expedition, virtually no information was available for assessment of changes to subsurface hydrographic baseline conditions or surface conditions that are not accurately assessed from space (i.e., satellite data). The Belcher Islands lie downstream of James Bay outflow meaning that surface waters south of the islands are more strongly influenced by freshwater than expected from the amount of local river discharge (Eastwood et al., 2020; Meilleur et al., 2023). This is particularly noticeable during winter when James Bay outflow contains large amounts of river discharge due, in part, to high discharge from the regulated La Grande River system (Peck et al., 2022; de Melo et al., 2022). South of the Belcher Islands, the water column remains shallowly stratified during winter (~20 m), in contrast to the winter mixed layers >40–60 m deep that develop in areas outside the influence of winter river discharge (Prinsenberg, 1987; Granskog et al., 2011; Eastwood et al., 2022). Subsurface waters surrounding Belcher Islands also have an increased risk of ocean acidification possibly due to the degradation of organic matter exported from James Bay (Azetsu-Scott et al., 2014). The 2023 James Bay and Belcher Islands Expedition built on oceanographic data collected during 2021-2022 through sampling of oceanographic conditions, retrieval of two moorings that continuously collected data southeast of Belcher Islands and in southern James Bay from August 2022 to August 2023, as well as deployment of three new moorings in Winisk and Moose River estuaries and at a new site south of Belcher Islands. Oceanographic data collected in 2023, including 169

CTD casts as well as surface water properties from continuous flow-through sampling using the ship's thermosalinograph, will contribute to a better understanding of the oceanography of James Bay and southern Hudson Bay marine systems.

Data Collection

Hydrographic Profiles

Hydrographic profiles were collected using conductivity, temperature, and depth (CTD) sondes. Two identical Sea-Bird SBE 19plus V2 SeaCAT profiler CTDs were used, each equipped with a Biospherical Instruments Inc. scalar photosynthetically active radiation (PAR) sensor (model QSP2350) and a Sea-Bird SBE 43 dissolved oxygen sensor. One CTD was in a standalone configuration (Figure 2.1a) and included Sea-Bird/WET Labs chlorophyll fluorometer (model FLRT), CDOM fluorometer (model FLCDRT), and a C-Star transmissometer (model CST). The other CTD was in a rosette configuration, mounted horizontally onto an SBE 32 carousel water sampler frame (Figure 2.1b), additionally equipped with an independently-logging Sea-Bird/Satlantic nitrate sensor (model SUNA). The rosette system would also typically have a Sea-Bird/WET Labs chlorophyll, CDOM, and phycoerythrin fluorometer (model FL3BAC), however, it was out of commission for the 2023 field season. RBRmaestro³ Multi-Channel Logger was added to the rosette frame for some of the casts to capture chlorophyll data.

Sea-Bird CTD profiles were collected at sites near estuaries in southern Hudson Bay, around the circumference of Belcher Islands, and across the length of James Bay (Figure 2.2). In addition to the Sea-Bird CTD units, a SonTek CastAway CTD and/or an RBRmaestro³ Multi-Channel Logger were deployed on a weighted line to sample from the ship's small boats when they visited near-shore and river sample sites. A total of 129 standalone Sea-Bird CTD profiles, 18 rosette Sea-Bird CTD profiles, and several RBRmaestro³ and CastAway CTD profiles were taken in James Bay and Belcher Islands, which complements the 173 CTD profiles taken in 2021 and 269 CTD profiles taken in 2022, giving extensive oceanographic observation coverage for southern Hudson Bay and James Bay.

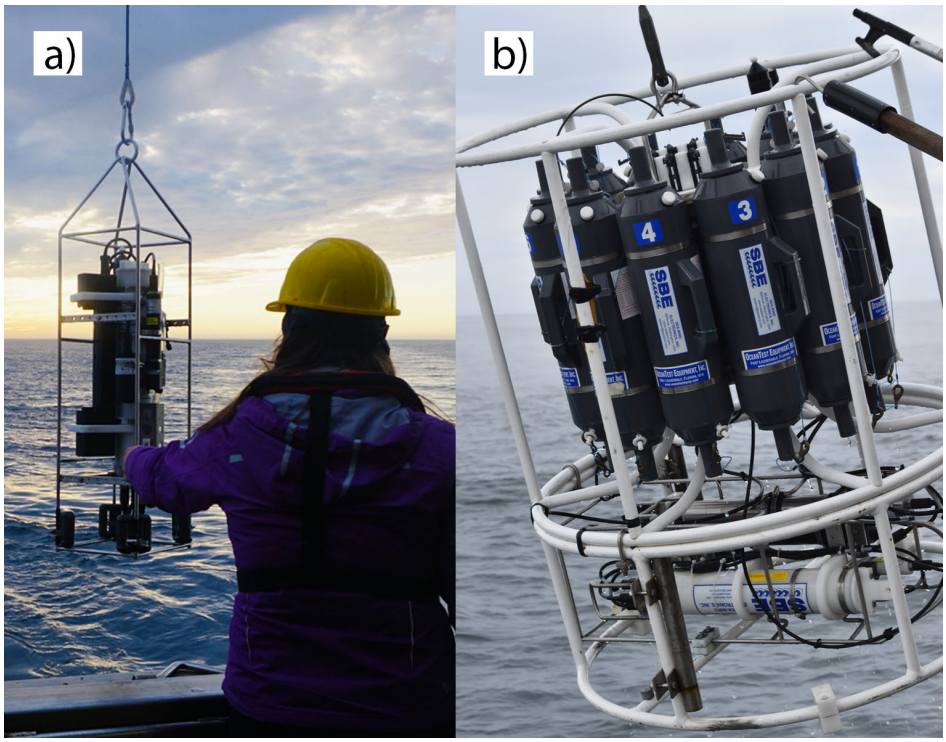

Figure 2.1. *Pictures of the standalone Sea-Bird CTD (a) and rosette-mounted Sea-Bird CTD (b) mounted horizontally below rosette. Photo credits: a) Brynn Devine, b) Nick Decker.*

Figure 2.2. *Locations of Sea-Bird CTD casts taken during Legs 1 and 2 of the 2023 James Bay and Belcher Islands Expedition.*

Mooring Recoveries

The 2023 James Bay and Belcher Islands Expedition continued oceanographic monitoring through the deployment and retrieval of oceanographic moorings. Of the five moorings deployed during the 2022 James Bay Expedition, three were recovered (Figure 2.3; Table 2.1). The recovery included the one mooring deployed in James Bay and two out of four moorings deployed in Hudson Bay. Mooring CMO-A deployed near Churchill, Manitoba, and mooring BI-M2 deployed southwest of Belcher Islands were not recovered this year.

Efforts to locate mooring CMO-A included a search within a several nautical mile radius of the deployed location using the ship's sounder. The original science logbook and the cruise track from 2022 were checked to confirm the ship was passing over the correct location. Original documents detailing the release/transponder configuration were checked to verify if there were any errors in the 2022 mooring schematic. Finally, two different deck boxes and transducers were used in case of malfunction. Mooring CMO-A was never located. Mooring BI-M2 was located but had lost its buoyancy and was unable to be recovered. Ship time will be allocated in 2024 to attempt to recover this mooring using larger grappling hooks.

Figure 2.3. *Locations of moorings from the 2022 and 2023 James Bay and Belcher Islands Expeditions.*

Table 2.1. *Moorings retrieved during the 2023 James Bay and Belcher Islands Expedition.*

Site	Bottom depth (m)	Lat (N)	Long (W)	Date of deployment	Date of retrieval	Depth of top float (m)
CMO-B	181	61.7603°	84.3012°	2022-07-25	2023-08-02	22
JB-H	78.1	52.4317°	79.4089°	2022-08-16	2023-08-14	44
BI-M1	92.8	55.6202°	79.0273°	2022-08-21	2023-08-28	16.4

Preliminary Nortek Signature500 5th beam data from the recovered mooring BI-01 (southeast of Belcher Islands) are shown in Figure 2.4. The satellite data show that the mooring position was ice-covered between December 13, 2022 and June 14, 2023. In the figure, this time is characterized by negative values of the observed sea surface heights, and one may also distinguish three periods characterized by different behaviour of the observed sea ice thicknesses. The first period, from December 13 to February 20, demonstrates the presence of mobile sea ice with the gradually growing but highly variable thicknesses. In the third week of February, the ice in the region became landfast and the ice thickness started growing thermodynamically from the initial 20 cm to the seasonal maximum of about 70 cm at the end of April. After that the depth of the ice-ocean interface shallowed by 20 cm during the first decade of May, apparently due to a combined effect of snow and ice melt. The last period began when the landfast ice broke on May 10 and lasted until mid-June. Sea ice thicknesses during this period were characterized by large variability (with an overall tendency to decreasing) alternating with ice-free periods. Such behaviour indicates the presence of mobile sea ice from other regions that passed the mooring position.

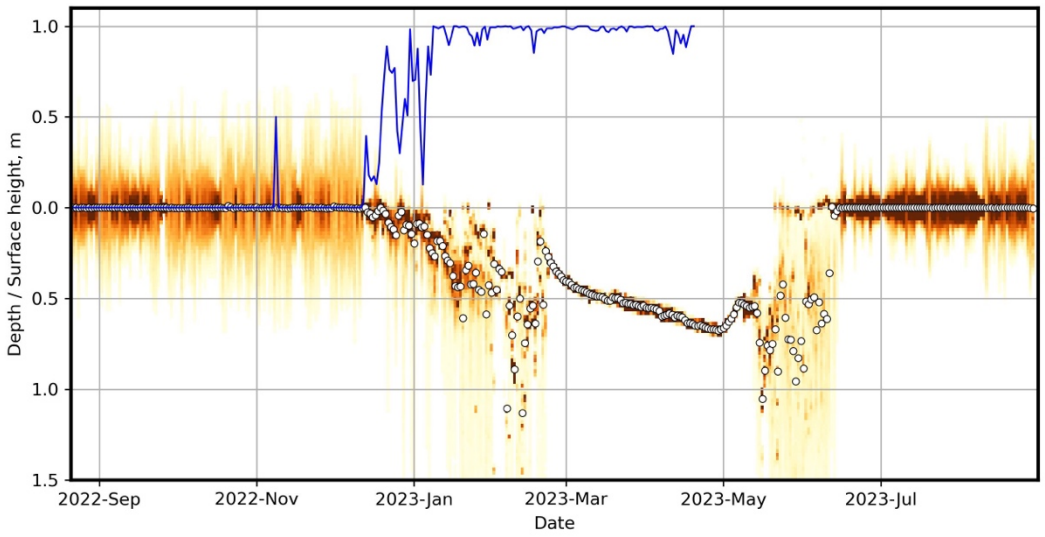

Figure 2.4. *The daily probability density function (PDF) of sea level heights and/or lower ice surface depths obtained with Nortek Signature500 southeast of Belcher Islands between August 2022 and September 2023. White circles show the position of medians. Blue line indicates the sea ice concentration in the vicinity of the mooring derived from satellite data (AMSR2).*

Mooring Deployments

A total of three moorings were deployed in Hudson and James Bays (Figure 2.3; Table 2.2). One mooring was deployed south of Belcher Islands, and two were deployed in Winisk River and Moose River estuaries.

Figures 2.5-2.7 present schematics of the instrument arrays on the three oceanographic moorings deployed during the cruise. The moorings contained a combination of equipment supplied by CMO and individual researchers within CEOS and DFO. The schematics include deployment information, instrument types, serial numbers, approximate depths, and acoustic release codes. The estuary moorings were programmed for >3 months of deployment, with recovery planned for September-October 2023. The Moose River mooring was lost during deployment on August 15, 2023, due to unexpectedly strong currents in the estuary. The Winisk River mooring was deployed on August 12, 2023, and successfully retrieved on September 18, 2023. BI-M3 mooring was deployed on August 26, 2023, and programmed to accommodate >12 months of deployment, with recovery planned for August 2024. Successful deployment of each sensor's position and vertical orientation in the water column was verified shortly after deployment of the BI-M3 mooring by passing across the mooring location while scanning with the WASSP multibeam sonar system.

Table 2.2. *Moorings deployed during the 2023 James Bay and Belcher Islands Expedition.*

Site	Bottom depth (m)	Lat (N)	Long (W)	Date of deployment	Depth of top float (m)
Winisk River	6	55.3583°	85.0083°	2023-08-12	0
Moose River	4	51.3819°	80.3741°	2023-08-15	0
BI-M3	171	55.7019°	79.7828°	2023-08-26	23.6

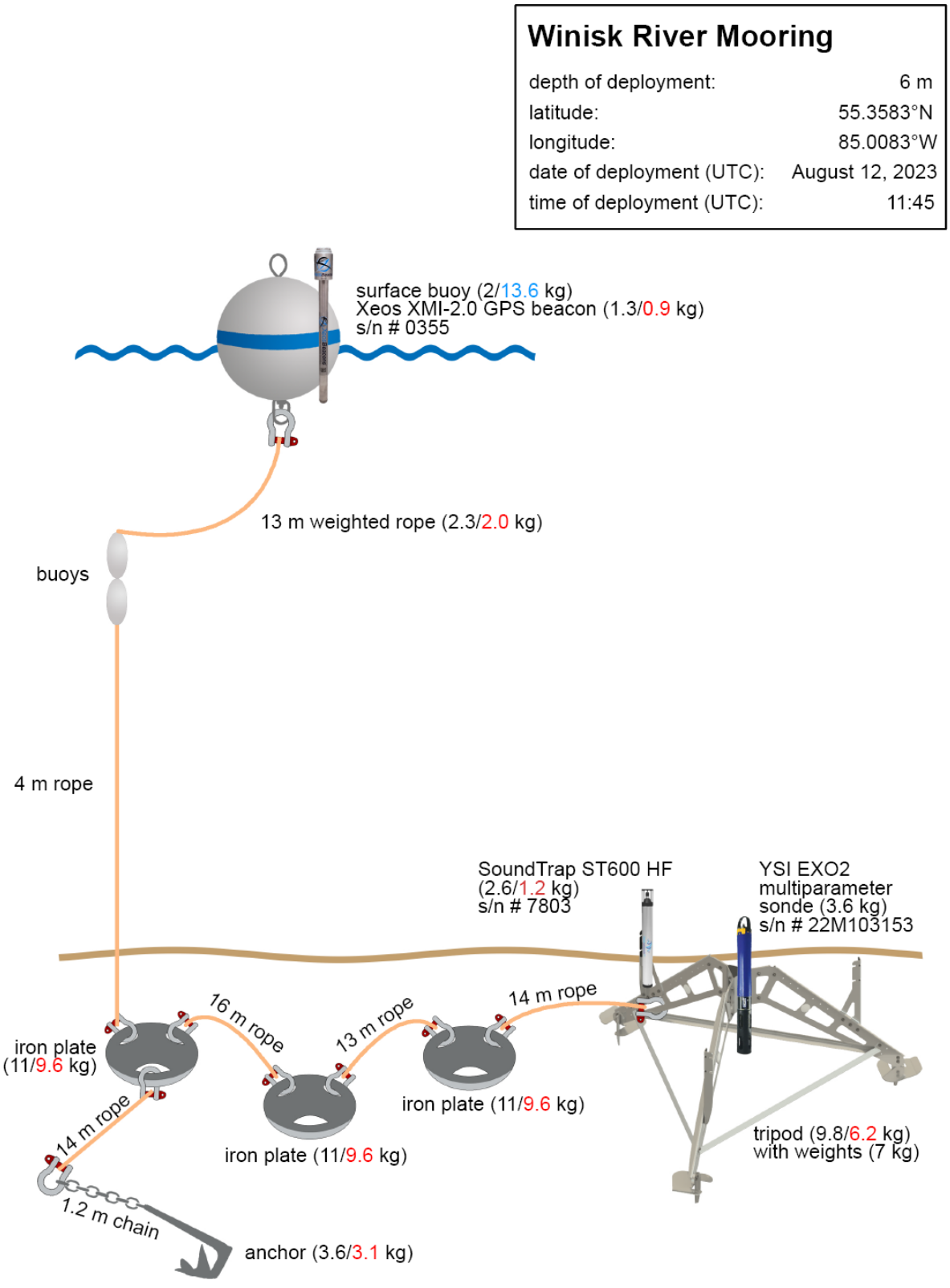

Figure 2.5. *Configuration and instrument serial numbers for the Winisk River mooring.*

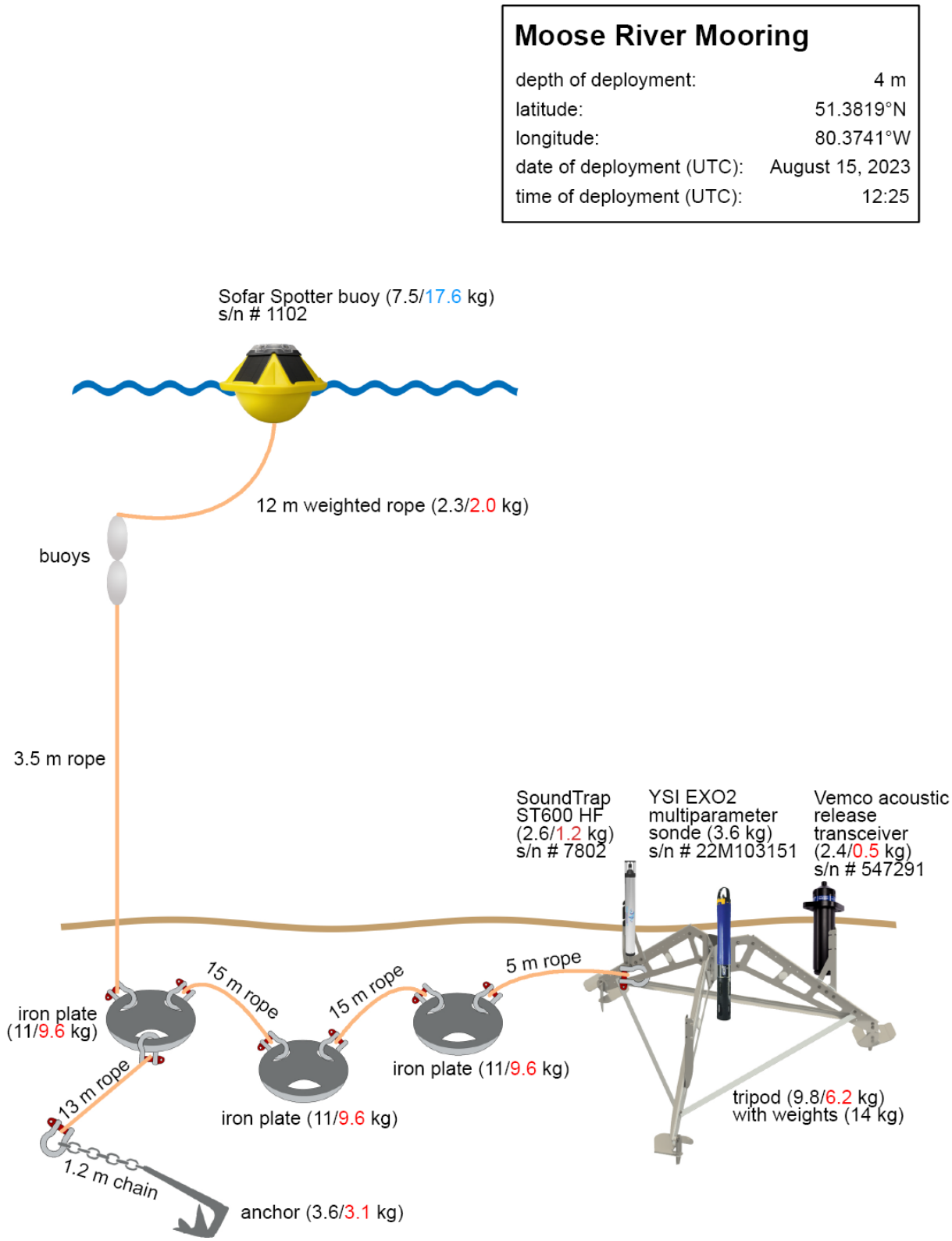

Figure 2.6. *Configuration and instrument serial numbers for the Moose River mooring.*

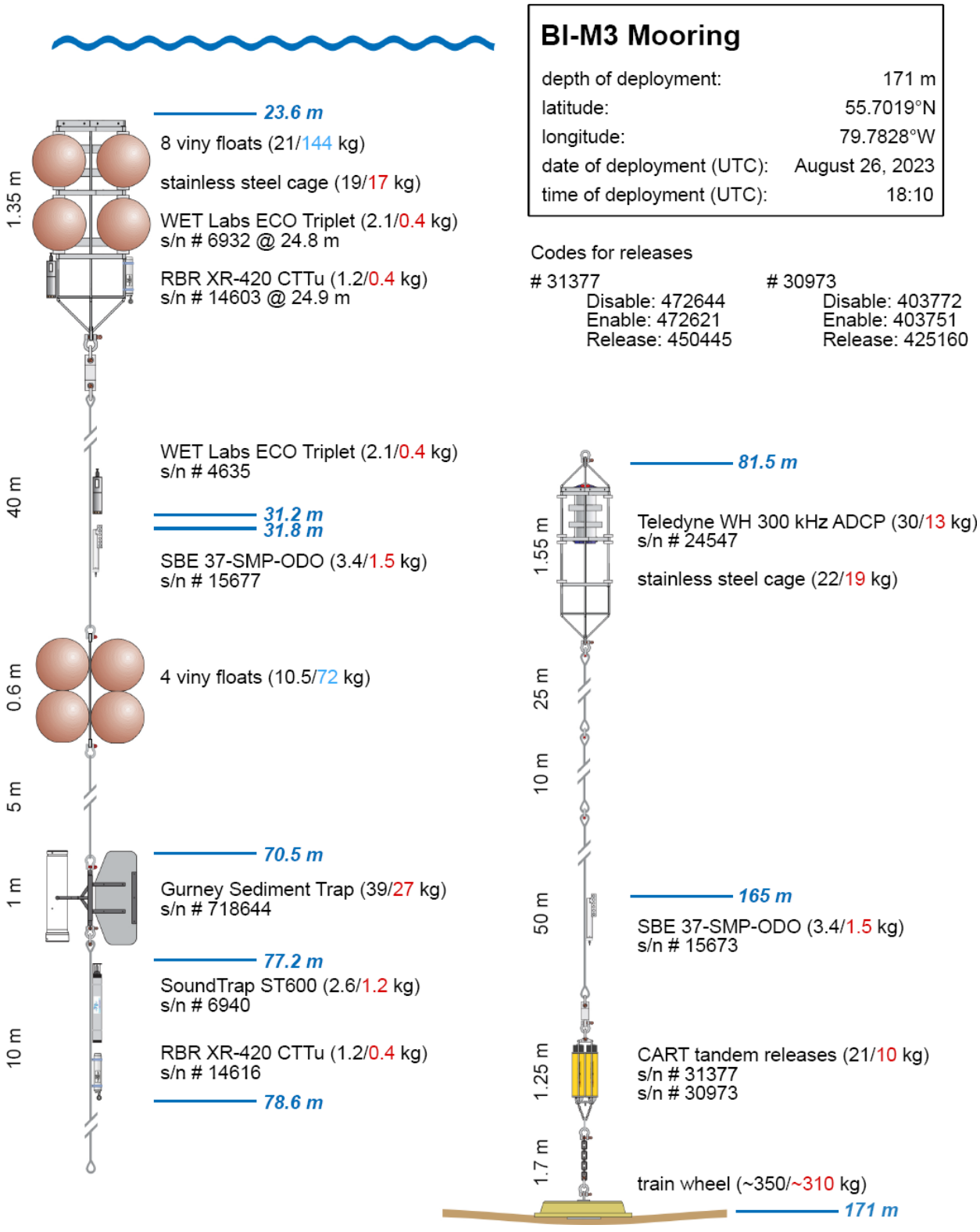

Figure 2.7. *Configuration and instrument serial numbers for mooring BI-M3.*

3. Sample Collection

Offshore and coastal samples were collected throughout western James Bay and southern Hudson Bay from the RV *William Kennedy*. Sample collection included water, phytoplankton, zooplankton, benthic invertebrates, benthic fish, and sediment. The sample collection and subsequent on-board processing are described in detail in the following sections. Due to unforeseen difficulties with the Rosette and the Rosette winch, some stations did not involve all sampling. Table 2.3 provides details of sample locations, type and date.

Table 3.1. *List of sample stations.*

Station ID	Latitude (deg	Longitude (d	Date on station (UTC)	SBE19plusV2	SonTek Cast/	Rosette cast	Niskin bottle	Underway/fl	WP2 conical	Bongo net ol	Benthic bear	Ponar grab	Box core	Gravity core	Mooring retr	Mooring dep	Drop camera
BI-04	55.7964	-79.4533	2023-08-27,2023-08-28	2	0	1	0	2	1	1	0	0	0	0	0	0	0
BI-06	56.0635	-77.9338	2023-08-17,2023-08-18	1	0	0	1	1	1	1	1	0	1	0	0	0	0
BI-07	56.1513	-78.5939	2023-08-18	2	0	0	6	1	1	1	4	0	0	0	0	0	1
BI-08	56.7721	-78.4017	2023-08-23	1	0	2	0	0	1	3	2	2	0	0	0	0	0
BI-09	56.8491	-78.8275	2023-08-23	2	0	2	0	0	1	2	2	1	2	0	0	0	0
BI-10	56.9483	-79.2438	2023-08-21	1	0	0	3	1	2	1	1	0	0	0	0	0	0
BI-11	57.0336	-79.6877	2023-08-24	1	0	2	0	0	1	1	1	1	3	0	0	0	0
BI-12	56.9948	-80.1378	2023-08-24	1	0	1	0	0	1	1	1	1	1	0	0	0	0
BI-16	55.7016	-79.7863	2023-08-26	2	0	1	4	0	1	2	1	0	1	0	0	1	0
BI-17	55.499	-78.6373	2023-08-17	1	0	0	0	0	3	2	1	0	2	0	0	0	0
BI-M1	55.6218	-79.0249	2023-08-27,2023-08-28	1	0	2	3	0	2	0	0	0	0	0	1	0	0
BI-M2	56.0064	-80.3048	2023-08-25,2023-08-26	1	0	2	0	5	1	2	2	1	0	0	0	0	0
CE1	58.7933	-94.2089	2023-08-08	2	0	0	0	1	1	0	0	0	0	1	0	0	2
CE2	58.8207	-94.1021	2023-08-09	1	0	0	0	3	0	2	1	0	0	0	0	0	0
CMO-A	59.9783167	-91.93895	2023-08-03	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CMO-B	61.7613	-84.29905	2023-08-01,2023-08-02	1	0	1	0	1	0	0	0	0	0	0	1	0	0
CTD-1/FT-1	55.3855	-82.2863	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-10	54.1137	-81.4075	2023-08-13	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-11/FT-6	53.9537	-81.3373	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-12	53.8213	-81.2757	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-13/FT-7	53.6898	-81.1045	2023-08-14	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-14	53.5576	-80.9332	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-15	53.4103	-80.7975	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-16	53.2437	-80.7936	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-17/FT-8	53.133	-80.6983	2023-08-14	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-18	53.0241	-80.608	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-2	55.277	-82.0693	2023-08-13	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-20/FT-1	52.7311	-80.0042	2023-08-14	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-21	52.5733	-79.8937	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-22	52.4203	-79.791	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-23/FT-1	52.3932	-79.579	2023-08-14	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-25	52.3809	-79.7116	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-26/FT-1	52.3729	-80.1174	2023-08-15	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-27	52.208	-80.1333	2023-08-15	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-28/FT-1	52.0378	-80.1531	2023-08-15	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-29	51.8724	-80.1722	2023-08-15	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-3/FT-2	55.1334	-81.9126	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-30/FT-1	51.7052	-80.1916	2023-08-15	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-31	51.5819	-80.2016	2023-08-15	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-32	54.7564	-80.0112	2023-08-16	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-33	54.8126	-79.9085	2023-08-16	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-34	54.8703	-79.8024	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-35	54.9254	-79.695	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-36	54.9826	-79.5907	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-37	55.0409	-79.4892	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-38	55.0977	-79.381	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-39	55.1546	-79.2799	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-4	54.9745	-81.8227	2023-08-13	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-40	55.21	-79.1757	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-41	55.2665	-79.0613	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-42	55.3271	-78.9647	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-43	55.3847	-78.8561	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-44	55.4407	-78.7533	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-45	55.5659	-78.5454	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-46	55.6356	-78.469	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-47	55.70154	-78.38212	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-48	55.7726	-78.3008	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-49	55.8386	-78.2121	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-5/FT-3	54.8176	-81.733	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-50	55.907	-78.1289	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-51	55.9768	-78.0403	2023-08-17	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-52	56.0877	-78.0746	2023-08-18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-53	56.1084	-78.2191	2023-08-18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-54	56.1283	-78.3606	2023-08-18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-55	56.1512	-78.5066	2023-08-18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-56	56.1995	-78.5713	2023-08-18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-57	56.2816	-78.5692	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-58	56.3641	-78.5829	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-59	56.4467	-78.591	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-6	54.655	-81.6615	2023-08-13	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-60	56.4807	-78.7133	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-61	56.4989	-78.8588	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-62	56.5549	-78.9723	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-63	56.6056	-79.0985	2023-08-19	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-64	56.8233	-78.6857	2023-08-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-65	56.7982	-78.5417	2023-08-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-66	56.8024	-78.5438	2023-08-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-67	56.8831	-78.9666	2023-08-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-68	56.9157	-79.1072	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-69	56.9771	-79.3857	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-7/FT-4	54.4943	-81.587	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-70	57.0029	-79.5321	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-71	57.0261	-79.8378	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-72	57.004	-79.9885	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-73	56.9491	-80.0392	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-74	56.8901	-80.1386	2023-08-24	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-75	56.8071	-80.1755	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-76	56.7253	-80.2111	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-77	56.6474	-80.2537	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-78	56.5645	-80.2837	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-79	56.4822	-80.2955	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-8	54.3841	-81.5356	2023-08-13	1	0	0	0	0	0	1	0	0	0	0	0	0	0
CTD-80	56.4014	-80.314	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-81	56.327	-80.3322	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-82	56.2408	-80.3218	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-83	56.1593	-80.3156	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-84	56.0758	-80.3053	2023-08-25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-85	55.9307	-80.3017	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-86	55.8623	-80.2818	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-87	55.7819	-80.2561	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-88	55.7091	-80.2092	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-89	55.7049	-80.096	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-9/FT-5	54.2769	-81.4792	2023-08-13	1	0	0	0	1	0	0	0	0	0	0	0	0	0
CTD-90	55.7088	-79.916	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-91	55.7071	-79.7089	2023-08-26	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-92	55.7518	-79.5809	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-93	55.7369	-79.391	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-94	55.6751	-79.3871	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-95	55.6054	-79.3742	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-96	55.6063	-79.2592	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CTD-97	55.6203	-79.1318	2023-08-27	1	0	0	0	0	0	0	0	0	0	0	0	0	0
FT-9	53.0219	-80.1923	2023-08-14	1	0	0	0	1	0	0	0	0	0	0	0	0	0
JB-H	52.4319	-79.4088	2023-08-14	1	0	0	0	0	0	0	0	0	0	0	1	0	0
M.R.M.	51.3819	-80.3741	2023-08-15	0	0	0	2	0	0	0	0	0	0	0	0	1	0
ME	52.8801	-80.1278	2023-08-14	1	0	0	0	0	1	3	1	0	0	0	0	0	0
MR	51.4727	-80.2432	2023-08-15	1	0	1	0	5	0	0	0	0	1	0	0	0	0
NE1	57.6723	-91.6078	2023-08-10	1	0	0	3	3	0	0	0	0	0	0	0	0	0
NE2	57.6056	-91.5167	2023-08-10	1	0	0	0	0	0	0	0	0	0	0	0	0	0
NE3	57.5419	-91.421	2023-08-10	1	0	0	3	1	0	0	0	0	0	0	0	0	0
NE4	57.477	-91.3275	2023-08-10	1	0	0	0	0	0	0	0	0	0	0	0	0	0
NE5	57.4113	-91.2287	2023-08-10	1	0	0	2	1	0	0	0	0	0	0	0	0	0
NE6	57.3457	-91.1345	2023-08-10	1	0	0	0	1	0	0	0	0	0	0	0	0	0
W-Z1	55.3401	-85.0109	2023-08-12	0	1	0	8	0	0	0	0	0	0	0	0	0	0
W-Z2	55.322	-85.0302	2023-08-12	0	1	0	4	0	0	0	0	0	0	0	0	0	0
W-Z3	55.3091	-85.066	2023-08-12	0	1	0	3	0	0	0	0	0	0	0	0	0	0
W-Z4	55.2855	-85.0891	2023-08-12	0	1	0	7	0	0	0	0	0	0	0	0	0	0
W.R.M.	55.3583	-85.0083	2023-08-12	0	0	0	0	0	0	0	0	0	0	0	0	1	0
W1	55.9469	-85.7266	2023-08-11,2023-08-12	1	0	1	0	0	1	1	1	0	0	0	0	0	0
W2	55.3592	-85.0095	2023-08-12	2	0	2	0	1	0	0	0	0	2	0	0	0	0

3a. Chemical Oceanography

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OBJECTIVES

Dissolved water properties (geochemical tracers) and particulate properties measured in bottle samples provide complementary information to physical in-situ measurements for improving understanding of the oceanography of James Bay. This includes circulation, water mass distributions, mixing of freshwater from river inflow and sea ice melt, and surface water properties that affect light penetration in James Bay. Several bay-wide studies were conducted in the 1970s and 1980s (El-Sabh & Koutitonsky, 1977; Peck, 1976; Prinsenberg, 1983), but recent studies have focused primarily within the La Grande plume along the northeastern shore (de Melo et al., 2022; Peck et al., 2022). It is thought that Hudson Bay surface waters have generally warmed and freshened throughout the 1980s and 1990s (Brand et al., 2014). As such, salinity, $\delta^{18}O$, CDOM, DOC, $\delta^{13}C$-DOC, SPM and aP were collected at various depths at stations located from southeastern Hudson Bay (Winisk, ON), down to southern James Bay (Moosonee, ON), and up to the Belcher Islands (Table 3.1) to better characterize the geochemical and biogeochemical oceanography of these study areas.

The objectives of this water sampling program were to:

1. Provide an in-situ dataset of water properties, including salinity and water stable isotope ratios, that may be applied to quantify the contribution of different freshwater sources (river water and sea ice melt). This data provides new baseline information for the James Bay and Belcher Island regions.

2. Determine how nutrients, DOC, and suspended particle properties vary both spatially and temporally, and in relation to changing light and sea ice conditions. The suspended particle dataset will be cross-referenced with current satellite imagery to gauge whether current remote sensing algorithms are suitable for high-latitude waters. This data provides insight into areas of high biological productivity/phytoplankton biomass.

3. Develop a better understanding of how variables from Objectives 1 and 2 are influenced by freshwater sources, including variations in salinity, temperature, and freshwater source.

METHODS & DATA COLLECTION

Water Collection

Water samples were collected by various methods, including 1.) by Sea-Bird Rosette, 2.) individual Niskins, and 3.) flowthrough underway system (FT). The bulk of samples were collected at various depths by a Sea-Bird Rosette consisting of twelve (12) 5 L Niskin bottles. When problems arose with the Rosette, individual 5 L Niskin bottles were attached to a rope, lowered into the water until the target depth was reached, and had a messenger sent down to close the bottle. The bottle was then brought back to surface and onto the deck. This process was repeated until all target depths were sampled. Samples collected through FT were typically those sampled during ship transit, though some surface samples were collected by FT at deeper stations to reserve Rosette Niskins for other depths. Water for salinity, $\delta^{18}O$, and syringe filtration (i.e. dissolved tracers) was collected directly from the Niskin (or FT) into acid-washed, 500mL brown Nalgene bottles. The Nalgene bottles were rinsed three times with sample water before collection of sample water. Water intended for aP and SPM filtration was collected from the Niskin (or FT) into either 3.8 L or 2.7 L plastic jugs. Jugs were rinsed with sample water three times prior to sample water collection.

Table 3.2. *Water Sampling Metadata for Legs 1 and 2 on the 2023 William Kennedy Cruise*

Date (mm-dd)	Time (UTC)	Latitude (N)	Longitude (W)	Ship station	Code	Sample depth [m]	Bottom depth[1] [m]	Salinity	δ18O	CDOM	DOC (4mL)	DOC (9mL)	13C-DOC	AP	SPM
08-08	23:52	58.7884	94.2127	CE1	FT	2	11.7	1	1	1	2	1	1	1	1
09-08	20:50	58.8205	94.1027	CE2	FT	2	20.9	1	1	1	2	1	1	1	1
10-08	13:42	57.6739	91.5974	NE1	FT	2	61.5	1	1	1	2	1	1	1	1
10-08	14:03	57.6749	91.5856	NE1	NISK	15	66.1	1	1	1	2	1	1	1	1
10-08	14:03	57.6749	91.5856	NE1	NISK	50	66.1	1	1	1	2	1	1	0	0
10-08	15:45	57.5419	91.4206	NE3	FT	2	31.8	1	1	1	2	1	1	1	1
10-08	16:04	57.5417	91.4180	NE3	NISK	27	31.6	1	1	1	2	1	1	0	0
10-08	16:15	57.5417	91.4171	NE3	NISK	12	32.7	1	1	1	2	1	1	0	0
10-08	16:33	57.5415	91.4163	NE3	NISK	13*	33.3	1	1	1	2	1	1	1	1
10-08	18:13	57.411	91.2287	NE5	FT	2	13	1	1	1	2	1	1	1	1
10-08	18:25	57.4088	91.2283	NE5	NISK	10	14.5	1	1	1	2	1	1	1	1
10-08	18:46	57.4045	91.2291	NE5	NISK	5	14.9	1	1	1	2	1	1	0	0
10-08	19:32	57.345	91.1340	NE6	FT	2	6.8	1	1	1	2	1	1	1	1
11-08	23:35	55.9461	85.7380	W1	ROS	1	64.8	1	1	1	2	1	1	1	1
11-08	23:35	55.9461	85.7380	W1	ROS	20	64.8	1	1	1	2	1	1	1	1
11-08	23:35	55.9461	85.7380	W1	ROS	60	64.8	1	1	1	2	1	1	1	1
12-08	7:48	55.3592	85.0095	W2-A	ROS	0.3	6.8	1	1	1	2	1	1	1	1
12-08	7:48	55.3592	85.0095	W2-A	ROS	5	6.8	1	1	1	2	1	1	2	2
12-08	10:13	55.3593	85.0095	W2-B	ROS	0.3	5.8	1	1	1	2	1	1	NA	NA
12-08	10:13	55.3593	85.0095	W2-B	ROS	4	5.8	1	1	1	2	1	1	NA	NA
12-08	12:30	55.3401	85.0109	W-Z1	NISK	Surf	5.5	1	1	1	2	1	1	1	1
12-08	12:30	55.3401	85.0109	W-Z1	NISK	4	5.5	1	1	1	2	1	1	1	1
12-08	14:08	55.322	85.0302	W-Z2	NISK	Surf	4.6	1	1	1	2	1	1	1	1
12-08	14:42	55.3091	85.0660	W-Z3	NISK	Surf	2.36	1	1	1	2	1	1	1	1
12-08	15:35	55.2855	85.0891	W-Z4	NISK	Surf	2.17	1	1	1	2	1	1	1	1
12-08	21:09	55.3591	85.0100	W2-C	FT	2	6	1	1	1	2	1	1	1	1
13-08	9:20	55.3839	82.2844	FT-1	FT	2	33.3	1	1	1	2	1	1	1	1
13-08	12:05	55.1334	81.9126	FT-2	FT	2	29.5	1	1	1	2	1	1	1	1

Table 3.2 *(cont.)*

Date (mm-dd)	Time (UTC)	Latitude (N)	Longitude (W)	Ship station	Code	Sample depth [m]	Bottom depth[1] [m]	Salinity	δ18O	CDOM	DOC (4mL)	DOC (9mL)	13C-DOC	AP	SPM
13-08	15:00	54.8176	81.7329	FT-3	FT	2	29.9	1	1	1	2	1	1	1	1
13-08	18:06	54.4939	81.5869	FT-4	FT	2	42	1	1	1	2	1	1	1	2
13-08	20:30	54.2769	81.4792	FT-5	FT	2	61.4	1	1	1	2	1	1	1	1
13-08	23:15	53.9537	81.3371	FT-6	FT	2	39.6	1	1	1	2	1	1	1	1
14-08	1:43	53.6899	81.1046	FT-7	FT	2	31	1	1	1	2	1	1	1	1
13-08	18:06	54.4939	81.5869	FT-4 Dup	FT	2	42	1	1	1	2	1	1	0	0
14-08	23:15	53.9537	81.3371	FT-6 Dup	FT	2	39.6	1	1	1	2	1	1	0	0
14-08	7:11	53.1331	80.6984	FT-8	FT	2	15.9	1	1	1	2	1	1	0	0
14-08	10:38	53.0219	80.1923	FT-9	FT	2	53.4	1	1	1	2	1	1	1	1
14-08	15:20	52.7232	80.0007	FT-10	FT	2	62.5	1	1	1	2	1	1	2	2
14-08	18:47	52.3935	79.5793	FT-11	FT	2	74.2	1	1	1	2	1	1	1	1
15-08	0:00	52.3729	80.1174	FT-12	FT	2	33.9	1	1	1	2	1	1	1	1
15-08	2:40	52.0378	80.1531	FT-13	FT	2	24.5	1	1	1	2	1	1	1	1
15-08	5:13	51.7052	80.1916	FT-14	FT	2	15.1	1	1	1	2	1	1	1	1
15-08	7:53	51.4727	80.2432	FT-15	FT	2	6.9	1	1	1	2	1	1	3	2
15-08	8:56	51.4728	80.2433	MR-A	ROS	NA	6.7	1	1	1	2	1	1	1	2
15-08	8:56	51.4728	80.2433	MR-A	ROS	2	6.7	1	1	1	2	1	1	1	2
15-08	12:28	51.4727	80.2431	FT-16	FT	2	5.3	1	1	1	2	1	1	1	1
15-08	--	51.3819	80.3741	MRM	NISK	2	~ 3.5	1	1	1	2	1	1	1	1
15-08	12:37	51.3819	80.3741	MRM	NISK	~3	~3.5	1	1	1	2	1	1	1	1
15-08	15:57	51.4723	80.2434	FT-17	FT	2	6.4	1	1	1	2	1	1	1	1
15-08	18:03	51.4723	80.2436	FT-18	FT	2	7.6	1	1	1	2	1	1	1	1
15-08	20:02	51.4727	80.2442	FT-19	FT	2	7.3	1	1	1	2	1	1	2	2
18-08	1:36	56.0674	77.9352	BI-06	FT	2	81.7	1	1	1	2	1	1	1	1
18-08	1:58	56.0683	77.9336	BI-06	NISK	75	82	1	1	1	2	1	1	1	1
18-08	22:08	56.1625	78.5790	BI-07	NISK	29	32.8	1	1	1	2	1	1	1	1

Table 3.2 *(cont.)*

Date (mm-dd)	Time (UTC)	Latitude (N)	Longitude (W)	Ship station	Code	Sample depth [m]	Bottom depth[1] [m]	Salinity	δ18O	CDOM	DOC (4mL)	DOC (9mL)	13C-DOC	AP	SPM
18-08	21:16	56.165	78.5845	BI-07	FT	2	34.1	1	1	1	2	1	1	1	1
18-08	21:36	56.1645	78.5927	BI-07	NISK	6	34.5	1	1	1	2	1	1	1	1
18-08	22:32	56.1596	78.5782	BI-07	NISK	20	37.3	1	1	1	2	1	1	1	1
23-08	2:39	56.8491	78.8275	BI-09	ROS	50	54.6	1	1	1	2	1	1	1	1
23-08	2:41	56.8491	78.8275	BI-09	ROS	40	54.6	1	1	1	2	1	1	0	0
23-08	2:44	56.8491	78.8275	BI-09	ROS	30	54.6	1	1	1	2	1	1	1	1
23-08	2:46	56.8491	78.8275	BI-09	ROS	20	54.6	1	1	1	2	1	1	1	1
23-08	4:24	56.8491	78.8275	BI-09	ROS	10	54.6	1	1	1	2	1	1	0	0
23-08	4:27	56.8491	78.8275	BI-09	ROS	1	54.6	1	1	1	2	1	1	1	1
23-08	15:22	56.7731	78.4015	BI-08	ROS	45	49.1	1	1	1	2	1	1	1	1
23-08	17:45	56.7714	78.4023	BI-08	ROS	30	54.3	1	1	1	2	1	1	1	1
23-08	17:47	56.7714	78.4023	BI-08	ROS	20	54.3	1	1	1	2	1	1	1	1
23-08	17:50	56.7714	78.4023	BI-08	ROS	10	54.3	1	1	1	2	1	1	1	1
23-08	15:36	56.7731	78.4015	BI-08	ROS	1	49.1	1	1	1	2	1	1	1	1
24-08	12:32	57.0333	79.691	BI-11	ROS	0.5	101	1	1	1	2	1	1	1	1
24-08	10:42	57.0341	79.688	BI-11	ROS	10	101	1	1	1	2	1	1	1	1
24-08	10:40	57.0341	79.688	BI-11	ROS	17.5	101	1	1	1	2	1	1	1	1
24-08	10:36	57.0341	79.688	BI-11	ROS	40	101	1	1	1	2	1	1	1	1
24-08	10:42	57.0341	79.688	BI-11	ROS	60	101	1	1	1	2	1	1	1	1
24-08	12:16	57.0333	79.691	BI-11	ROS	97	101	1	1	1	2	1	1	1	1
24-08	19:02	56.9903	80.1369	BI-12	ROS	1	31.7	1	1	1	2	1	1	1	1
24-08	19:00	56.9903	80.1369	BI-12	ROS	10.5	31.7	1	1	1	2	1	1	1	1
24-08	18:57	56.9903	80.1369	BI-12	ROS	20	31.7	1	1	1	2	1	1	1	1
24-08	18:55	56.9903	80.1369	BI-12	ROS	28	31.7	1	1	1	2	1	1	1	1
25-08	12:25	56.0079	80.3021	BI-M2	FT	2	109	1	1	1	2	1	1	1	1
25-08	14:20	56.0084	80.3039	BI-M2	ROS	21.5	109	1	1	1	2	1	1	1	1
25-08	14:18	56.0084	80.3039	BI-M2	ROS	28.7	109	1	2	1	2	1	1	1	1
25-08	12:51	56.0084	80.3019	BI-M2	ROS	40	109	2	1	1	2	1	1	1	1

Table 3.2 *(cont.)*

Date (mm-dd)	Time (UTC)	Latitude (N)	Longitude (W)	Ship station	Code	Sample depth [m]	Bottom depth[1] [m]	Salinity	δ18O	CDOM	DOC (4mL)	DOC (9mL)	13C-DOC	AP	SPM
25-08	14:14	56.0084	80.3039	BI-M2	ROS	79.1	109	1	1	1	2	1	1	1	1
25-08	14:12	56.0084	80.3039	BI-M2	ROS	98.2	109	1	1	1	2	1	1	1	1
25-08	13:44	55.7024	79.7884	BI-16	ROS	2	176	1	1	1	1	1	2	1	1
25-08	13:26	55.7024	79.7884	BI-16	ROS	170	176	1	1	1	1	1	2	1	1
25-08	21:07	55.7032	79.7815	BI-16	NISK	77	173	1	1	1	1	1	2	1	1
25-08	22:00	55.7003	79.7897	BI-16	NISK	30	175	1	1	1	1	1	2	1	1
25-08	22:42	55.7039	79.7795	BI-16	NISK	21	172	1	1	1	1	1	2	1	1
26-08	1:00	55.7964	79.4533	BI-04	FT	2	50	1	1	1	1	1	2	1	1
27-08	13:13	55.6198	79.0283	BI-M1	ROS	1	94	1	1	1	1	1	2	1	1
27-08	15:11	55.6198	79.0283	BI-M1	ROS	19	94	1	1	1	1	1	2	1	1
27-08	15:09	55.6198	79.0283	BI-M1	ROS	27	94	1	1	1	1	1	2	1	1
27-08	15:04	55.6198	79.0283	BI-M1	ROS	69.9	94	1	1	1	1	1	2	1	1
27-08	13:00	55.6198	79.0283	BI-M1	ROS	86	94	1	1	1	1	1	2	1	1
28-08	18:06	55.7979	79.03	BI-04	ROS	13	45.4	1	1	1	1	1	2	1	1
28-08	18:03	55.7979	79.03	BI-04	ROS	20	45.4	1	1	1	1	1	2	1	1
28-08	18:01	55.7979	79.03	BI-04	ROS	30	45.4	1	1	1	1	1	2	1	1
28-08	17:57	55.7979	79.03	BI-04	ROS	40	45.4	1	1	1	1	1	2	1	1
28-08	18:43	55.7952	79.4505	BI-04	FT	2	32.2	1	1	1	1	1	2	1	1

[1]Depths are taken directly from ship log. Depths are subject to change slightly, pending calibration corrections for the Rosette.

Salinity and $\delta^{18}O$

Water for salinity and $\delta^{18}O$ was collected into 250 mL glass bottles and 20 mL glass scintillation vials, respectively. Bottles and scintillation vials were cleaned three times with sample water before filling. Salinity samples were filled to the bottle neck, while vials for $\delta^{18}O$ were filled to the top until the water formed a convex shape (to avoid headspace). Caps were tightly closed and sealed with parafilm. $\delta^{18}O$ vials were inverted to check for bubbles. Samples were then placed in a cool dark place (salinity) or at 4°C ($\delta^{18}O$).

Dissolved Organics (CDOM, DOC, $\delta^{13}C$ -DOC)

Filtration for dissolved organic tracers (CDOM, DOC, $\delta^{13}C$ -DOC) followed a process similar to salinity and $\delta^{18}O$. Notably, sample vials used for dissolved organic tracers differed depending on the tracer, which is shown in Table 3.3. Dissolved tracer samples were filtered through a 25 mm GF/F filter (previously baked at 500°C), using an acid-washed syringe and Sweenex filter holder. A 0.2 µm GF/F filter was attached to the end of the Sweenex. Each vial was rinsed three times with filtered sample water prior to sampling. Sample water was passed through both sets of filters slowly, so as not to burst the filters, until the vial was full (Figure 3.1a). Samples were then capped, wrapped with parafilm, wrapped in burnt foil, and stored at 4°C. DOC was sampled in two separate vial types. One set of DOC was for analysis at UQAR laboratories (9 mL), and the other set was for analysis at CEOS (4 mL). All samples were handed with vinyl gloves except for the CDOM vials, which were handed with poly gloves.

Table 3.3. *Water sampling vial types and their destinations*

Parameter	Vial Type
Salinity	1x 120 mL clear glass Boston round bottle
$\delta^{18}O$	1x20 mL clear glass scintillation vial with white caps
CDOM	1x40 mL glass amber vial with regular cap
DOC/TN	2x4 mL glass vials with septa caps
DOC/TN	1x9 mL glass tube septa caps
$\delta^{13}C$ – DOC	1x40 mL glass amber vial with septa caps

SPM and aP

Whatman ProWeigh® filters (47 mm; Figure 3.1b) were used for SPM analysis. Filters were pre-purchased to minimize preparation time and mitigate human error. Whatman GF/F filters (25 mm) were used for aP analysis. Filters for aP analysis were not burned or rinsed with deionized water prior to use. Water samples collected for SPM and aP analysis were transferred from the bulk sampling container to a graduated cylinder for filtration. Each bulk container was equipped with a spigot for ease of transfer. In areas with low suspended solids in the water column (i.e. Belchers), a 2.7 L jug was inverted and strapped above the filtration funnel and left until all water from the jug had been filtered. The prepared 47 mm Whatman ProWeigh® filters and 25 mm Whatman GF/F filters were placed on the filtration system for SPM and aP analysis,

respectively. The filtration system consisted of three 250 mL funnels for SPM filtrations and three 250 mL funnels for aP.

A GAST vacuum pump was incorporated into the filtration system to expedite the filtration process. Samples were filtered until there was visible colour on the filters, at which point the filtration valves would be closed and the pump would be turned off to avoid the collection of any airborne particles. For each sampling location, the volume of water filtered was recorded in milliliters. Also recorded was the filter weight (in grams) and code identifier for SPM, which was found on the side of the Whatman ProWeigh® filters. Following filtration, the SPM filter would be removed from the filtration stand with a pair of tweezers and placed in its respective labelled aluminum container. These containers were stacked and immediately stored at 4°C. The aP filters were placed in plastic polyethylene capsules that were manufactured to size and labelled with the station and sample depth. The capsules were wrapped in regular, unbaked aluminum foil and stored at -80°C.

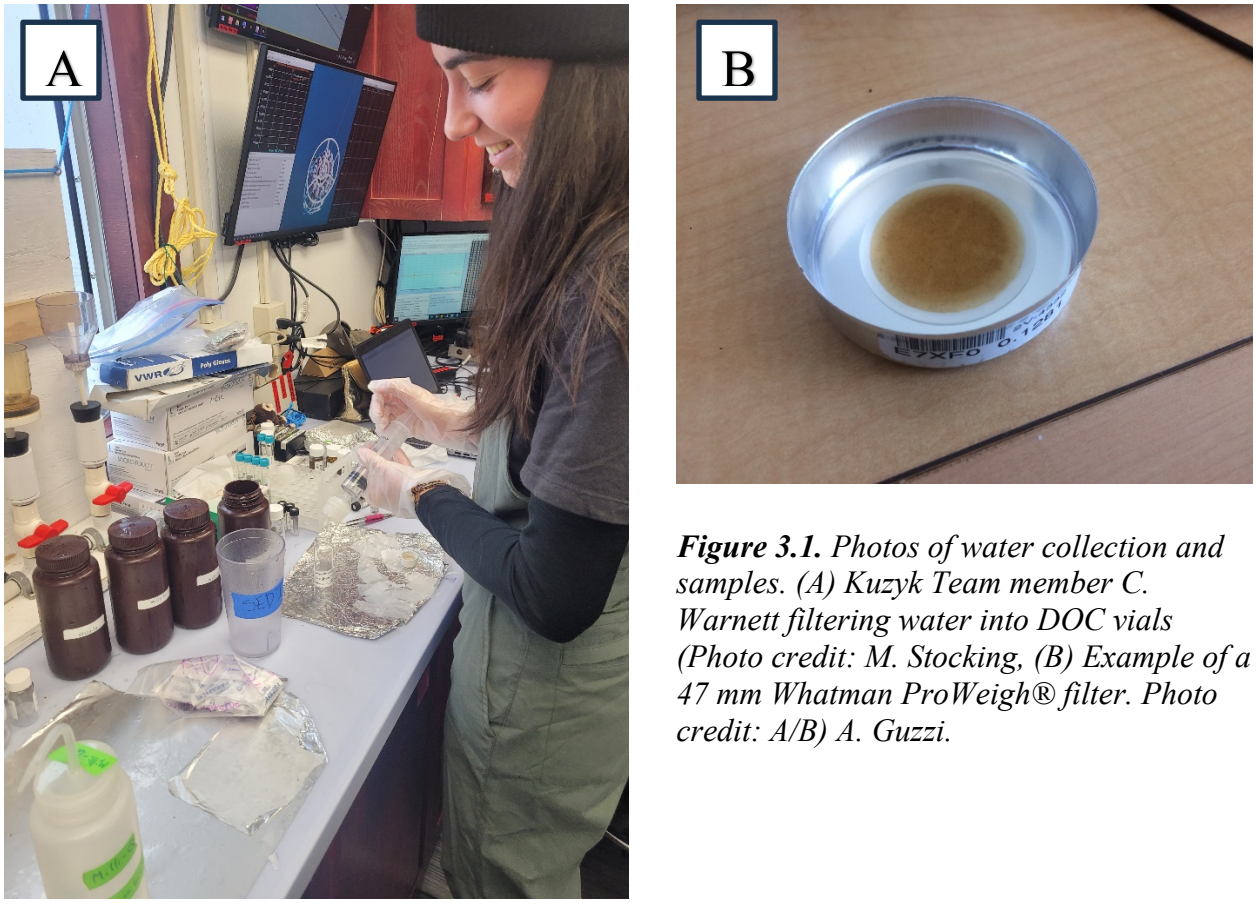

Figure 3.1. *Photos of water collection and samples. (A) Kuzyk Team member C. Warnett filtering water into DOC vials (Photo credit: M. Stocking, (B) Example of a 47 mm Whatman ProWeigh® filter. Photo credit: A/B) A. Guzzi.*

3b. Biogeochemistry

Cruise Participant: Céline Guéguen
Principal Investigator: Céline Guéguen

OBJECTIVES

Coloured and fluorescent dissolved organic matter (CDOM and FDOM, respectively) can be used as tracers of river discharge in the estuaries and coastal waters of Hudson Bay (Granskog et al., 2007; Guéguen et al., 2011, 2016; Meilleur et al., 2023). As data regarding the influence of James Bay in Hudson Bay is scarce, the objective of this study is to contribute to the understanding of carbon fluxes in Hudson Bay and the influence of riverine inputs on the biogeochemistry of the coastal James Bay waters. Lignin-phenols, barium, and other tracers of oceanic circulation will also be collected and subsequently analyzed.

METHODS & DATA COLLECTION

Data Collection

DOM samples were collected using the zodiac, underway system, and Rosette for a total of 46 samples (Table 3.4). Depth profiles were obtained for 17 sites using Rosette casts NE1, NE3, NE5, and W1. Samples were also obtained from zodiac transects along the Winisk and Moose River estuaries. Underway samples were collected whenever possible, totaling 32 samples. Shipboard incubations were conducted using Winisk and Moose River estuarine waters to assess how microbes and light can alter the composition and concentration of DOM and lignin-phenols.

CDOM/FDOM/Barium

CDOM/FDOM/Barium samples were filtered through a 25 mm GF/F filter which was previously baked at 500°C, and a 0.2 µm PES filter attached to the end of the Sweenex, respectively. Each amber vial was rinsed three times with filtered sample water, then filled to the top. Samples were then stored at 4°C until analyses.

Dissolved Lignin-Phenols

Dissolved lignin-phenol samples were collected at the beginning and at the end of 3-day incubations. The incubated samples were filtered through a 0.3 µm filter and acidified with concentrated HCl. Solid-phase extraction (SPE) cartridges conditioned with MeOH were used to concentrate DOM and lignin-phenols. The SPE cartridges were frozen at -20°C until further processing at the Université de Sherbrooke.

Table 3.4. *List of biogeochemical samples.*

Station	Sample ID	Latitude (°N)	Longitude (°W)	Depth (m)
NE1	WK3	57.6755	-91.5795	2
NE1	WK4	57.6755	-91.5795	15
NE1	WK5	57.6755	-91.5795	50
NE3	WK6	57.5415	-91.4163	2
NE3	WK7	57.5415	-91.4163	12
NE3	WK8	57.5415	-91.4163	27
NE5	WK9	57.4688	-91.2283	2
NE5	WK10	57.4688	-91.2283	5
NE5	WK11	57.4688	-91.2283	10
NE6	WK12	57.4688	-91.2283	2
W1	WK13	55.9461	-85.738	1
W1	WK14	57.4688	-91.2283	20
W1	WK15	57.4688	-91.2283	60
W2a	WK16	55.3592	-84.0095	3
W2a	WK17	55.3592	-84.0095	5
W2b	WK18	55.3592	-84.0095	3
W2b	WK19	55.3592	-84.0095	4
W-Z1	WK20	55.3401	-85.0109	0.5
W-Z1	WK21	55.3401	-85.0109	4
W-Z2	WK22	55.3401	-85.0109	0.5
W-Z3	WK23	55.3091	-85.066	0.5
W-Z4	WK24	55.2855	-85.0891	0.5
W2c	WK25	55.3591	-85.0095	2
FT1	WK26	55.3839	-82.2044	2
FT2	WK27	55.1334	-81.9126	2
FT3	WK28	54.8176	-81.7329	2
FT4	WK29	54.4939	-81.5869	2
FT5	WK30	54.2769	-81.4792	2
FT6	WK31	53.9537	-81.3373	2
FT7	WK32	53.6899	-81.1046	2
FT8	WK33	53.1331	-80.6984	2
FT9	WK34	53.0219	-80.1923	2
FT10	WK35	52.732	-80.0007	2
FT11	WK36	52.39335	-79.5793	2
FT12	WK37	52.3729	-80.1174	2
FT13	WK38	52.0378	-80.1531	2
FT14	WK39	51.7052	-80.1916	2
FT15	WK40	51.4727	-80.2432	2
MR-A	WK42	51.4728	-80.2433	1
MR-A	WK41	51.4728	-80.2433	5
FT16	WK43	51.4727	-80.2431	2
FT17	WK46	51.4723	-80.2434	2
FT18	WK47	51.4723	-80.2436	2

FT19	WK48	51.4727	-80.2442	2
MRM	WK44	51.38187	-80.3741	1
MRM	WK45	51.38187	-80.3741	3

3c. Inorganic Carbon

Cruise Participant: Nicholas Decker (CEOS)
Principal Investigator: Tim Papakyriakou (CEOS)

OBJECTIVES

The carbon system of Hudson Bay and James Bay remain poorly studied. What data is available suggests that waters at the confluence between James Bay and Hudson Bay have regionally low aragonite saturation state and pH, collectively indicating a susceptibility to ocean acidification. The circulation of the Bay causes an accumulation of freshwater sources, river water, and sea ice melt in the southern portion of Hudson Bay. Susceptibility to ocean acidification is attributed to the compounding effects of this freshwater on the region's carbon system. The 2023 cruise of the RV William Kennedy is among the first opportunities to measure attributes of the carbon system in James Bay, while also revisiting previously sampled regions in the southern portion of Hudson Bay.

The objectives of the cruise are to:

1. Provide an assessment of inorganic and organic carbon distribution across James Bay and in southern Hudson Bay to determine their regionally susceptibility to ocean acidification, in addition to CO_2 source or sink status.

2. Assess the main drivers of both ocean acidification and CO_2 exchange budgets, including an assessment of the role of carbon inflow from select rivers and estuaries of James Bay.

The inorganic carbon system includes dissolved inorganic carbon (DIC), total alkalinity (TA), pH, the saturation state for calcium carbonate minerals aragonite and calcite, the partial pressure of carbon dioxide (pCO_2). The inorganic carbon system is linked to the organic carbon system through the processes of mineralization (by respiration and photolysis) and photosynthesis. While CO_2 has been the main driver of current greenhouse gas (GHG) warming, methane (CH_4) is a potent GHG and will be measured as well.

We expect the carbon system (specifically pH and pCO_2) and GHG footprint of the marine system to be strongly modified by river inflow to an extent dictated by the water properties of the rivers. We expect sea ice melt to also impact the region's carbon system, however the relative role of the freshwater sources (river and sea ice melt), temperature, and biology remain uncertain. The cruise will allow us to establish a baseline understanding of the southern Hudson Bay and James Bay carbon system, its role relative to other Arctic and subarctic seas as a net GHG source or sink, and better prepare us to project future states of the carbon system, including the GHG source/sink and OA.

METHODS & DATA COLLECTION

Discrete Water Samples

Sample collection took place from August 8 – 28, 2023, from RV William Kennedy. Water samples were collected using a Sea-Bird Rosette equipped with twelve, 5 L Niskin bottles and a Sea-Bird 19+ V2 CTD. At each selected depth, at least one Niskin bottle was "fired" and closed to ensure there was enough sample water for all requirements. Additionally, water samples were collected from the seawater sampling line connected to the ship's water intake system that continuously sampled water from ~2 m depth. Lastly, water samples were taken using a 5 L Niskin bottle from small boats deployed from RV William Kennedy to sample in shallow estuaries. Also, 5 L Niskin bottles were deployed from the back deck of RV William Kennedy when the Rosette was unable to be used. Water samples were sampled in the following order: CH_4, 13C-DIC, pH, DIC/TA. First, a sampling tubing was connected to the Niskin spigot or the seawater sampling line in the ship's laboratory, and water was allowed to run through to clean and remove any air bubbles from the tubing. For CH_4 and 13C-DIC samples, the vials were filled smoothly with tubing touching the bottom of the vial, and were overflowed three times their volume. For pH, the bottle was rinsed three times with ~100 mL of sample water, and then filled slowly from the bottom with the tubing touching the bottom of the vial. For DIC, the bottle was rinsed twice with ~100 mL of sample water, then filled smoothly from the bottom, with tubing touching the bottom of the vial, and overflowed by a full volume. A glass stopper was inserted to prevent contamination. After all sampling was completed (5-15 minutes), 10% of the stoppered DIC sample was removed to prevent the bottles from breaking in case of freezing temperatures. The gas samples were then spiked with saturated mercuric chloride solution ($HgCl_2$), with volumes of $HgCl_2$ used outlined in Table 3.5. Once the samples were spiked, the DIC stopper was greased and the sample was securely closed with electrical tape around the bottle and stopper, CH_4 samples were crimped, and CH_4 and 13C-DIC samples were wrapped with Parafilm. The pH samples were measured on board using a spectrophotometer. Information for the Rosette, small boat, and water intake line samples are given in Tables 3.6, 3.7, and 3.8, respectively. The DIC/TA samples will be analyzed at BIO DFO, and the CH_4 and 13C-DIC samples will be analyzed at UM.

Table 3.5. *Volumes of saturated mercuric chloride solution used to spike gas samples.*

Variable	Vial type	Volume of $HgCl_2$ used (µL)
DIC/TA	500 mL borosilicate glass bottle with glass stopper 300 mL borosilicate glass bottle with glass stopper	100
CH_4	60 mL clear glass vial with rubber stopper and aluminum crimp seal	20
13C-DIC	30 mL amber vial	20
pH	250 mL borosilicate glass bottle	0

Table 3.6. *Samples collected from the rosette. At each sampling depth, 1 CH_4 vial, 1 13C-DIC vial, 1 pH bottle, and 1 DIC/TA bottle were collected, unless noted otherwise. Dates and times are in UTC.*

Date	Time	Stn	Lat (N)	Long (W)	Stn depth (m)	Sample depth (m)
08/08/2023	23:55	CE-1	58.7884	-94.2127	11.7	2[a]
09/08/2023	20:50	CE-2	58.8205	-94.1027	20.9	2[a]
28/08/2023	17:57	BI-04	55.7964	-79.4482	45.4	2[a], 13, 20, 30, 40
18/08/2023	01:58	BI-06	56.0683	-77.9336	82	2[a], 75[b]
18/08/2023	22:08	BI-07	56.1645	-78.5927	34.5	2[a], 6[b], 20[b], 29[b]
23/08/2023	17:45	BI-08	56.7731	-78.4015	50.7	2[a], 10, 20, 30, 40, 46, 50
23/08/2023	02:41	BI-09	56.8498	-78.8272	54.3	2[a], 11, 20, 30, 40
21/08/2023	04:14	BI-10	56.9464	-79.2151	86.8	2[a], 12[b], 45[b], 80[b]
24/08/2023	10:33	BI-11	57.0370	-79.6872	101	2, 10, 17.5, 40, 60, 97
24/08/2023	18:55	BI-12	56.9861	-80.1392	31.7	2, 10.5, 20, 28
26/08/2023	13:26	BI-16	55.7076	-79.7811	176	2, 21[b], 30[b], 77[b], 170
27/08/2023	13:00	BI-M1	55.6239	-79.0186	94.5	2, 12[b] 19, 27, 69.9, 86
25/08/2023	12:51	BI-M2	56.0090	-80.3030	109	2[a], 3.2, 21.5, 28.7. 40, 79.1, 98.2
15/08/2023	09:09	MR-A	51.4728	-80.2433	6.7	2, 6
10/08/2023	13:36	NE-1	57.6734	-91.6000	60.8	2[a], 15[b], 50[b]
10/08/2023	16:15	NE-3	57.5417	-91.4171	32.7	2[a], 12[b], 27[b]
10/08/2023	18:25	NE-5	57.4045	-91.2291	14.5	2[a], 5, 10
10/08/2023	19:32	NE-6	57.3450	-91.1300	40.0	2[a]
11/08/2023	23:36	W-1	55.9461	-85.7380	65.3	2, 20, 60
12/08/2023	07:49	W-2a	55.3592	-85.0095	6.8	2, 5
12/08/2023	10:17	W-2b	55.3593	-85.0095	5.8	2, 4
12/08/2023	21:50	W-2c	55.3591	-85.0100	6.0	2[a]

[a] Surface sample taken via water intake line
[b] Sample collected with Niskin

Table 3.7. *Samples collected from small boat operations. At each sampling depth, 1 CH_4 vial, 1 13C-DIC vial, 1 pH bottle, and 1 DIC/TA bottle were collected, unless noted otherwise. Dates and times are in UTC.*

Date	Time	Stn	Lat (N)	Long (W)	Stn depth (m)	Sample depth (m)
15/08/2023	12:37	MRM	51.3819	-80.3741	3.5	0, 3.5
12/08/2023	12:39	W-Z1	55.3401	-85.0109	5.5	0, 4

12/08/2023	14:10	W-Z2	55.322	-85.0302	4.6	0
12/08/2023	14:44	W-Z3	55.3091	-85.0660	2.4	0
12/08/2023	15:51	W-Z4	55.2855	-85.0891	2.2	0

Table 3.8. *Samples for DIC collected from the ship's water intake line.*

Date	Time	Associated stn	Lat (N)	Long (W)	Station depth (m)
13/08/2023	09:15	FT-1	55.3839	-82.0693	28.3
13/08/2023	12:10	FT-2	55.1334	-81.9126	29.5
13/08/2023	15:00	FT-3	54.8176	-81.7329	29.9
13/08/2023	18:10	FT-4	54.4939	-81.5869	42
13/08/2023	20:30	FT-5	54.2769	-81.4792	61.4
13/08/2023	23:15	FT-6	53.9537	-81.3373	39.6
14/08/2023	01:45	FT-7	53.6899	-81.1046	31
14/08/2023	07:11	FT-8	53.1331	-80.6984	15.9
14/08/2023	10:40	FT-9	53.0219	-80.1923	53.4
14/08/2023	15:20	FT-10	52.7232	-80.0070	62.5
14/08/2023	18:47	FT-11	52.3935	-79.5793	74.2
15/08/2023	00:00	FT-12	52.3729	-80.1174	33.9
15/08/2023	02:40	FT-13	52.0378	-80.1531	24.5
15/08/2023	05:13	FT-14	51.7052	-80.1916	15.1
15/08/2023	07:20	FT-15	51.4727	-80.2432	6.9
15/08/2023	12:28	FT-16	51.4727	-80.2431	5.3
15/08/2023	16:00	FT-17	51.4723	-80.2434	6.4
15/08/2023	18:07	FT-18	51.4723	-80.2436	7.6
15/08/2023	20:05	FT-19	51.4727	-80.2442	7.3

Note: At each sampling depth, 1 CH_4 vial, 1 13C-DIC vial, 1 pH bottle, and 1 DIC/TA bottle were collected, unless noted otherwise. Dates and times are in UTC.

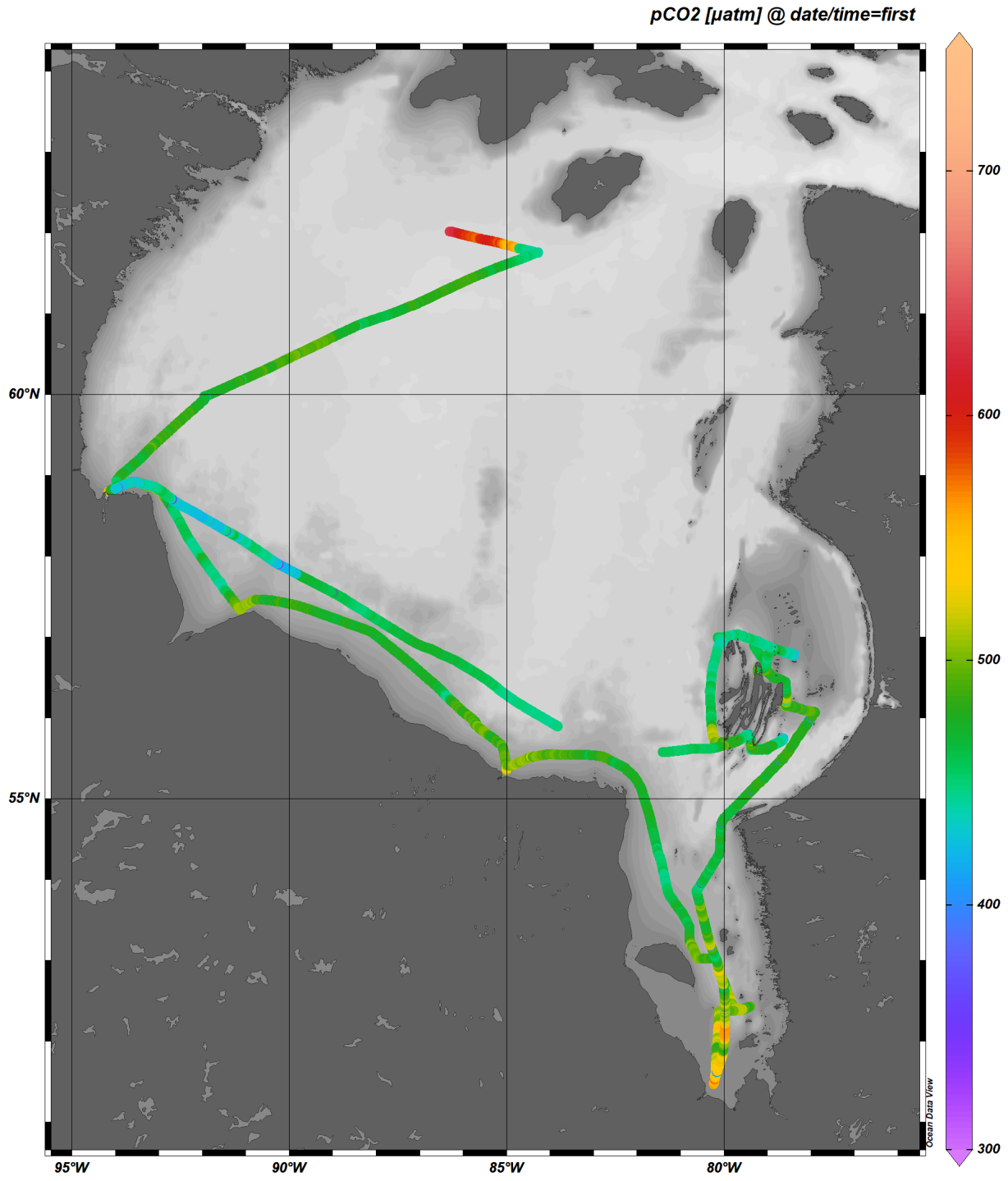

Figure 3.2. *Flow through system pCO_2 system track.*

3d. Primary Production

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OBJECTIVES

1. Characterize the phytoplankton community and estimate rates of net ecosystem production (NEP), gross primary production (GPP), and gross respiration (GR).

2. Quantify new versus regenerated primary production rates across James Bay.

3. Examine spatial differences and establish baseline estimates in phytoplankton production, phytoplankton taxonomic composition, and photosynthetic pigment concentrations.

4. Investigate how primary production and other variables related to primary production are influenced by freshwater sources, including variations in water salinity and temperature.

METHODS & DATA COLLECTION

Water Sampling

Water samples, kelp samples, and conductivity, temperature, and depth (CTD) profiles were collected using a Sea-Bird Rosette with twelve 5L Niskin bottles, individual 5L Niskin bottles, water underway flow-through system, and CTD. Depths for Rosette stations were chosen prior to the cruise for the majority of the water sampling variables, with the number of depths being determined upon arrival at each station. The depths were surface water, 10, 20, 30, 40 m, and bottom depth. If present and not captured within a listed depth, a Chlorophyll a (Chl *a*) maximum depth (SCM) was determined via the downcast data of the autonomous CTD. The exception to the set depths was the primary production depths, which were chosen based on the photosynthetically active radiation (PAR) profiles for set light depths of 100, 55, 28, 17, 8, and 2% PAR. The Secchi disk depth (i.e. the depth at which a weighted, black-and-white disk, 30cm in diameter, disappeared from view) corresponds to the depth at which approximately 10% of the surface light remains.

Water was collected at a 2 m depth from the flow-through underway system in the engine room of the ship, which was continuously pumped up to the lab workspace and fed into an incubation system used for NEP, GPP, and GR estimations. These samples were collected for 3 hours on days without Rosette sampling stations. Several stations were sampled from small research vessels, with water being collected from the surface estimated to be 0.5 m in depth.
Bulk water was collected at Rosette stations and small research vessel stations using acid-washed

Tygon tubing and polyethylene bulk water containers (9 L and 20 L, respectively) that were first rinsed in sample water three times before being filled with the sample. Collected water samples were then transferred to the lab for filtration and taxonomy. Water needed for primary production was subsampled from the bulk water containers and then moved to a dark area of the lab. The bulk water was then subsampled for specific analyses in the following order: nutrient concentration, nitrate isotope concentration, flow cytometry, Lugol taxonomy (at Chl *a* maximum and surface), Chl *a* concentration at every depth, particulate absorption (ap), particulate organic carbon and nitrogen (POC/N) at every depth, and high-performance liquid chromatography (HPLC) at SCM and surface.

Four nutrient samples were collected at each sampling depth. Water samples were drawn through an acid washed 60 mL syringe and then a Swinnex filter with a 25 mm combusted GF/F was attached. The syringe, filter, and acid-washed 15 mL falcon tube were rinsed three times with filtered sample before the falcon tube was filled with 13 mL and stored in the -20°C freezer. One nitrate isotope sample was collected at each depth following the same procedure as used for nutrient collection, with the exception that the vials were 50 mL.

Seven flow cytometry samples (FC) were collected at each sampling depth using the same 60 mL syringe used for nutrient sample collection without a Swinnex filter. A subsample of 4 mL was added to a pre-spiked cryovial containing 20 µL or 100 µL of glutaraldehyde (6 contained 20 µL and 1 contained 100 µL, the larger volume designated for virus preservation). They were gently inverted several times before being placed in the dark for 15 minutes and then finally stored in the -80°C freezer.

Lugol taxonomy samples were collected at the SCM depth. A subsample of 200 mL was collected at each depth and placed in amber bottles. Following this, 0.8 mL of Lugol was added, and the bottle was gently inverted five times. Each bottle was then sealed with Parafilm and stored in the fridge (4°C).

Two Chl *a* samples were filtered for each sampling depth onto a 25 mm GF/F filter. The amount of water filtered varied between 100 and 700 mL, depending on colouration of the filter. The filters were then placed into tinfoil sleeves and stored in the -80°C freezer.

High-performance liquid chromatography (HPLC) samples for measurement of algal pigment composition was filtered from the Chl *a* maximum depth and surface water. The amount filtered at each station ranged between 910 and 2000 mL depending on colouration of the filter. The samples were filtered on a 47 mm pre-combusted GF/F and then placed in 2 mL cryovials. The cryovials were then stored in the -80°C freezer.

POC/N, filter collections were described earlier in the report and are briefly mentioned here as they will contribute to the primary production work as well.

Incubations

For primary production (PP) incubations for the estimation of new and regenerated primary production, 2000 mL of bulk water was sampled into four 500 mL clear Nalgene polycarbonate bottles. Each subsample was spiked with 500 µL of Carbon-13 (^{13}C) in the form of $NaH^{13}CO_3$. Then two bottles were spiked with 500µL of NH_4 in the form of $(^{15}NH_4)2SO_4$ and the other two with 500 µL of NO_3 in the form of $K^{15}NO_3$. This was done for each of the light depths (100, 55, 28, 17, 8, and 2% PAR), and then the 24 bottles were turned upside down three times gently before being placed into the incubator for 4 hours. The incubators were placed on the top deck of the ship and surface water was circulated through.

Each set of bottles was placed in clear plastic tubes covered with a film that replicates the light received at each of the light depths. Two 500 mL T_0 bottles were taken at the 2% light depth from rosette or Niskin sampling stations. The water was immediately filtered, and when there was approximately 20 mL remaining, 500µL of Carbon-13 (^{13}C) in the form of $NaH^{13}CO_3$ was added to each filtration funnel, with one spiked with 500 µL of NH_4 and the other with 500 µL of NO_3. After the 4-hour incubation, water from the light incubations was filtered onto pre-combusted (450°C for 5 hours) 21 mm glass fibre filters (GF/F). Filters were placed into pre-combusted (450°C for 5 hours) aluminum foil sleeves and stored in the -80°C freezer.

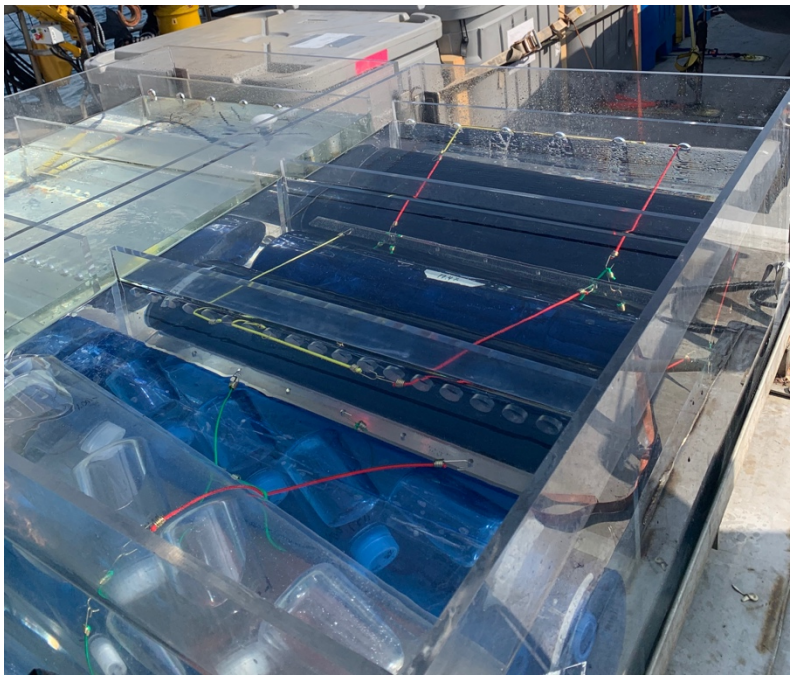

Figure 3.3. *Incubation set up for primary production, on top deck.*

Phytoplankton community abundance was estimated using an Algae Online Analyser (bbe Moldaenke) (Figure 3.4). The instrument uses fluorescence at four wavelengths to estimate the abundance of Chlorophyll concentration among four different algal groups (greens, blue-greens, diatoms, and Chlorophytes). It also estimates the concentration of fluorescent yellow substance, essentially a measure of coloured dissolved organic matter (CDOM), as well as turbidity. Water samples were pumped from the ship's seawater intake line to the Algal Online Analyser and measured every 10 minutes over the duration of the cruise.

In addition to the algal analyzer, an automated incubator was installed to estimate NPP, GPP, and GR along the cruise track. The incubator consists of two spherical chambers which are filled with seawater from the ship's water intake line once every hour. Once filled, a stirring pump mixes the water inside the chamber while an oxygen probe measures dissolved oxygen and temperature. The oxygen and temperature probes are calibrated before the cruise and can be cross-referenced against the ship's underway thermosalinograph and periodic CTD casts, which include O_2 concentrations. The chambers are cleaned daily by adding 10 mL of household bleach to each chamber during filling. The subsequent three incubations are discarded. The incubators are housed inside coolers to control light levels and minimize water temperature changes during the course of the incubation. One chamber is illuminated by an LED light, the other cooler is kept dark. The change in oxygen concentration over the course of the incubation is a function of primary production and respiration in the light chamber, while the change in oxygen in the dark chamber is a function of respiration only. Together, these can be used to estimate the rates of primary production and respiration in the near-surface (~2 m) water column along the cruise track at hourly intervals (Yezhova et al., 2021).

Finally, a CO_2 sensor (Licor LI-820) was used to measure dissolved CO_2 in surface water continuously (~1/second) along the cruise track. Water was pumped from the same reservoir used by the Algal Analyser and incubator system via a 1⁄4" OD nylon tube with a peristaltic pump, through a semi-permeable membrane (3M LiquiCell Mini-Module Membrane Contractor), the dissolved CO_2 passes through the membrane into a flow of air from the exterior (stern, aft side, ~4 m above the water surface) and into the CO_2 detector. At hourly intervals, the water pump is reversed, drawing air into the membrane contractor instead of water, allowing the detector to measure the atmospheric CO_2 concentration. A Garmin GPS antenna was connected to this system, to record the position with each measurement. The CO_2 sensor was zeroed and spanned every 1–3 days by first connecting a CO_2 scrubber to the air inlet line (zero), followed by a gas-tight bag containing a certified reference CO_2 gas mixture (~400 ppm CO_2 in nitrogen, Praxair). Each standard was passed through the system for 2–5 minutes, until the reading stabilized. Post-processing is required to adjust the CO_2 measurements based on the calibrations and to remove any air samples that were collected while the air intake was downwind of the

ship's exhaust (which would contaminate the air sample with CO_2 from the diesel fumes).

Figure 3.4. *Algal online analyzer, Dark and Light incubator chambers, and CO_2 sensor set up.*

Appendix. Logbook of samples collected for the primary production group.

Station ID	Type (ROS, FT, ZOD, DINO)	Date (UTC)	Time (UTC)	Latitude	Longitude	bot. depth (m)	depths sampled (m)	Chl max	Nutrients	Flow cytometry	chl a	POC/N
CMO-B	ROS	02-Aug-23	00:15:00	61.7609	81.2911	180.5	10, 25, 40, 68, 100, 176	-	✓	☒	✓	✓
CMO-B	FT	02-Aug-23	0:20:00	61.7609	81.2911	180.5	2	-	✓	☒	✓	✓
CMO-A	FT	03-Aug-23	2:15:00	59.9783	91.8390	105.8	2	-	✓	☒	✓	✓
CE-1	FT	08-Aug-23	23:54:00	58.7857	94.2115	20.7	2	-	✓	✓	✓	✓
CE-2	FT	09-Aug-23	20:50:00	58.8218	94.0975	20.9	2	-	✓	✓	✓	✓
NE-1	NISK	10-Aug-23	1:21:00	57.6734	91.6000	60.8	2, 15, 50	-	✓	✓	✓	✓
NE-3	NISK	10-Aug-23	16:04:00	57.5417	91.4180	32.9	2, 13, 27	-	✓	✓	✓	✓
NE-5	NISK + FT	10-Aug-23	18:25:00	57.4088	91.2283	14.5	2, 5, 10	-	✓	✓	✓	✓
W1 (offshore)	ROS	11-Aug-23	23:26:00	55.9461	85.7380	64.8	2, 20, 60	20	✓	✓	✓	✓
W2-a	ROS	12-Aug-23	7:48:00	55.3592	85.0095	6.8	0.3, 5	0.3	✓	✓	✓	✓
W2-b	ROS	12-Aug-23	10:13:00	55.3593	85.0095	5.8	0.3, 4	-	✓	✓	✓	✓
WZ 1	ZOD	12-Aug-23	12:30:00	55.3401	85.0109	5.5	4	-	✓	✓	✓	✓
WZ 2	ZOD	12-Aug-23	14:04:00	55.3220	85.0302	4.6	surf	-	✓	✓	✓	✓
WZ 3	ZOD	12-Aug-23	14:42:00	55.3091	85.0660	2.36	surf	-	✓	✓	✓	✓
WZ 4	ZOD	12-Aug-23	15:35:00	55.2855	85.0891	2.17	surf	-	✓	✓	✓	✓
FT 1	FT	13-Aug-23	9:20:00	55.3839	82.2844	33.3	2	-	✓	✓	✓	✓
FT 2	FT	13-Aug-23	12:05:00	55.1334	81.9126	29.5	2	-	✓	☒	✓	✓
FT 3	FT	13-Aug-23	15:00:00	54.8176	81.7329	29.9	2	-	✓	☒	✓	✓
FT 4	FT	13-Aug-23	18:06:00	54.4939	81.5870	42	2	-	✓	☒	✓	✓
FT 5	FT	13-Aug-23	20:30:00	54.2769	81.4729	61.4	2	-	✓	☒	✓	✓
FT 6	FT	13-Aug-23	23:15:00	53.9537	81.3373	39.6	2	-	✓	☒	✓	✓
FT 7	FT	14-Aug-23	1:43:00	53.6899	81.1046	31	2	-	✓	☒	✓	✓
FT 8	FT	14-Aug-23	7:11:00	53.1331	80.6984	15.9	2	-	✓	☒	✓	✓
FT 9	FT	14-Aug-23	10:38:00	53.0219	80.1923	53.4	2	-	✓	☒	✓	✓
FT 10	FT	14-Aug-23	15:20:00	52.7232	80.0007	62.5	2	-	✓	☒	✓	✓
FT 11	FT	14-Aug-23	10:47:00	52.3935	79.5793	74.2	2	-	✓	☒	✓	✓
FT 12	FT	15-Aug-23	0:00:00	52.3729	80.1174	33.5	2	-	✓	☒	✓	✓
FT 13	FT	15-Aug-23	2:04:00	52.0378	80.1531	24.5	2	-	✓	☒	✓	✓
FT 14	FT	15-Aug-23	5:13:00	51.7052	80.1916	15.1	2	-	✓	✓	✓	✓
FT 15	FT	15-Aug-23	7:53:00	51.4727	80.2432	6.9	2	-	✓	✓	✓	✓
MRA	ROS	15-Aug-23	8:56:00	51.4728	80.2433	6.7	0.5, 5	-	✓	☒	✓	✓
FT 16	FT	15-Aug-23	12:28:00	51.4727	80.2431	5.3	2	-	✓	☒	✓	✓
MRM	ZOD	15-Aug-23	12:37:00	51.3819	80.3741	-	surf, 3.5	-	✓	☒	✓	✓

FT 17	FT	15-Aug-23	15:57:00	51.4723	80.2434	6.4	2	-	✓	☒	✓	✓	☒	✓	✓	☒
FT 18	FT	15-Aug-23	18:03:00	51.4723	80.2436	7.6	2	-	✓	☒	✓	✓	☒	✓	✓	☒
FT 19	FT	15-Aug-23	20:02:00	51.4727	80.2439	7.3	2	-	✓	☒	✓	✓	☒	✓	✓	☒
BI-06	NISK + FT	18-Aug-23	1:56:00	56.0683	77.9336	82	2, 75	-	✓	✓	✓	✓	☒	✓	✓	✓
BI-07 PP	NISK	18-Aug-23	14:45:00	56.1755	78.5944	28.7	surf, 3, 6.5, 9, 13, 20	-	☒	☒	☒	☒	✓	✓	☒	☒
BI-07 REG	NISK	18-Aug-23	22:05:00	56.1645	78.5927	34.5	2, 6, 20, 29	6	☒	☒	✓	✓	☒	✓	✓	✓
BI-10	FT	21-Aug-23	3:57:00	56.9474	79.2393	86.2	2	-	✓	✓	✓	✓	☒	✓	✓	✓
BI-10	NISK	21-Aug-23	4:41:00	56.9464	79.2151	86.8	12	12	✓	✓	✓	✓	☒	✓	✓	✓
BI-10	NISK	21-Aug-23	5:03:00	56.9463	79.2022	88.3	45, 80	12	✓	✓	✓	✓	☒	✓	✓	☒
BI-09	ROS	23-Aug-23	2:29:00	56.8489	78.8259	54.6	20, 30, 40, 50	12	✓	✓	✓	✓	☒	✓	✓	☒
BI-09	ROS	23-Aug-23	4:12:00	56.8498	78.8259	54.3	1, 11	11	✓	✓	✓	✓	☒	✓	✓	☒
BI-08 PP	ROS	23-Aug-23	15:12:00	56.7731	78.4015	49.1	1, 4, 8.8, 12.2, 17.4, 26.9	-	☒	☒	☒	☒	✓	☒	☒	☒
BI-08 REG	ROS	23-Aug-23	17:33:00	56.7714	78.4023	48.3	1, 10, 21, 30, 40, 45	10.5	✓	✓	✓	✓	☒	✓	✓	✓
BI-11 REG	ROS	24-Aug-23	10:16:00	57.0341	79.6880	101	0.5, 10, 17.5, 40, 61, 97	3.2	✓	✓	✓	✓	☒	✓	✓	✓
BI-11 PP	ROS	24-Aug-23	12:03:00	57.0333	79.6910	103	0.5, 3.7, 7.9, 11, 15.7, 24.3	3.2	☒	☒	☒	☒	✓	✓	☒	☒
BI-12	ROS	24-Aug-23	18:28:00	56.9903	80.1369	31.7	surf, 10.5, 20, 28	-	✓	✓	✓	✓	☒	✓	✓	✓
BI-M2 PP	ROS	25-Aug-23	12:47:00	56.0084	80.3019	109	0.5, 3.2, 7, 9.8, 13.9, 21.5, 40	-	☒	☒	☒	☒	✓	✓	☒	☒
BI-M2 REG	ROS	25-Aug-23	14:01:00	56.0084	80.3039	109	0.5, 3.2, 21.5, 28.7, 79.1,98.2	-	✓	✓	✓	✓	☒	✓	✓	✓
BI-16 PP	ROS	26-Aug-23	13:11:00	55.7024	79.7884	176	0.5, 3.5, 7.5, 10.4, 14.8, 22.9	-	☒	☒	☒	☒	✓	✓	☒	☒
BI-16	FT	26-Aug-23	21:15:00	55.7032	79.7815	173	2	-	✓	✓	✓	✓	☒	✓	✓	✓
BI-16	NISK	26-Aug-23	21:07:00	55.7032	79.7815	173	80	-	✓	✓	✓	✓	☒	✓	✓	☒
BI-16	NISK	26-Aug-23	22:23:00	55.7025	79.7832	175	30	-	✓	✓	✓	✓	☒	✓	✓	☒
BI-16	NISK	26-Aug-23	22:38:00	55.7039	79.7795	173	21	-	✓	✓	✓	✓	☒	✓	✓	☒
BI-M1 PP	ROS	27-Aug-23	12:49:00	55.6198	79.0283	94.5	1, 3.2, 6.8, 10.4, 13.4, 20.8, 86	12	☒	☒	☒	☒	incomplete	☒	☒	☒
BI-M1 REG	ROS	27-Aug-23	14:24:00	55.6218	79.0249	102	1, 19, 27, 69.9	12	✓	✓	✓	✓	☒	✓	✓	☒
BI-M1 REG	NISK	27-Aug-23	15:52:00	55.6260	79.0102	97.8	12	12	✓	✓	✓	✓	☒	✓	✓	☒
BI-04	ROS	28-Aug-23	17:47:00	55.6244	79.0300	45.4	13, 20, 30, 40	13	✓	☒	✓	✓	☒	✓	✓	✓
BI-04	FT	28-Aug-23	18:50:00	55.7941	79.4468	45.4	2	13	✓	☒	✓	✓	☒	✓	✓	✓

3e. Zooplankton, Benthic Invertebrates and Fish

Cruise Participants: Kallie Strong, Natalie Vachon, Paloma Carvalho, (DFO)
Principal Investigators: Andrea Niemi, David Yurkowski, Paloma Carvalho (DFO)

OBJECTIVES

To characterize the biodiversity and distribution of zooplankton, ichthyoplankton, benthic invertebrate and fish communities by assessing taxonomic identifications, taxon-specific fatty acid signatures, stable isotope signatures, and DNA barcode signatures, and using highly-branched isoprenoids to assess food web connections and sources of energy (ice or pelagic) by looking at the dietary presence (or absence) of sea ice diatoms.

METHODS & DATA COLLECTION

Zooplankton and Ichthyoplankton

Vertical Tows

A Hydrobios WP2 conical net (1 net, 0.57 m diameter, 150 µm mesh) was deployed to collect zooplankton and fish larvae (ichthyoplankton) samples for taxonomic analyses. A single vertical tow was conducted at each full station (Table 3.9), integrating the entire water column. A flow meter (General Oceanics) attached to the net was used to determine filtration volume. The net was lowered at 1 m/s to within 2-10 m from the bottom, depending on sea state, and then recovered at 0.5 m/s. Deployment time, depth, and coordinates were collected at the beginning and end of each tow. Once at the surface, the outside of the net was rinsed with a saltwater hose prior to bringing the net onboard to ensure the catch was rinsed down into the cod-end. Ichthyoplankton was removed and preserved frozen, and the remainder of the sample was preserved (10% (v/v) buffered formalin in filtered sea water) and stored at room temperature. The net was equipped with an RBR Solo depth sensor to verify if it reached depth desired, and weighted to ensure it remained vertical in the water column during deployment in cases where there was wind/current. If the net was not deployed as expected, the samples were discarded, and the deployment was repeated.

Oblique Tows

To collect high biomass samples for food web analyses, and for the study of larger zooplankton and ichthyoplankton, a bongo net (2 nets, 0.5 m diameter, 500 µm mesh) was deployed from the ship (Figure 3.5). Nets were towed obliquely at each full station at approximately 2 knots speed-over-ground with a vertical line out at a winch speed of 2 m/s to within 10 m of the bottom. Line out was estimated using a combination of a line counter on the winch and physical markings on the line. Once near bottom, the net was retrieved at a winch speed of 0.5 m/s. The procedure was repeated until the net had been towed for 15 minutes. Deployment time, depth, and coordinates were collected at the beginning and end of each tow, along with warp length and towing speed. Prior to bringing onboard, the outside of the nets was rinsed with a gentle saltwater spray to concentrate the catch into the cod-ends (Figure 3.5). Two flow meters were attached to both nets

and the numbers were recorded before and after deployment. Samples were sorted by hand, using a 500 µm sieve, into target groups of zooplankton (e.g., copepods, amphipods, euphasiids, chaetognath, jelly fish, pteropod and pelagic tunicates) and frozen at -20°C for later food web analysis (Figure 3.6). The remaining of the sample were frozen as bulk. An RBR Solo depth sensor was attached to verify net deployment depth. If the net was not deployed as expected, the samples were discarded, and the deployment was repeated. To compensate for poor deployment performance observed on Leg 1, two 10 lbs dive weights were added to the frame of the net (Figure 3.7).

Benthic Invertebrates and Fish

Benthic Beam Trawl

A Hi-lift 3 m benthic beam trawl was deployed to target benthic invertebrates and fish (Figure 3.8 and 3.9). The beam trawl was lowered to the bottom and towed at ~2 knots for 15 minutes in James Bay and reduced to 7 minutes around the Belcher Islands when sea state and bottom morphology allowed. Time, depth, and coordinates were collected at the beginning and end of each tow, along with warp length and towing speed. An RBR Solo depth sensor was attached to verify net deployment depth. If the net was not deployed as expected, the samples were discarded, and the deployment was repeated.

Upon completing each trawl, the catch was placed in fish bins for sorting and documentation, then invertebrates and fish were separated in sorting trays (Figure 3.10). Fish from the benthic trawl were measured for length and weight, then frozen at -20°C (Figure 3.11; Table 3.10). At DFO Winnipeg, the taxonomy of frozen samples will be verified to the lowest taxonomic level possible, tissue samples will be sub-sampled for food web analyses (stable isotopes, mercury, highly branched isoprenoids, and fatty acids), and stomachs will be dissected for diet analysis using DNA metabarcoding.

Collected invertebrates from the beam trawl were sorted into groups by sieving and were subsequently sorted to the lowest taxonomic level, photographed, counted, and preserved. Catch with multiple individuals of the same species were subsampled. Soft-bodied organisms (e.g. polychaetas) of particular interest were preserved in 95% ethanol to retain shape and characteristics for identification, and determination of abundance and biomass (to be completed at Winnipeg). All other remaining taxa were frozen at -20°C for future confirmation of identity, abundance, biomass, and food web analyses (to be completed at labs in Winnipeg). Preservation of specimens by freezing and in ethanol will also allow for genetic barcoding as a possible means of confirming species identifications where there is uncertainty. For all samples preserved in ethanol, the fluids were drained and replaced after 24 hours to ensure adequate preservation.

Figure 3.5. *Rinsing of bongo nets following its deployment. Photo credit: Pascale Bouchard CEOS).*

Figure 3.6. *Zooplankton and pelagic invertebrates from the bongo nets sorted into taxonomic groups using a 500 µm sieve. (Photo credit: Natalie Vachon DFO).*

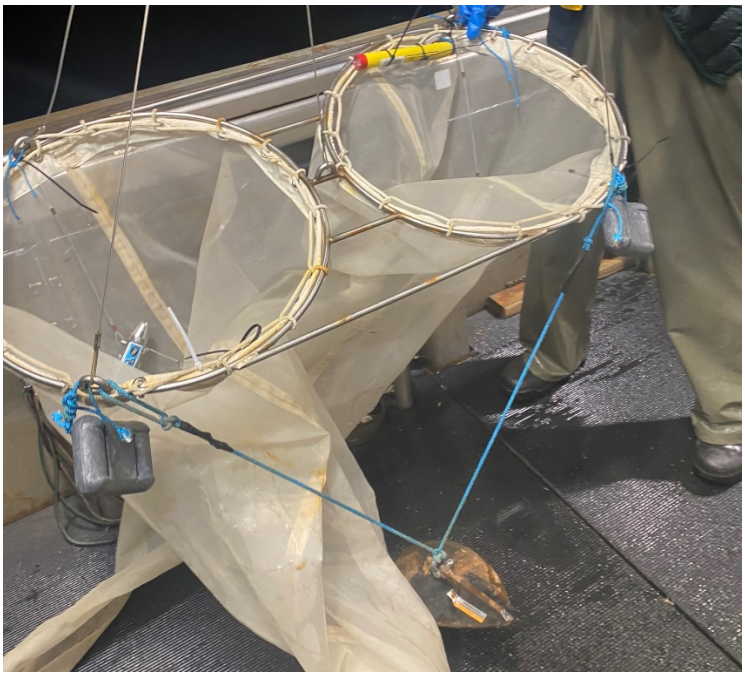

Figure 3.7. *Reconfiguration of weights on the bongo nets. (Photo credit: Natalie Vachon DFO).*

Figure 3.8*. Nighttime deployment of benthic beam trawl. (Photo credit: Grace Fedirchuk CEOS).*

Figure 3.9 *Benthic beam trawl set-up. (Photo credit: Kallie Strong DFO).*

***Figure* 3.10.** *Full beam trawl catch (left) and specimens being sorted (right). (Photo credit: Paloma Carvalho DFO).*

Figure 3.11. *Fish specimens being identified and measured. (Photo credit: Paloma Carvalho DFO).*

Table 3.9. *Equipment deployment at each station.*

Date	Station	WP2	Bongo	Benthic Beam Trawl
08/08/2023	CE1	Y		
08/09/2023	CE2		Y	Y
08/12/2023	W1	Y	Y	Y
08/13/2023	CTD-8-BON		Y	
08/14/2023	ME	Y	Y	Y
08/17/2023	BI-17	Y	Y	Y
08/18/2023	BI-06	Y	Y	Y
08/18/2023	BI-07	Y	Y	Y
08/21/2023	BI-10	Y	Y	Y
08/23/2023	BI-09	Y	Y	Y
08/23/2023	BI-08	Y	Y	Y
08/24/2023	BI-11	Y	Y	Y
08/24/2023	BI-12	Y	Y	Y
08/25/2023	BI-M2	Y	Y	Y
08/26/2023	BI-16	Y	Y	Y
08/27/2023	BI-04	Y	Y	
08/27/2023	BI-M1	Y		

Table 3.10. *Total number of fish specimens by family and station caught with benthic beam trawl.*

Fish Family	**Stations**													**Total**
	CE2	W1	ME	BI-17	BI-06	BI-07	BI-10	BI-09	BI-08	BI-11	BI-12	BI-M2	BI-16	
Agonidae							3	3				5	17	28
Stichaeidae	4		1		3		17	20	1	2		4		52
Cottidae	1		1		1		2	45			1	1	2	54
Pleuronectidae									1					1
Osmeridae								1				1		2
Gadidae			2		1		3	5					55	66
Cyclopteridae					1			1						2
Liparidae				1			2	2			1		3	9
Zoarcidae			14		4		8							26
Pholidae						1								1
Total	5	0	18	1	10	1	35	77	2	2	2	11	77	**241**

3f. Sediments

Cruise Participants: Grace Fedirchuk, Madelyn Stocking (CEOS)
Principal Investigator: Zou Zou Kuzyk (CEOS)

OBJECTIVES

Several sediment studies have been conducted along the coast of James Bay, including Attawapiskat (Martini & Grinham, 1984), Eastmain (D'Anglejan, 1982), Waskaganish (D'Angelejan, 1980), and more recently, Chisasibi. However, a large knowledge gap exists for 'offshore' JB sediments, as well as the larger role of these sediments within the Hudson Bay Complex. Hudson Bay sediments have been characterized in the past (cf. Kuzyk et al., 2009), but smaller-scale study of the BI sediments have not been undertaken These surface sediment samples and cores from JB and BI will provide much-needed data on sediment properties, such as particle size distribution and organic carbon content. Profiles of radioisotopes will be assessed for sediment sources and, when applicable, sediment accumulation rates (SARs). First surveys for possible proxies also will be conducted.

1. Characterize surface sediment properties across JB, including particle size distribution, organic matter content and composition
2. Determine profiles of radioisotopes (^{210}Pb, ^{137}Cs) in sediment cores and where possible estimate modern sedimentation rates and burial rates of organic carbon
3. Qualitatively look at the JB and BI suspended sediment in the surface water
4. Quantify dinoflagellate cysts in relation to environmental properties to develop a basis for applying these as paleo proxies in JB

METHODS & DATA COLLECTION

Box Cores

A Petite PONAR grab sampler was deployed on Leg 2 to determine if the sediment was suitable for a box core. A grab sampler was not available on the ship during Leg 1, so other methods were used to determine 'softness' of the sediment surface. In deeper water (>80 m) when the PONAR was not heavy enough to adequately sample surface sediment (or in the case of Leg 1, no access to a grab sampler), the ship's sounder and multibeam were used to detect the firmness of the sediment. If they indicated a likely firm bottom, operations were delayed until after the benthic beam trawl in hopes of getting more information. In clear and relatively shallow waters (< 60 m), a drop camera was deployed to visualize the sediment via video during Leg 1 (Figure 3.12A). If sediment and weather conditions were suitable, the box corer was deployed. If PONAR was deployed and sediment present was not ideal for coring, surface samples (< 3 cm) for dinoflagellates, geochemistry, or bulk properties were placed in whirl packs and either frozen at -20 °C (geochemical and bulk samples) or kept cool at 4 °C (dinoflagellates).

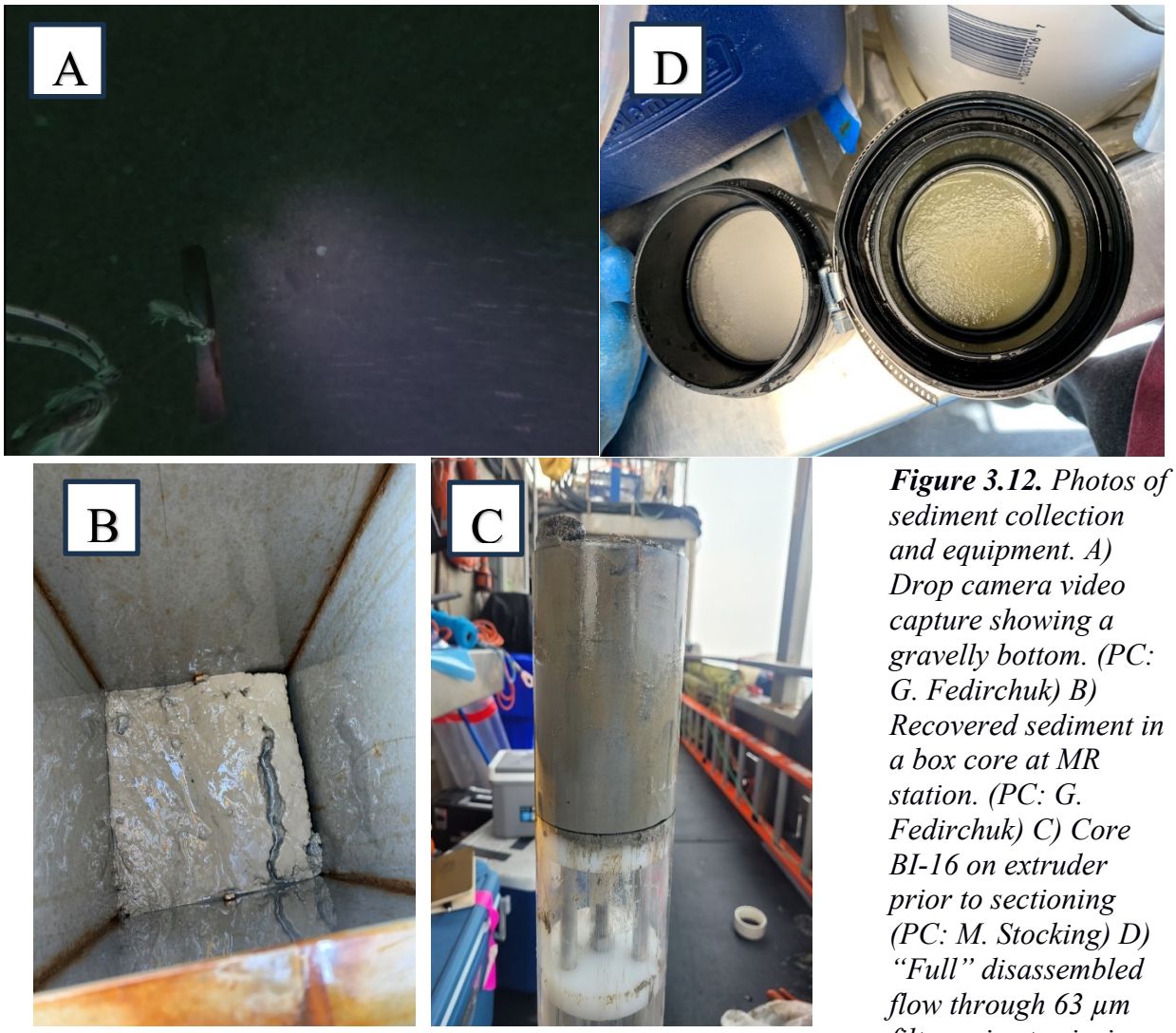

Figure 3.12. *Photos of sediment collection and equipment. A) Drop camera video capture showing a gravelly bottom. (PC: G. Fedirchuk) B) Recovered sediment in a box core at MR station. (PC: G. Fedirchuk) C) Core BI-16 on extruder prior to sectioning (PC: M. Stocking) D) "Full" disassembled flow through 63 µm filter prior to rinsing (PC: G. Fedirchuk).*

If box core sediment recovery was successful and sediments qualified for coring, as much excess water as possible was siphoned off without disturbing the sediment (Figure 3.12B). A coring tube was inserted slowly, away from the edges of the box, and pushed down until refusal. Prior to tube capping, a spoon was used to scoop surface samples (< 3cm) from the sediment around the core for dinoflagellate, geochemical or bulk properties analyses. The box was then opened to allow the person sampling to insert a plug into the bottom of the tube by reaching into the bottom of the box. Once sealed, the tube held a core of sediment inside and its overlying water. The tube was carefully removed from the box, lifting it slowly and smoothly out of the top of the box. The top of the core was capped and held securely in an upright position until ready for extrusion, for a maximum of twelve (12) hours after retrieval. At time of sectioning, the core tube was placed on the extruding stand (Figure 3.12C). The cap was removed from the top and any overlying water was siphoned off the surface into a whirlpak bag labelled "surface". The core was extruded and sectioned at one (1) cm intervals for the first ten (10) cm and two (2) cm intervals until the bottom of the core was reached, unless otherwise stated. Sections were placed in whirl pak bags

and frozen at -20 °C. A total of five (5) cores were collected from JB and BI (Table 3.11), as well as sixteen (16) surface samples that included eight (8) for dinoflagellates, four (4) for geochemical analysis, and four (4) bulk property samples. All box core/PONAR deployment metadata (regardless of sample retrieval) and general core descriptions can be found in Table 3.12.

Flow through sediment collection

Throughout the 2023 cruise, bulk surface water filtrate was collected to qualitatively look at the JB and BI suspended sediment in the surface (~2 m) water. Particles ranging from 63-500 µm were collected from constant surface flow via a two-filter system (Figure 3.12D). Filtrate was rinsed off of the 63 µm filter at regular intervals and was stored at 4 °C. Filtrate was collected in jars and coordinates were noted when collection began and ended.

Table 3.11. *List of Surface samples and Sediment Cores for the 2023 William Kennedy Cruise.*

Station	Type	Date (dd-mm-yyyy)	Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Surface Sediment Samples			Core ID	Core Length (cm)	Notes
							Bulk	Geochemistry	Dinoflagellates			
MR	BOX	15-08	20:58	51.4729	80.2439	6.8	0	0	1	MR	15.75	Core retrieved
BI-17	BOX	17-08	16:31	55.5171	78.6275	92.4	0	0	1	BI-17	12.5	Core retrieved
BI-06	BOX	17-08	2:32	56.0722	77.9292	69.9	0	0	1	BI-06	12	Core retrieved
BI-09	BOX	23-08	5:03	56.848	78.8239	55.3	1	1	1	-	-	large rock in jaws; surface samples
BI-08	PON	23-08	19:05	56.7725	78.4021	47	1	1	1	-	-	surface samples only
BI-11	BOX	24-08	13:10	57.0273	79.6733	92.1	1	1	1	-	-	not enough for core; surface samples
BI-11	BOX	24-08	13:24	57.0297	79.6725	107	0	0	0	BI-11	9	core retrieved
BI-16	BOX	26-08	18:36	55.7019	79.7862	172	1	1	1	BI-16	15	core retrieved, surface samples

Table 3.12. *Sediment Metadata for all PONAR and Box Core Attempts for William Kennedy 2023 Cruises.*

Station	Type	Date (dd-mm-yyyy)	Time (UTC)	Latitude (N)	Longitude (W)	Water Depth (m)	Surface Sediment Samples			Core ID	Core Length (cm)	Notes
							Bulk	Geochem.	Dino.			
W2	BOX	12-08	18:25	55.3591	85.0095	7.5	0	0	0	-	-	Unsuccessful, did not sample
W2	BOX2	12-08	18:28	55.3591	85.0095	7.5	0	0	1	-	-	Clay, sand, gravel, bulk sample (W2BC)
MR	BOX	15-08	20:58	51.4729	80.2439	6.8	0	0	1	MR	15.75	Core retrieved
BI-17	BOX	17-08	16:18	55.5154	78.6258	104	0	0	0	-	-	Washed out, sloped, didn't sample
BI-17	BOX2	17-08	16:31	55.5171	78.6275	92.4	0	0	1	BI-17	12.5	Core retrieved
BI-06	BOX	17-08	2:32	56.0722	77.9292	69.9	0	0	1	BI-06	12	Core retrieved
BI-07	NA	18-08	---	---	---	---	0	0	0	-	-	Used drop cam to visualize bottom, showed gravel. Did not deploy box.

BI-09	PON	23-08	4:45	56.85	78.8285	46.5	0	0	0	-	-	mud present, but some gravel; box core could be risky
BI-09	BOX1	23-08	4:55	56.8486	78.826	54.4	0	0		-	-	not enough sed to core
BI-09	BOX2	23-08	5:03	56.848	78.8239	55.3	1	1	1	-	-	large rock in jaws; surface samples
BI-08	PON1	23-08	17:56	56.7741	78.4051	44.3	0	0	0			mud present, too many rocks for coring
BI-08	PON2	23-08	19:05	56.7725	78.4021	47	1	1	1			surface samples
BI-11	PON	24-08	12:42	57.3036	79.6786	105	0	0	0			didn't trigger; soft bottom noted on radar
BI-11	BOX1	24-08	12:56	57.0286	79.6733	105	0	0	0			didn't trigger; changed lines
BI-11	BOX2	24-08	13:10	57.0273	79.6733	92.1	1	1	1			not enough for core; surface samples
BI-11	BOX3	24-08	13:24	57.0297	79.6725	107	0	0	0	BI-11	9	core retrieved

BI-12	PON	24-08	19:22	56.9814	80.1425	31.6	0	0	0			only water; not heavy enough
BI-12	BOX	24-08	19:30	56.9948	80.1384	35	0	0	0			too windy; only brought up 3 drop stones
BI-M2	PON	25-08	15:36	56.0053	80.2944	40	0	0	0			only water; radar show little/no sediment
BI-16	BOX	26-08	18:36	55.7019	79.7862	172	1	1	1	BI-16	15	Rosette hit bottom, mud on frame; core retrieved, surface samples

3g. Marine Microbiology

Cruise Participants: Anna Shypilova. Xander Bjornsonn (CEOS)
Principal Investigator: Dr. R. Eric Collins (CEOS)

OBJECTIVES

Microbial communities in highly transited areas like Hudson's Bay can tell the story of water mass history, riverine input, and biogeochemical processes. Understanding microbial communities in the water column is essential for understanding ecosystem processes and the future of ecosystem services.

1) To characterize patterns of biodiversity, distribution, and composition of microbial species along the Hudson-James Bay coast based on metagenomic analysis.
2) To evaluate the relationships between environmental variables and microbial composition
3) To determine co-occurrence and possible interactions among phytoplankton and bacteria in the presence of phytoplankton blooms.

METHODS & DATA COLLECTION

Water Sample Collection

Water samples for metagenomic analysis were collected from the rosette deployed off the ship at each of the full sampling stations.

In most cases, metagenomic samples were taken concurrently with primary productivity and biogeochemistry sampling/measures to allow for later exploration of relationships between metagenomic-based biodiversity and environmental conditions in different areas within Hudson Bay.

For each of the full stations, samples were collected from surface, bottom, and if present, the chlorophyll a maximum. In total, 63 samples were collected. Whenever possible, samples were filtered shortly after collection. If this was not possible, water samples were stored temporarily in the refrigerator (on the ship) until they could be filtered.

Filtration

Sterile nitryl gloves were worn during the entirety of the filtration process. Samples were filtered using a 50 ml Syringe through 0.22 μm Sterivex Filters. Water was filtered until the filter became clogged, approximately 1-2 L for most samples. Water was expelled from the filters using an air-filled syringe and immediately preserved at -80^{o}C.

Samples were shipped back to Winnipeg in coolers containing icepacks for later lab analysis. Further analysis will include DNA extractions and Nanopore metagenomic sequencing.

Appendix 1. Sample Log

cruise	date	station	sample target	depth (m)
WK2023	20230823	BI-08	surface	0
WK2023	20230823	BI-08	chl max	10
WK2023	20230823	BI-08	bottom	50
WK2023	20230823	BI-09	surface	0
WK2023	20230823	BI-09	chl max	11
WK2023	20230823	BI-09	bottom	50
WK2023	20230824	BI-11	surface	0
WK2023	20230824	BI-11	chl max	17.5
WK2023	20230824	BI-11	bottom	98
WK2023	20230824	BI-12	surface	0
WK2023	20230824	BI-12	chl max	10.5
WK2023	20230824	BI-12	bottom	28
WK2023	20230825	BI-M2	surface	2
WK2023	20230825	BI-M2	chl max	3.2
WK2023	20230825	BI-M2	bottom	98
WK2023	20230826	BI-16	surface	2
WK2023	20230826	BI-16	bottom	
WK2023	20230827	BI-M1	surface	0
WK2023	20230827	BI-M1	chl max	
WK2023	20230827	BI-M1	bottom	
WK2023	20230828	BI-04	surface	0
WK2023	20230828	BI-04	surface	0
WK2023	20230828	BI-04	surface	0
WK2023	20230828	BI-04	chl max	
WK2023	20230808	W-Z1	surface	1
WK2023	20230808	Churchill Esturary	surface	0
WK2023	20230809	CE2	surface	2
WK2023	20230810	NE1	surface	2
WK2023	20230810	NE5	surface	2
WK2023	20230812	W1	surface	2
WK2023	20230812	W1		20
WK2023	20230812	W2	surface	5
WK2023	20230812	W2-B	surface	0.3
WK2023	20230812	W2-B	bottom	4
WK2023	20230812	W-Z1	surface	0
WK2023	20230812	W-Z1	bottom	
WK2023	20230812	W62	surface	0.3
WK2023	20230813	FT-1	surface	2

WK2023	20230813	FT-5	surface	2
WK2023	20230814	FT-10	surface	2
WK2023	20230814	FT-11	surface	2
WK2023	20230814	FT-17	surface	2
WK2023	20230814	FT-18	surface	2
WK2023	20230814	MRM	surface	0
WK2023	20230818	BI-06	surface	0
WK2023	20230818	BI-06	bottom	75

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