Arctic Conservation, Observation, Research and Engagement (ArcticCORE): 2024 Eureka Spring Field Expedition Report, NU

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2026

ARCTIC CONSERVATION, OBSERVATION, RESEARCH AND ENGAGEMENT (ARCTICCORE): 2024 EUREKA SPRING FIELD EXPEDITION REPORT, NU

by

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The marine waters northwest of Ellesmere and Axel Heiberg Islands are shaped by the multiyear ice (MYI) pack of the Central Arctic Ocean and provide critical habitat for ice-dependent species. In 2019, the Tuvaijuittuq Marine Protected Area was established for the interim protection of this unique sea ice refuge, which is projected to be home to the remaining MYI within a warming Arctic. However, the same thick ice cover has made the area relatively inaccessible, limiting scientific observations of the ice, ocean and glaciers in the area apart from satellite observations. The Arctic Conservation, Observation, Research and Engagement (ArcticCORE) program was implemented by Fisheries and Oceans Canada (DFO) in 2021 as a continuation of the DFO-led Multidisciplinary Arctic Program (MAP) – Last Ice (2017 – 2021). The ArcticCORE program aims to better understand the role of sea ice in this understudied region of the Canadian Arctic, and to provide critical baseline oceanographic information on the marine ecosystem and emerging ecosystem stressors in Tuvaijuittuq to support future decision-making on management and conservation strategies. As part of the ArcticCORE program, a field expedition to the Nansen Sound/Greely Fiord complex, based out of the Environment and Climate Change Canada (ECCC) Eureka weather station, was carried out between 16 April – 17 May 2024 to collect the first spring sea ice ecosystem data of the southernmost part of Tuvaijuittuq. Within this sampling period, 30 stations in the Nansen Sound/Greely Fiord complex were visited by helicopter to study the physical, chemical and biological characteristics of collected water and sea ice samples. This report presents an overview of the sampling activities and logistics of the 2024 Eureka ArcticCORE spring field expedition.

Résumé

Reimer, J., Charette, J., Kitching, E., Atchison, S., Ferland, J., Lee, M., Pućko, M., Hedges, K., Michel, C., Matthes, L. C. 2026. Arctic Conservation, Observation, Research and Engagement (ArcticCORE): 2024 Eureka Spring Field Expedition Report, NU. Can. Manuscr. Rep. Fish. Aquat. Sci. 3338: vii + 24 p. https://doi.org/10.60825/wt8b-q993

Les eaux marines situées au nord-ouest des îles d'Ellesmere et d'Axel Heiberg sont influencées par le pack de glace pluriannuelle de l'océan Arctique central et fournissent un habitat crucial pour les espèces qui dépendent de la glace de mer. En 2019, la zone de protection marine (ZPM) de Tuvaijuittuq fût désignée afin d'offrir une protection provisoire à ce refuge unique pour la glace de mer, le seul endroit où il est attendu que la glace pluriannuelle persiste dans un Arctique en voie de réchauffement rapide. Cette importante couverture de glace épaisse a rendu l'endroit relativement inaccessible par le passé, limitant ainsi les observations scientifiques de la glace de mer, de l'océan et des glaciers autres que les observations satellitaires. Le programme Arctique Conservation, Observation, Recherche et Engagement (ArcticCORE) fut instauré par Pêches et Océans Canada (MPO) en 2021 comme le prolongement du Programme multidisciplinaire arctique (PMA) – Glace séculaire (2017-2021). Ce nouveau programme vise à mieux comprendre le rôle de la glace de mer dans cette région sous-étudiée de l'Arctique canadien et à fournir d'importantes informations océanographiques de référence sur l'écosystème marin et sur les stresseurs écosystémiques émergents dans Tuvaijuittuq, afin de supporter la prise de décision sur les stratégies de gestion et de conservation. Dans le cadre du programme ArcticCORE, une expédition s'est tenue dans le complexe du détroit de Nansen et du fjord Greely, entre le 16 avril et le 17 mai 2024. Cette expédition, basée à la station météorologique Eureka d'Environnement et Changement Climatique Canada (ECCC) avait pour but de collecter les premières données écosystémiques printanières dans la région la plus au sud de Tuvaijuittuq. Durant cette période d'échantillonnage, 30 stations situées dans le complexe du détroit de Nansen et du fjord Greely furent visitées en hélicoptère afin d'étudier les caractéristiques physiques, chimiques et biologiques des échantillons d'eau et de glace de mer récoltés. Ce rapport présente une revue des activités et de la logistique d'échantillonnage de l'expédition printanière 2024 d'ArcticCORE à Eureka.

1. Overview of the ArcticCORE program, sampling region and expedition objectives

Tuvaijuittuq, which means "where the ice never melts" in Inuktitut, encompasses marine waters north of Ellesmere and Axel Heiberg Islands and is home to some of the oldest and thickest sea ice in the Arctic (e.g., Fol et al., 2025, Newton et al., 2021). Due to its significance as habitat for ice-dependent species and its growing accessibility to human activities in an increasingly ice-free Arctic, Tuvaijuittuq was established by Ministerial order as an interim Marine Protected Area (MPA) in 2019 for a period of five years, with renewed status in 2024 for an additional five years (Figure 1; Charette et al., 2020). Tuvaijuittuq also holds important cultural significance to Indigenous communities and has historically been used by Inuit for travel and harvesting (DFO 2020).

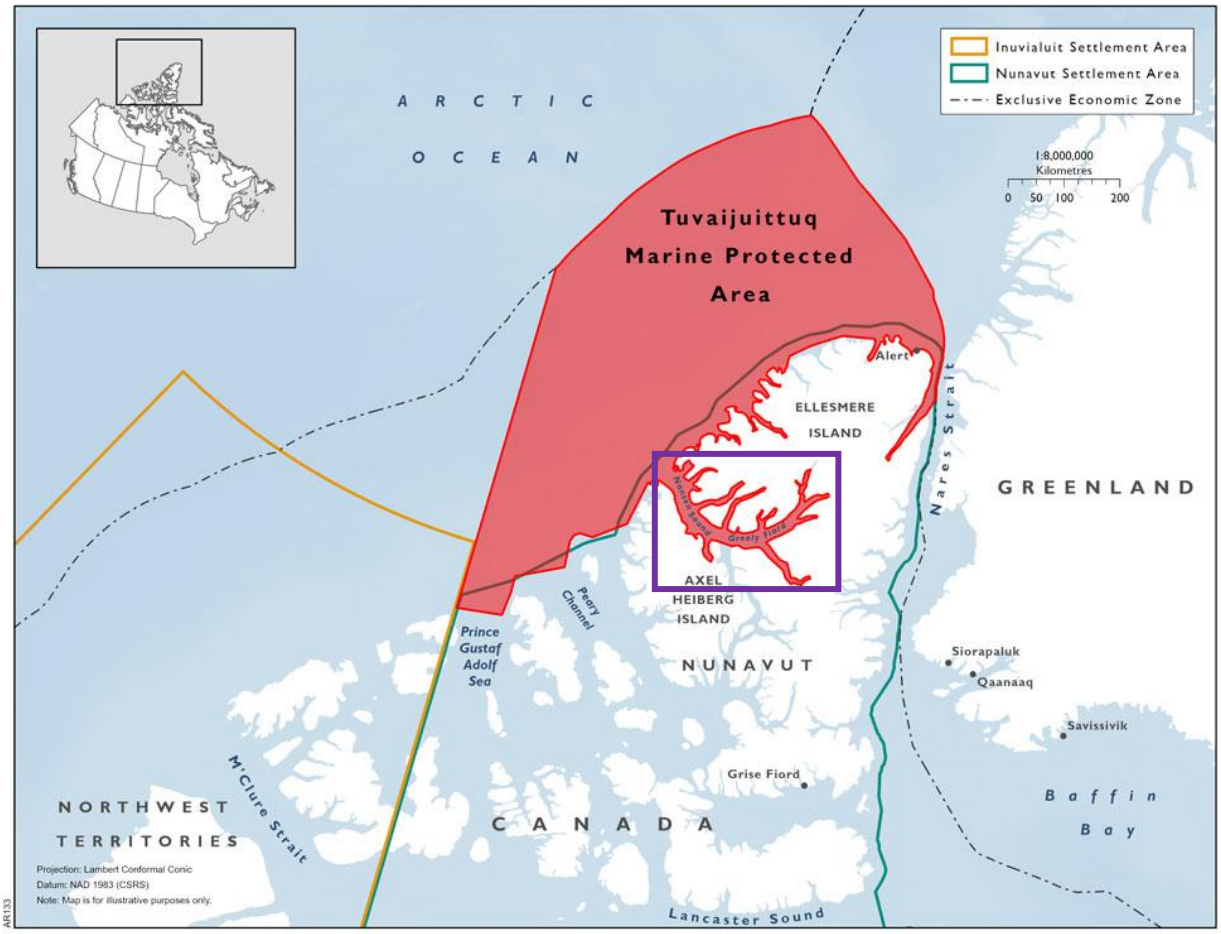

Figure 1. Map of the Canadian High Arctic highlighting the Tuvaijuittuq Marine Protected Area in red (DFO, 2025). The purple rectangle highlights the Nansen Sound/Greely Fiord complex.

Currently, the dominance of thick multiyear sea ice (MYI) makes the area relatively inaccessible, acutely limiting scientific research, including observations of the glaciers, ice, ocean, seafloor, and marine biota in the area. The Arctic Conservation, Observation, Research and Engagement (ArcticCORE) program was implemented by Fisheries and Oceans Canada (DFO) to continue research in Tuvaijuittuq and connected ecosystems, as follow-up to the pioneering scientific work carried out within the DFO-led Multidisciplinary Arctic Program (MAP) – Last Ice program initiated in 2017 (Charette et al. 2022, Michel & Lange 2018, Michel et al., 2019). The overarching goal of the ArcticCORE program is to better understand the role of sea ice in this understudied region of the Canadian Arctic, and to provide critical baseline oceanographic and ecosystem knowledge of the unique and rapidly changing ecosystems in Tuvaijuittuq (e.g., sea ice marine and estuarine systems, glacier-connected fiords) and their emerging ecosystem stressors, to support future decision-making on management and conservation strategies (DFO, 2020). The ArcticCORE program includes ship-, ice- and aerial-based research components as well as long-term observations (e.g., moorings, satellite records). Previous ArcticCORE field campaigns include the first marine ecosystem characterization of Archer Fiord-Lady Franklin Bay in 2023 (Geoffroy et al., 2026), marine mammal aerial surveys around Ellesmere Island (MacLean et al., 2024), and the deployment of long-term observation platforms (moorings) to monitor oceanographic conditions in Archer Fiord, Nares Strait and further downstream in Baffin Bay (Amundsen Science, 2023).

In spring 2024, a comprehensive sea ice-oceanographic ArcticCORE field expedition was carried out in the Nansen Sound/Greely Fiord (NG) complex, based out of the ECCC Eureka weather station to collect the first spring sea ice ecosystem data of the southernmost part of Tuvaijuittuq (Figures 1, 2). The NG complex spans 400 km in length, is located on the northwest coast of Ellesmere Island, and stretches from the Arctic Ocean on the west side across Nansen Sound and Greely Fiord to Tanquary Fiord on the eastside (Figure 2). There are nine major tributary fjords flowing into the NG complex, with four of them, namely Otto Fiord, Canon Fiord, D'Iberville Fiord and Antoinette Bay, being influenced by marine-terminating glaciers. Consequently, the NG complex acts as a drainage basin for glaciers and the Ellesmere ice caps (DFO 2020, Walker, 1977). It is also the only region in Tuvaijuittuq that is dominated by first-year sea ice (FYI) with limited MYI coverage due to an ice plug at the entrance of Nansen Sound, that restricts MYI export from the central Arctic Ocean into Nansen Sound (Jefferies, 2002, Pućko et al., 2023). Ice breakup

typically occurs in early June, with periods of open water occurring throughout the summer into September (Dumas et al., 2007; Walker, 1997).

In the past, the remote northern location has proven difficult to study resulting in only a few local studies providing very limited ecosystem and bathymetric data (Cairns, 2011, Ford and Hattersley-Smith, 1965, Jefferies, 2002; Walker, 1977). Carved by glacial erosion, the average bottom depths through the NG complex range from 500–1000 m (Ford and Hattersley-Smith, 1965, Hattersley-Smith, 1969, Walker., 1977). Oceanographic surveys conducted in the 1960s and 1970s revealed the presence of fresher Arctic surface water which was separated from saltier and deeper Atlantic water by a layer of less salty Pacific-modified water (Fissel et al., 1983, Ford and Hattersley-Smith, 1965). Isothermal and isohaline differences at 300 m also pointed towards a shoal at the mouth of Nansen Sound (Ford and Hattersley-Smith, 1965, Walker, 1977). Water depth decreases into Tanquary Fiord with the presence of a sill at 175 m (Ford and Hattersley-Smith, 1965). These sills can restrict water exchange, creating unique water masses and under-ice and pelagic habitats that warrant further investigation (Cobb, 2011).

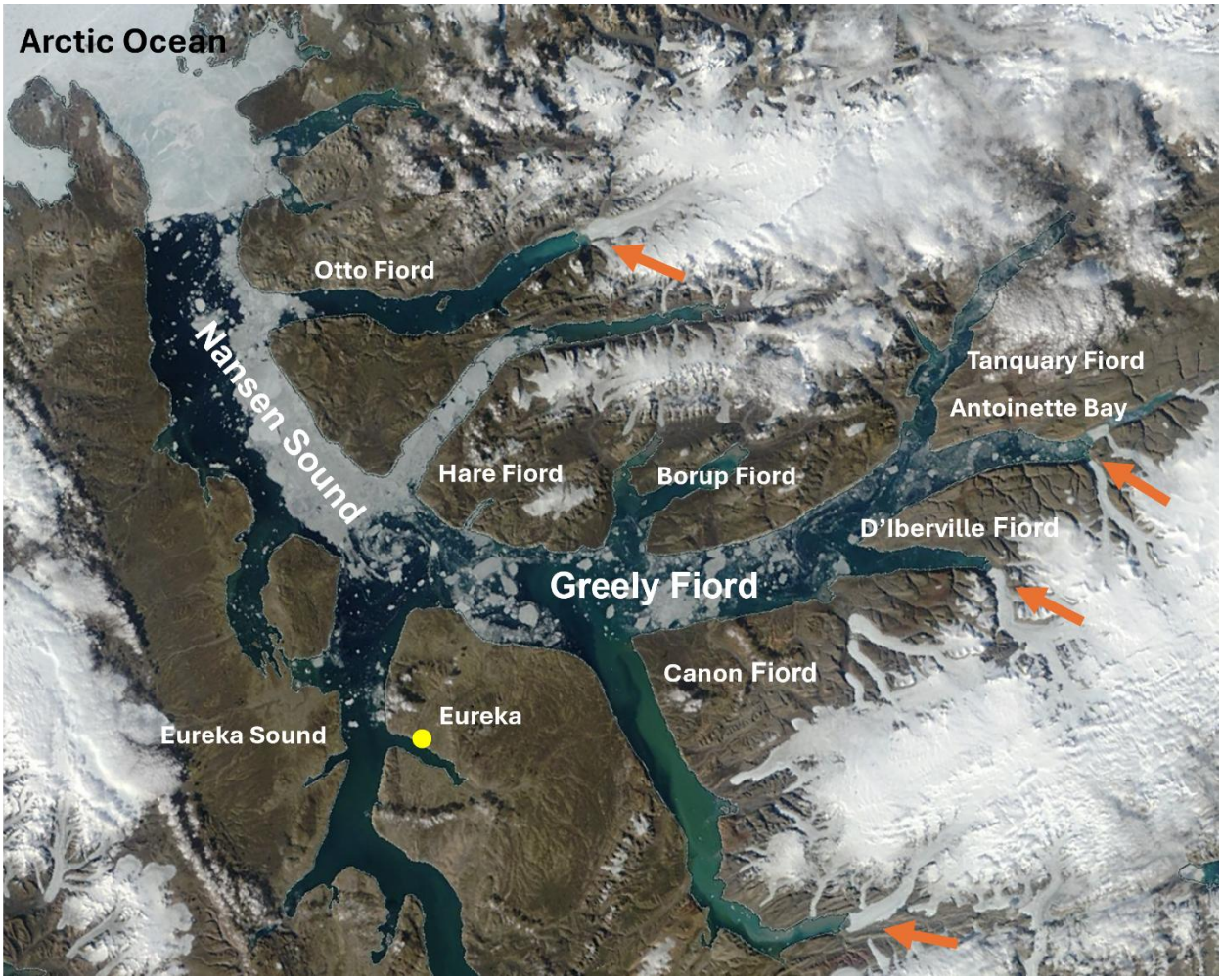

Figure 2. Satellite image of the Nansen Sound/Greely Fiord complex highlighting marine-terminating glaciers (orange arrows) and the Environment and Climate Change Canada Eureka weather station (yellow circle; EOSDIS Worldview; 14 August 2023).

To address significant knowledge gaps on the physical, chemical and biological conditions of the ice-covered marine ecosystem of the NG complex at the beginning of the Arctic growth period, field sampling of sea ice and water as well as physical oceanographic profiling was conducted over four weeks in April and May via helicopter transportation from the ECCC Eureka weather station.

The 2024 Eureka ArcticCORE spring expedition objectives were to:

- Characterize the physical sea ice and oceanographic environmental conditions before the spring melt onset

- Investigate light and nutrient availability at the sea ice bottom and underlying water column
- Evaluate the regional diversity of sea ice and under-ice microalgal communities at the beginning of the seasonal growth period
- Conduct a preliminary fish survey assessment using Environmental DNA (eDNA) signatures to assess the presence and composition of under-ice fish communities

2. Expedition highlights

The 2024 Eureka ArcticCORE spring field expedition collected first-ever ecosystem data on the first-year sea ice habitat, its microalgal and fish biodiversity and the underlying oceanographic conditions prior to the spring melt in Nansen Sound and Greely Fiord, meeting all program objectives and supporting future science-based decision making on long-term conservation and management strategies for Tuvaijuittuq. Between 16 April – 17 May 2024, physical and biochemical data were collected at 30 stations across the large NG Fiord complex, providing new knowledge on light and nutrient availability, sea ice and under-ice microalgal communities and preliminary fish diversity. These data form a critical foundation for understanding ecosystem processes in the region such as drivers of primary production, regional productive capacity and local biodiversity, and strengthen our ability to evaluate the vulnerability of these unique sea ice and marine habitats.

Field sampling of 14 biogeochemical (BGC) and 16 conductivity, temperature, depth (CTD) stations was carried out by a five-member DFO team with support of two helicopter pilots and one helicopter technician. The team was based out of the ECCC Eureka weather station located near the southern border of Tuvaijuittuq, which together with several strategically placed fuel caches enabled a comprehensive sampling coverage of the central NG complex. Smaller tributary fjords of the complex were outside the helicopter range planned capacity (time and fuel balance) and could not be sampled. Despite days with poor visibility, which first delayed the start of field work by a week and then occasionally prevented helicopter operations, all sampling objectives were accomplished within 12 field days.

3. Program participants

Program Leads:

Lisa Matthes, Research Scientist, Fisheries and Oceans Canada

Christine Michel, Research Scientist (Emeritus Scientist), Fisheries and Ocean Canada (lead until March 2024)

Scientific Coordinator: Joannie Charette, Biologist, Fisheries and Oceans Canada

Principal Investigators:

Kevin Hedges, Research Scientist, Fisheries and Oceans Canada

David Capelle, Research Scientist, Fisheries and Oceans Canada

Field participants:

Lisa Matthes, Research Scientist, Fisheries and Oceans Canada; Field Lead

Sheila Atchison, Biologist, Fisheries and Oceans Canada

Joannie Ferland, Biologist, Fisheries and Oceans Canada

Elizabeth Kitching, Biologist, Fisheries and Oceans Canada

Jillian Reimer, Biologist, Fisheries and Oceans Canada

Logistical support:

Megan Lee, Biologist, Fisheries and Oceans Canada

Monika Pućko, Biologist, Fisheries and Oceans Canada

4. Sampling overview

4.1 Sampling area and operations

Field sampling took place from 16 April to 17 May 2024. Accommodation and a temporary laboratory to process collected samples were provided at the ECCC Eureka weather station at the entrance to the NG complex (Figure 2). Transportation into the NG complex was accomplished via two Bell 206L helicopters (Great Slave Helicopters). For regular sampling, one helicopter was used to transport the research team, while the other was used to transport equipment only (Figure 3). Stations were selected to provide maximum coverage of the sampling region within the range

constraints of the helicopters and to capture cross sections across different fjord locations (Figure 4). Sample collection, including physical oceanographic measurements, ice and water sampling took place between 28 April – 13 May 2024 with several days of poor visibility, which limited helicopter operations to 12 field days (Table 1). A total of 30 stations were sampled in this time period. Stations were split into biogeochemical (BGC) stations (BGC station labels 1 through 14, Figure 4) and conductivity, temperature and depth (CTD) stations (labels A through P, Figure 4). Station bottom depth was measured using a dual frequency echo sounder (50/200 kHz), either a FCV-620 or a FCV-588 Furuno fish finder, depending on maximum depth measurement limits of 800 or 1500 m, respectively. Station bottom depths ranged from 86 m to >800 m (Table 1). At each BGC station, physical measurements including snow depth, ice thickness, freeboard, snow temperature, ice surface temperature, air temperature and surface light measurements were recorded. Sea ice cores with a maximum length of 2.4 m and seawater at five depths were sampled at each BGC station and seawater for environmental DNA at some CTD stations (Tables 1, 4). Vertical CTD profiles down to 300 m as well as vertical light (photosynthetically available radiation, PAR, 400 – 700 nm) and fluorescence profiles down to 100 m were conducted at each BGC and CTD station. An overview of sampling activities at each station is provided in Table 1.

Figure 3. Overview of sampling activities including (a) Bell 206L helicopters used to transport field equipment and participants to and from stations, (b) helicopter sling operation to transport equipment, (c) sea ice sampling using a core barrel, (d) field participants cutting and bagging ice samples, (e) preparation of electric ice auger used to auger holes for water sampling, (f) recording of a CTD profile through a drilled ice hole, (g) field participants holding light and fluorescence sensor before deploying through a drilled ice hole (Source: ArcticCORE field team, 2024).

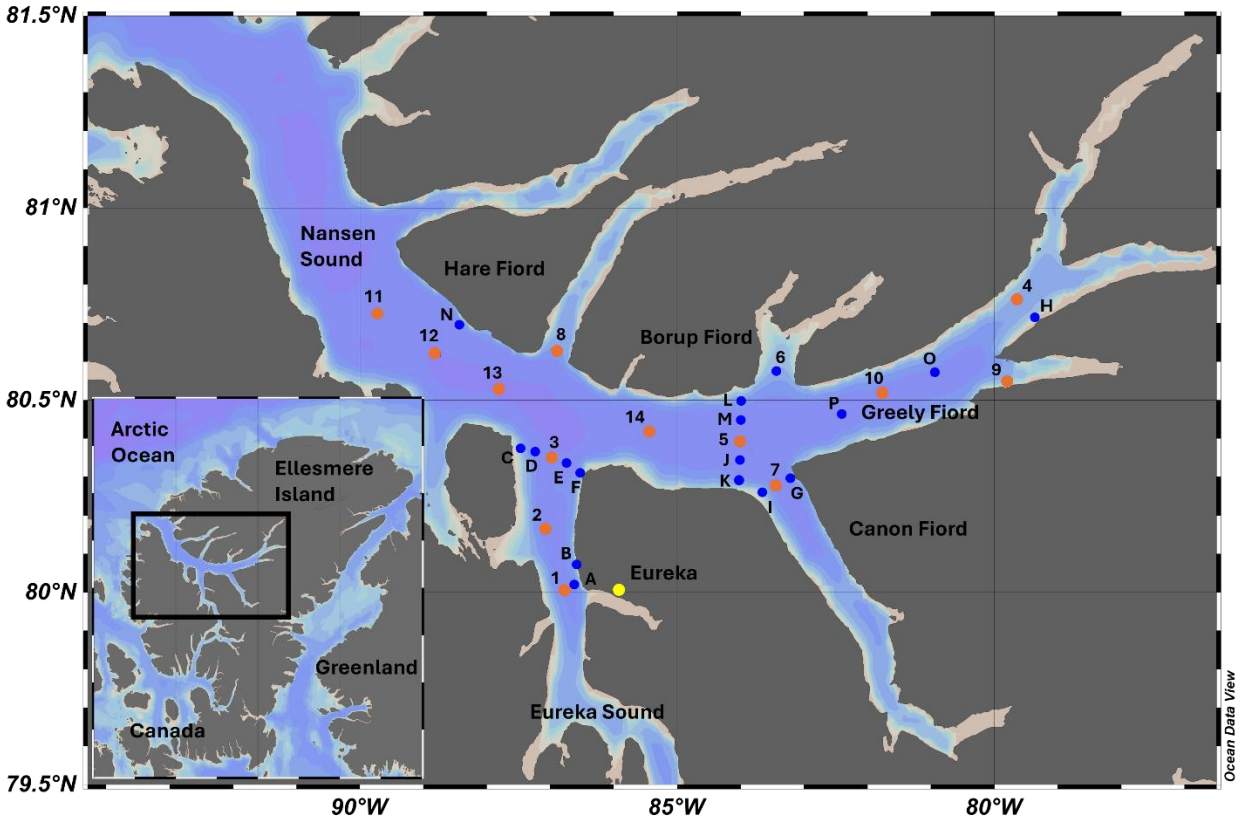

Figure 4. Locations of sampling stations during the 2024 Eureka ArcticCORE spring field expedition. Biogeochemical (BGC) stations, labelled 1 – 14, are shown in orange and CTD stations, labelled A – P, are shown in blue. The inset map shows the sampling region delineated by a black rectangle.

Table 1. Sampling overview of each station visited during the 2024 Eureka ArcticCORE spring field expedition. Acronyms for measured variables include conductivity, temperature, depth (CTD); photosynthetically active radiation (PAR); chlorophyll fluorescence (Fluo) and surface seawater (SW); X indicates the type of sampling at a given station.

Date (MM/DD /YY)	Station label	Latitude (°N)	Longitude (°W)	Bottom depth (m)	Water sampling depth (m)	CTD profile	PAR/Fluo profile	Sea ice sampling
04/28/24	**1**	80.0206	86.6256	512	SW, 25, 50, 100, 250	X	X	X
04/28/24	**A**	80.0206	86.6256	505	-	X		
04/29/24	**2**	80.1640	87.0652	595	SW, 25, 50, 100, 250	X	X	X

04/29/24	**3**	80.3536	86.9773	472	SW, 25, 50, 100, 250	X	X	X
04/30/24	**B**	80.0725	86.5842	131	125	X		
05/01/24	**C**	80.3744	87.4703	528	-	X	X	
05/01/24	**D**	80.3664	87.2394	360	-	X		
05/01/24	**E**	80.3367	86.7478	600	-	X		
05/01/24	**F**	80.3111	86.5283	85.5	125	X	X	
05/01/24	**G**	80.2967	83.2153	485	-	X		
05/02/24	**4**	80.7615	79.6408	224	SW, 25, 50, 100, 220	X	X	X
05/02/24	**H**	80.7151	79.3622	157	SW	X	X	
05/02/24	**I**	80.2601	83.6606	622	-	X		
05/06/24	**5**	80.3950	84.0030	>800	SW, 25, 50, 100, 250	X	X	X
05/06/24	**J**	80.3445	84.0105	808	-	X		
05/06/24	**K**	80.2878	84.0422	-	-	X		
05/07/24	**6**	80.5757	83.4396	183	SW, 25, 50, 100, 173	X	X	X
05/07/24	**L**	80.4980	83.9936	683	-	X		
05/07/24	**7**	80.2780	83.4490	692	SW, 25, 50, 100, 250	X	X	X
05/08/24	**8**	80.6263	86.8915	450	-	X	X	X
05/09/24	**9**	80.5504	79.8004	300	SW, 25, 50, 100, 250, 300	X	X	X
05/09/24	**10**	80.5165	81.7652	736	SW, 25, 50, 100, 250	X	X	X
05/09/24	**M**	80.4482	83.9962	664	-	X		
05/10/24	**11**	80.72403	89.7319	744	SW, 25, 50, 100, 250	X	X	X
05/10/24	**12**	80.62112	88.79747	786	SW, 25, 50, 100, 250	X	X	X
05/10/24	**N**	80.69634	88.43297	658	-	X	X	
05/11/24	**13**	80.52761	87.81955	861	SW, 25, 50, 100, 250	X	X	X
05/11/24	**8.2**	80.62625	86.8915	450	SW, 25, 50, 100, 250			X
05/11/24	**14**	80.41728	85.42847	678	SW, 25, 50, 100, 250	X	X	X
05/13/24	**O**	80.57286	80.93875	449	SW	X	X	
05/13/24	**P**	80.46407	82.40694	729	-	X		

4.2 Physical oceanographic sampling

Table 1 provides an overview of all oceanographic sensor deployments during the expedition. CTD profiles were recorded at each sampling station using a RBR Brevio CTD (RBRbrevio[3], RBR

Global), which was factory calibrated in January 2024 before the expedition. The CTD probe was attached to a marked rope and deployed through a drilled 10-inch hole in the sea ice into the under-ice surface water, where it acclimated for two minutes. It was then lowered by hand at a constant speed of 0.5 m/s to record a downcast until it was stopped at 2 m above the sea floor. A weight attached 2 m below the CTD probe ensured that the instrument was not dragged away by currents and would not hit the seafloor. The CTD probe was lifted at the same speed to also record an upcast.

In addition to CTD casts, a factory calibrated RBR Concerto (calibrated in January 2024), equipped with an internal pressure sensor, an underwater PAR sensor (LI-192, LI-COR) and a chlorophyll fluorometer (Turner Cyclops), was deployed through the same 10-inch hole to record vertical chlorophyll fluorescence and PAR profiles from the sea ice bottom to 100 m water depth (Table 1, Figure 3). The instrument was lowered by hand at a constant speed of 0.5 m/s to record a downcast until the 100-m mark on the rope was reached. An upcast at the same speed was also recorded. To complement underwater light measurements, five replicated upwelling and downwelling surface PAR measurements (LI-190R, LI-COR) were taken at each sampling location to calculate surface albedo. During each underwater light profile, continuous downwelling surface PAR was also recorded.

4.3 Sea ice sampling

Sea ice sampling was carried out at each BGC station at an undisturbed sampling site and away from the water and CTD sampling to avoid interference (Table 1). After sample site selection, the above mentioned physical surface measurements were performed before collecting six full or partial sea ice cores for different variables (physical, nutrient, biological). Ice cores were extracted in a pattern of two rows taken 1 m apart from each other (Table 2).

Table 2. Overview of sea ice cores collected at each biogeochemical (BGC) station, including core treatment and measured variables for each core during the 2024 Eureka ArcticCORE spring field expedition. Acronyms include total alkalinity (TA), stable oxygen isotopes ($\delta^{18}O$), size-fractioned

chlorophyll a (Chl *a*); epifluorescence microscopy (DAPI), particulate organic carbon and nitrogen (POC/N), fast repetition rate fluorometry (FRRF).

Sampling	Number of cores	Core section	Core treatment	Measured variables
Physical	1	Full core, sections of 10 cm	Undiluted	Temperature, salinity, TA[1]
Nutrient	1	Top 10-20 cm, Bottom 3 cm	Undiluted	Nutrients, $\delta^{18}O$, TA[1], salinity
Biology	4	Top 10-20 cm, Bottom 3 cm	Pooled, undiluted top sections, diluted bottom sections	Chl *a*, flow cytometry, taxonomy, DAPI, DNA, POC/N, fatty acids, FRRF

[1]Top 10-20 cm section only

Sea ice cores were extracted with a 9-cm diameter core barrel (Mark II, Kovacs Enterprises) connected to a 36V Bosch power drill after the snow was removed from the sampling site (Figure 3). To record a full temperature and salinity profile of the sea ice layer, one ice core was immediately sampled for onsite measurement of temperature in the middle of each 10 cm section (i.e. starting at 5 cm from the top, then 15 cm, etc.) using a small handheld Bosch 18V drill with a 1/8" drill bit and Testo 720 temperature probe. The 10-cm sections were then cut and put into whirl-packs in a dark cooler for transportation to later measure salinity. Each 10-cm core section was thawed in the laboratory and salinity was measured using a WTW Salinometer conductivity 3210 probe, calibrated in April 2024 before the expedition using a 1413 microS/cm conductivity standard. The 10-20 cm thawed section was also bottled for further total alkalinity (TA) analysis. A separate nutrient ice core was collected for chemistry analysis. The top 10-20 cm section and bottom 3 cm section were immediately packed in a whirl-pack bag, kept in a dark cooler for transportation, thawed in the laboratory and subsampled for the analysis of dissolved nutrients (nitrate, phosphate and silicate), salinity, TA (top section only) and stable oxygen isotopes ($\delta^{18}O$) (Table 3).

For biological sampling, top (10-20 cm from snow-ice interface) and bottom (bottom 3 cm) sections were collected from another four sea ice cores. Immediately after extraction, the bottom of each core was shaded to avoid elevated light stress in the sea ice algal community. Top and

bottom sections were shaded from the sun while cutting. Top and bottom sections were pooled in separate whirl-pack bags and kept in a dark cooler for transport. At the laboratory, 2 L of 0.2 µm-filtered surface sea water, sampled from the corresponding station, was added to the bottom core sections to avoid osmotic stress during the melt process in the dark. The four top 10-20 cm core sections were not diluted, but also melted in the dark. As listed in Table 2 and 3, top and bottom core sections were analyzed for various variables including size-fractioned chlorophyll *a* (Chl *a,* total and >5 µm), microscopic species identification (taxonomy), bacteria and protist abundance (flow cytometry and epifluorescence microscopy – DAPI (bacteria only)), genomics (DNA) analysis, particulate organic carbon and particulate nitrogen (POC and PN), fatty acids and algal photosynthetic parameters using fast repetition rate fluorometry (FRRF).

4.4 Water sampling

Water sampling at five depths was carried out at each BGC station through a drilled 10-inch auger hole (Table 1). Surface sea water was collected at 2 m depth below the sea ice, using a bilge pump coupled to a 12V battery, and pumped into a triple-rinsed dark 20 L Nalgene container. Additionally, sea water was sampled at 25, 50, 100, and 250 m depth using a General Oceanics 2.5 L Niskin bottle and stored in triple-rinsed 2 L brown Nalgene bottles. Water depths were determined by permanent marks on the rope. TA samples were collected directly from the bilge pump or Niskin bottle. At 10 stations, seawater from the surface and from 2 m above the seafloor was also sampled for the analysis of environmental DNA (eDNA) to determine local fish and invertebrate biodiversity (Table 4). Bottom water samples were collected using a 2.5 L Niskin bottle at four stations (B, 4, 6 and 9), while surface samples were collected using the bilge pump from eight stations (1, 5, 6, 9, 11, 8.2, 14 and O; Figure 5). Sampling containers were stored in coolers to prevent freezing until post-processing at the ECCC Eureka weather station.

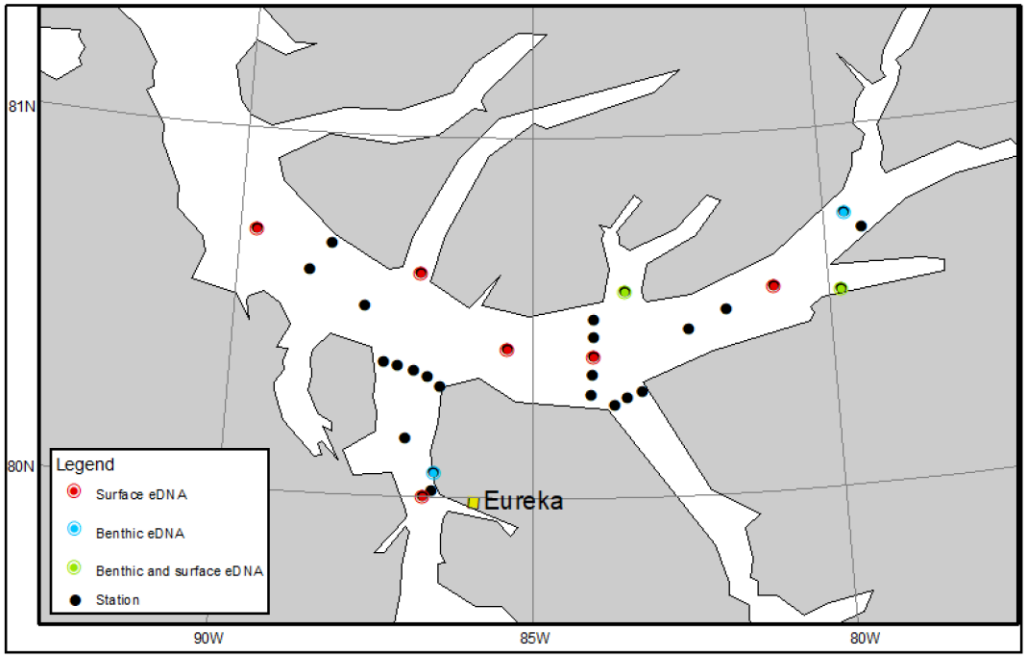

Figure 5. Locations of environmental DNA sampling during the 2024 Eureka ArcticCORE spring field expedition; surface water samples are red, benthic samples are blue, and stations where both surface and benthic water were sampled are green.

After return to the laboratory on the same day, surface water was subsampled and processed for dissolved nutrients, salinity, $\delta^{18}O$, size-fractioned Chl *a*, DAPI, microalgal taxonomy, POC/N, bacteria and phytoplankton cell abundance (flow cytometry), phytoplankton DNA, eDNA, fatty acids and photosynthetic parameters (FRRF) (Table 3). Collected bottom water was processed for eDNA. The other sampled depths (25, 50, 100 and 250 m) were only processed for nutrients, salinity, $\delta^{18}O$, total Chl *a* and flow cytometry. Salinity was measured in the laboratory with the WTW Salinometer conductivity 3210 probe, and additional sub-samples were bottled for further salinity measurements at a higher precision at the Freshwater Institute in Winnipeg.

Table 3. Overview of biochemical analyses and replication conducted for ice and water column sampling during the 2024 Eureka ArcticCORE spring field expedition. Acronyms include stable oxygen isotopes ($\delta^{18}O$), size-fractioned chlorophyll a (total Chl *a* and Chl *a* >5 µm), epifluorescence microscopy (DAPI), particulate organic carbon and nitrogen (POC/PN), Fast Repetition Rate Fluorometry (FRRF), genetics (DNA), fatty acids, microalgal taxonomy (Taxonomy Lugol, Formol) and environmental DNA (eDNA).

Sample type	TA	Nutrients	Salinity		$\delta^{18}O$	Chlorophyll *a*		Flow cytometry		DAPI	POC/ PN	FRRF	DNA	Fatty Acids	Taxonomy		eDNA
			Instant	Bottle		Total	>5 µm	Bacteria	Protists						Lugol	Formol	
Sea ice section (cm)																	
Top (10–20)	1x	2x	1x	-	1x	2x	2x	2x	2x	-	1x	-	1x	-	1x	-	-
Bottom (Bot–3)	-	2x	1x	-	1x	2x	2x	2x	2x	2x	2x	1x	2x	1x	1x	-	-
Water depth (m)																	
2	1x	2x	1x	1x	1x	2x	2x	2x	2x	2x	2x	1x	2x	2x	1x	1x	1x
25	1x	2x	1x	1x	1x	2x	-	2x	2x	-	-	-	-	-	-	-	-
50	1x	2x	1x	1x	1x	2x	-	2x	2x	-	-	-	-	-	-	-	-
100	1x	2x	1x	1x	1x	2x	-	2x	2x	-	-	-	-	-	-	-	-
250 or bottom	1x	2x	1x	1x	1x	-	-	2x	2x	-	-	-	-	-	-	-	1x

Table 4. Station details and sample numbers, including blanks, for environmental DNA samples collected during the 2024 Eureka ArcticCORE spring field expedition.

Date (MM/DD/YY)	Station label	Sample ID	Blank ID	Latitude (°N)	Longitude (°W)	Bottom depth (m)	Sample type	Sample depth (m)
04/28/24	1	1, 2, 3	4	80.0067	86.7622	512	Surface	2
04/30/24	B	5, 6, 7	8	80.0725	86.5842	131	Bottom	128
05/02/24	4	9, 10, 11	12	80.7615	79.6408	224	Bottom	220
05/06/24	5	13, 14, 15	16	80.395	84.003	>800	Surface	2
05/07/24	6	17, 18, 19	20	80.5757	83.4396	183	Surface	2
		12, 22, 23					Bottom	173
05/09/24	9	24, 25, 26	27	80.5504	79.8004	300	Surface	2
		28, 29, 30					Bottom	296
05/10/24	11	31, 32, 33	34	80.7240	89.7319	744	Surface	2
05/11/24	8.2	35, 36, 37	38	80.6263	86.8915	450	Surface	2
05/11/24	14	39, 40, 41	42	80.4173	85.4285	678	Surface	2
05/13/24	O	43, 44, 45	46	80.5729	80.9388	449	Surface	2

4.5 Laboratory post-processing and analysis

Total Alkalinity (TA)

Seawater and thawed sea ice samples were directly transferred into 250 mL plastic bottles, which were rinsed three times with sample water and then filled to the shoulder. Samples were stored at –20°C until further analysis following Dickson (2007).

Dissolved Inorganic Nutrients

Samples for the analysis of dissolved inorganic nutrients including nitrate (NO_3^-), nitrite (NO_2^-), silicate ($Si(OH)_4$) and phosphate (PO_4^{3-}) were collected in duplicates from each water depth and from the melted undiluted top and bottom cores (Tables 2, 3). Sub-samples of 15 mL were transferred into acid-washed triple-rinsed 15 mL Falcon tubes tubes after filtration through a pre-combusted (450°C for 4 hours) 25 mm Whatman GF/F filter in an acid-washed Swinnex filter holder to remove large particles. Samples were flash frozen at –80°C and then stored at –20°C until analysis with a continuous-flow AutoAnalyzer III (Bran and Luebbe GmbH) using a routine colorimetric method adapted from Hansen and Koroleff (1999).

Salinity

Besides instant salinity measurements using a WTW Salinometer conductivity 3210 probe, discrete salinity samples were collected at each water depth. Sub-samples were transferred into high-density polyethylene (HDPE) 125 mL bottles, which were filled to the shoulder, sealed with electrical tape and stored in the dark at 4°C until analysis at the Freshwater Institute in Winnipeg with a Portasal Salinometer (model 8410A; calibrated with IAPSO seawater salinity standard (S = 35 PSU)).

Oxygen Isotopes

Seawater and thawed sea ice sub-samples were transferred into 30 mL plastic brown Nalgene bottles. Samples were sealed with electrical tape and stored in the dark at 4°C until analysis following Rosa et al. (2016).

Size-fractioned Chlorophyll *a*

For all water depths, duplicate sub-samples of 250-500 mL were filtered onto a 25 mm Whatman GF/F filter to measure total Chl *a*. For surface water only, additional duplicate sub-samples of 250-500 mL were filtered onto 25 mm 5 µm filters to measure the fraction of >5 µm cells. For pooled undiluted top and pooled diluted bottom ice cores, duplicate thawed sub-samples of 100-150 mL were filtered on 25 mm GF/F and 25 mm 5 µm filters to measure size-fractioned Chl *a*. Afterwards, filters were placed in 20 mL glass scintillation vials filled with 10 mL of 90% Acetone and stored in the dark at 4°C for 18-24 hours for pigment extraction. Samples were brought to room temperature for 1 hour before being analyzed with a Turner Design 10AU fluorometer before and after acidification using three drops of 5% HCl following Parsons et al (1984). The fluorometer was calibrated using pure Chl *a* extract (*Anacystis nidulans*, Sigma) prior to and after the expedition. The concentrations of Chl *a* and phaeopigments were calculated using the equations of Holm-Hansen et al. (1965).

Microalgal taxonomy

For surface water, 250 mL of sample was transferred into two HDPE bottles. One sample was spiked with 1 mL of Lugol acidic solution to preserve the cells. The other bottle was spiked with 1 mL of borate-buffered formaldehyde. Similarly, for each top and bottom ice sample, 125 mL of melted sample was transferred into one HDPE bottle and spiked with 0.5 mL of Lugol acidic

solution. Samples were gently inverted to mix the sample, sealed with parafilm and stored in the dark at 4°C. Lugol samples were stored for further analysis following the inverted microscope method (Lund et al., 1958).

Bacteria abundance by epifluorescence microscopy

Samples for bacterial abundance measurements by epifluorescence microscopy technique after staining with DAPI (4,6-diamidino-2-phenylindole) is used to validate flow cytometry results. Using an acid-washed syringe, triple rinsed with sample water, 10 mL duplicate sub-samples were transferred into 20 mL black glass scintillation vials. Samples were spiked with 100 µL of buffered formaldehyde for the final concentration of 1% by volume, sealed with parafilm and stored in the dark at 4°C until analysis. Blank Milli-Q and filtered sea water DAPI samples were collected at every other station and processed identically.

Particulate Organic Carbon and Nitrogen (POC/PN)

To measure the concentration of particulate organic carbon and particulate nitrogen and stable isotopes (SI) of $\delta^{13}C$ and $\delta^{15}N$, samples were collected from surface water and bottom ice cores in duplicates, and in singles from the top core. For surface water and melted top cores, 2000 mL of sample was filtered on pre-combusted (450°C for 4 hours) 21 mm Whatman GF/F filters. For melted bottom cores, 500 mL of sample was filtered. Filters were placed in acid-washed 2 mL cryovials and stored at –80°C until further analysis following Barrios-Guzman et al. (2019). Blank filters for water and ice samples were collected at each station.

Bacteria and protist abundance by flow cytometry

To determine bacteria and protist abundance, 4 mL of sample was added to 5 mL cryovials pre-spiked with 20 µL of 25% glutaraldehyde. Samples were collected in duplicates for bacteria and protist abundance. Samples were gently inverted, kept in the dark for 15 minutes and stored at –80°C until further analysis following Belzile et al. (2008).

Genomics (DNA/RNA)

Samples for genomic analysis were collected from 2000 mL of surface water in duplicates and from 300 mL of melted diluted bottom ice cores in singles. Samples were filtered onto 47-mm individually wrapped, sterile, cellulose filters (0.22 µm pore size, Millipore). After filtration, filters were placed in 2-mL sterile vials and spiked with 1.8 ml of RNAlater tissue storage reagent, kept

at room temperature for 30 minutes and then stored at –80°C until further analysis. One blank filter for each ice and water sample was collected with 20-50 mL of Milli-Q. Filtration equipment including funnels and graduated cylinders for DNA analysis was kept separately, was regularly cleaned with 90% Ethanol and rinsed with Milli-Q water.

Fatty Acids

To determine microalgal fatty acid composition, samples were collected in duplicates from surface water and in singles from melted diluted bottom ice cores. For surface water and bottom cores, 2000 mL and 750 mL, respectively, was filtered onto a pre-combusted (450°C for 4 hours) 47-mm GF/F filter. Samples were placed in sterile 2 mL cryovials and stored at –80°C until further analysis. One blank filter for each water and ice sample was collected for each station.

Fast Repetition Rate Fluorometry (FRRF)

To estimate photosynthetic parameters and gross primary production, approximately 2 mL of sample was pipetted into the analysis vial of the FastOcean FRR fluorometer and analyzed using the Act2Run software (Chelsea Technologies). Within the fluorometer, samples were exposed to irradiance ranging from 0 to 2000 µmol photons m^{-2} s^{-1} for 40 to 120 seconds, with three dark periods of 20 seconds, for a total exposition of 21 minutes 40 seconds.

Environmental DNA collection (eDNA)

For each seawater sample, three replicates of 1000 mL each were collected along with a 1000 mL blank (bottled drinking water). Water was filtered at the laboratory using an eDNA Citizen Scientist Sampler and self-preserving filter packs (Smith-Root). All equipment was handled using nitrile gloves and Eliminaze was used to wipe down surfaces and reduce contamination.

4.6 Drop camera deployment

Drop camera footage was collected using a Deep Trekker™ DTPod drop camera at station 6 to record the ice bottom, the under-ice habitat and the seafloor at 183 m to capture biota, ice and sediment conditions (Figure 6). Due to a maximum cable length of 300 m and the heavy nature of the camera equipment that required a separate helicopter flight, only one station was surveyed by camera. The drop camera was manually lowered at a constant speed of 0.5 m/s through the ice and held approximately 1 m above the seafloor.

Figure 6. Drop camera photos of (left) under-ice and (right) benthic environment collected during the 2024 Eureka ArcticCORE spring field expedition.

5. Logistical overview and recommendations

The ECCC Eureka weather station was chosen for this spring field expedition due to the available logistical support, accommodations, and its close proximity to the Nansen Sound/Greely Fiord complex. Most of the NG complex could be reached by helicopters; some stations could only be reached due to strategically placed fuel caches at the beginning of the field sampling. This enabled us to sample 30 stations on 12 sampling days within an approximately two-week window, which made the 2024 Eureka ArcticCORE spring field expedition unambiguously successful with all major sampling objectives achieved. The DFO research team stayed at Eureka for four weeks to compensate for weather delays in the arrival of helicopters, which were delayed due to poor visibility in Resolute Bay, for mandatory rest days for the pilots set by Transport Canada, and for cancelled sampling days due to poor visibility.

The ArcticCORE field mission also benefitted from excellent logistical support by the Polar Continental Shelf Program (PCSP) team and the ECCC Eureka weather station team, who provided transport to the weather station, equipment rental, accommodations and laboratory space. Furthermore, logistical support from Great Slave Helicopters facilitated access to our sampling locations on the sea ice, which was instrumental in conducting this large spatial survey of the study area. Transporting bulky sampling equipment in a sling by helicopter proved to be essential to carry out the planned sampling of water and ice at many stations.

5.3 Safety and Security

DFO is responsible for the safety and security of DFO personnel. All DFO personnel were familiar with departmental approved safe work procedures and safety measures unique to sea ice and helicopter work. All DFO personnel received appropriate training for the field work, including Remote First Aid and CPR training, a valid Firearm Possession and Acquisition License and practical firearm training to operate a firearm in the field (bear safety). Daily field gear also included first aid and safety kits, and survival equipment to safely shelter in case of sudden poor weather conditions that would have made the immediate return from station to Eureka impossible. This situation was not encountered during this field expedition.

5.4 Licensing

The following licenses for the 2024 Eureka ArcticCORE 2024 spring field expedition were obtained to carry out the described field work in Nunavut, Canada:

NIRB Screening (File 18YN002)

Nunavut Research Institute Scientific License: 02 015 24R-M

Resolute Bay Hunters & Trappers Association Letter of Support

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