

Multidisciplinary Arctic Program (MAP) - Last Ice: Expedition Report, Spring 2019 Field Campaign

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2026

**Canadian Manuscript Report of
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Fisheries and Aquatic Sciences 3340

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MULTIDISCIPLINARY ARCTIC PROGRAM (MAP) – LAST ICE: EXPEDITION REPORT, SPRING 2019
FIELD CAMPAIGN

by

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Cat. No. Fs97-4/3340E-PDF ISBN 978-1-100-00254-5 ISSN 1488-5387

<https://doi.org/10.60825/3qm9-bh60>

Correct citation for this publication:

Charette, J., Duerksen, S., Lange, B.A., Tremblay, P., Hussherr, R., Duffaud, C., Carlyle, C., Coupel, P., Atchison, S., Amarualik, U., Galicia, M., Ferguson, S., Hedges, K., Richards, C., Platt, A., Steffen, A., Stupple, G., Underwood G.J.C., Matthes, L., Michel, C. 2026. Multidisciplinary Arctic Program (MAP) – Last Ice: Expedition Report, Spring 2019 Field Campaign. Can. Manuscr. Rep. Fish. Aquat. Sci. 3340: viii + 51 p. <https://doi.org/10.60825/3qm9-bh60>

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ABSTRACT

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<https://doi.org/10.60825/3qm9-bh60>

The Multidisciplinary Arctic Program (MAP) – Last Ice, led by Fisheries and Oceans Canada, provides the first ecosystem study of the multi-year sea ice ecosystem of the Last Ice Area, including physical, chemical and biological processes, sea ice-associated biodiversity, habitat and habitat use. This foundational scientific knowledge is crucial in order to characterize the current state of the unique ecosystem of the Last Ice Area, and understand its evolution in a rapidly warming Arctic. This report presents a review of the scientific activities that took place during the second MAP – Last Ice field campaign, from 25 March to 12 June, 2019, North of Ellesmere Island. An ice camp was established 9 km away from Canadian Forces Station (CFS) Alert in a region of mixed first-year and multi-year sea ice cover. The camp was accessed daily from CFS Alert between 30 March and 1 June 2019. Sea ice and water samples were processed at the ice camp immediately after collection. Additional samples were brought back to CFS Alert for simulated *in situ* experiments. Several continuously observing systems were deployed to monitor atmospheric and oceanographic conditions as well as sea ice properties over the sampling period. An Unmanned Aerial Vehicle (UAV) was used to describe snow and sea ice surface variability and a Remotely Operated Vehicle (ROV) was deployed to characterize the under-ice and benthic environment. Aerial surveys were also carried out to document marine mammal abundance and habitat usage. These surveys were conducted by Twin Otter between 6-12 June 2019. This report provides a logistical overview as well as details of the sampling strategy, observational systems, biochemical measurements, experiments and marine mammal aerial surveys during the MAP-Last Ice 2019 spring field campaign.

RÉSUMÉ

Charette, J., Duerksen, S., Lange, B.A., Tremblay, P., Hussherr, R., Duffaud, C., Carlyle, C., Coupel, P., Atchison, S., Amarualik, U., Galicia, M., Ferguson, S., Hedges, K., Richards, C., Platt, A., Steffen, A., Stupple, G., Underwood G.J.C., Matthes, L., Michel, C. 2026. Multidisciplinary Arctic Program (MAP) – Last Ice: Expedition Report, Spring 2019 Field Campaign. Can. Manuscr. Rep. Fish. Aquat. Sci. 3340: viii + 51 p.
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Le programme multidisciplinaire arctique (PMA) – Glace séculaire, sous l’égide de Pêches et Océans Canada, réalise la première étude écosystémique de la glace pluriannuelle de la Zone de Glace Séculaire (Last Ice Area), incluant les processus physiques, chimiques, biologiques, la diversité associée à la glace de mer, les habitats et l’utilisation de ces habitats. Ces connaissances scientifiques fondamentales sont cruciales afin de caractériser l’état actuel de l’écosystème unique de la Zone de Glace Séculaire et d’en comprendre l’évolution dans l’arctique en voie de réchauffement rapide. Ce rapport présente une revue des activités scientifiques qui se sont déroulées lors de la deuxième campagne de terrain du Programme multidisciplinaire arctique (PMA) – Glace séculaire, qui a eu lieu entre le 25 mars et le 12 juin 2019, au nord de l’île d’Ellesmere. Un camp de glace fut aménagé à 9 km de la Station des Forces Canadiennes (SFC) Alert, dans une région de couvert de glace mixte, composée de glace de première année et de glace pluriannuelle. L’accès au camp de glace s’est fait depuis SFC Alert, tous les jours entre le 30 mars et le 1^{er} juin. Le traitement des échantillons de la glace de mer et de la colonne d’eau se déroulait au camp, immédiatement après l’échantillonnage. Des échantillons additionnels furent ramenés à SFC Alert pour des expériences en conditions simulées *in situ*. Puiseurs systèmes d’observation en continu ont été déployés pour caractériser les conditions atmosphériques et océanographiques ainsi que les propriétés de la glace de mer. Un véhicule aérien autonome a été utilisé pour décrire la variabilité du couvert de neige et de la glace de mer et deux véhicules sous-marins téléopérés furent utilisés pour caractériser l’environnement sous la glace ainsi que celui benthique. Des survols aériens furent également réalisés du 6 au 12 juin 2019 à l’aide d’un Twin Otter, afin de documenter les populations de mammifères marins et l’utilisation de l’habitat. Ce document présente les détails de la stratégie d’échantillonnage, les systèmes d’observation en continu, les mesures biogéochimiques et les expériences ainsi que les survol aérien effectués lors de la campagne de terrain 2019 du PMA – Glace séculaire.

1.0 INTRODUCTION

As Arctic temperatures continue to increase, the rapid declines of sea ice calls for urgent efforts to better characterize the role of sea ice in Arctic marine ecosystems (e.g., AMAP 2017, 2021; IPCC 2019). Model forecast projects that most of the Arctic will be ice-free during summer over the coming decades, with the exception of the region north of Ellesmere Island and northern Greenland where summer sea ice is projected to be retained by mid-century (Pfirman 2009; DFO 2011; WWF 2013). This area, known as the Last Ice Area (LIA), could provide the last summer sea ice habitat, which is critical for ice-dependent and ice-associated flora and fauna that depend on it for food, protection from predators, reproduction and other ecosystem services (Pfirman 2009; Speer and Laughlin 2011; AMAP 2017). This region of enduring sea ice is also of critical importance to northern communities relying on ice-dependent species for food and cultural use.

Recognizing the ecological importance of this region, the Tuvaijuittuq Marine Protected Area (MPA) was established by Ministerial Order in Canada on 21 August 2019 (Fig. 1; DFO 2019) and, in August 2024, was extended for an additional 5 years (DFO 2026). Despite the importance of Tuvaijuittuq for the larger Arctic ecosystem, its sensitivity to warming, and changes to its sea ice cover, there are widespread knowledge gaps and a lack of ecosystem baseline data in the region, largely due to logistical challenges and difficulty of access (Charette et al. 2020). Recognizing the urgent need for comprehensive ecosystem research in support of conservation of the remaining multi-year sea ice (MYI) area, the Government of Canada moved forward to support an extensive ecosystem research program in Tuvaijuittuq, which in collaboration with Inuit and northern partners, would allow evaluation and development of long-term protection and monitoring strategies for the region (DFO 2020).

In 2017, Fisheries and Oceans Canada (DFO), in collaboration with northern partners, as well as national and international stakeholders, implemented the Multidisciplinary Arctic Program (MAP) – Last Ice. Over four years (2017-2021), the program integrated multidisciplinary ecosystem research to improve understanding of key physical, chemical and biological processes, sea ice-associated biodiversity, habitats and habitat use within Tuvaijuittuq MPA. The ecological data collected through MAP-Last Ice program provides critical baseline information on the current state of this vulnerable sea ice ecosystem and enhanced understanding of the structure, function and role of the multi-year sea ice associated ecosystem in the Arctic Ocean. These findings contribute to better decision making and support long-term protection and conservation of Tuvaijuittuq.

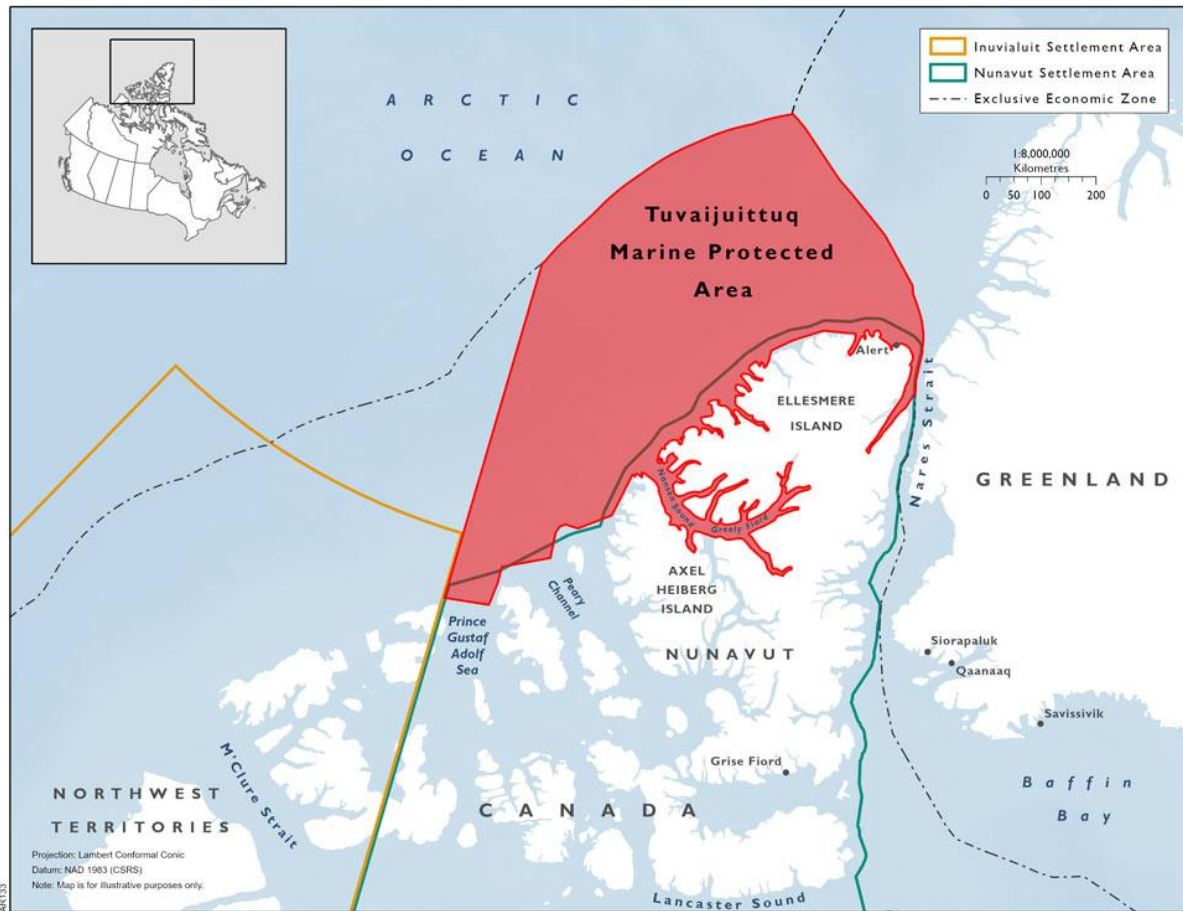


Figure 1. Boundaries of the Tuvaitsuittuq Marine Protected Area (red area). DFO, 2026.

1.1 PROGRAM OBJECTIVES

The Arctic cryosphere is experiencing fundamental changes, with already observed and anticipated far-reaching impacts from sea ice loss and the transition from MYI to first-year ice (FYI) (e.g., Underwood et al. 2019; Ardyna and Arrigo 2020; Sugden et al. 2026). Tuvaitsuittuq constitutes a refuge for the enduring Arctic MYI, offering a window into a unique sea ice-dominated ecosystem threatened by climate change. The overarching objective of MAP-Last Ice is to assess the role of MYI in the ecosystem of Tuvaitsuittuq and in the larger Arctic Ocean. In partnership with Canadian and International partners, the program provided an integrated study of the atmosphere-sea ice-ocean connected system, characterizing key physical, chemical and biological processes including sea ice biodiversity, habitats and habitat usage in Tuvaitsuittuq. The proximity of MYI and FYI in the study area further provides an opportunity to compare ice types and associated ice communities. Specific objectives are detailed in the MAP – Last Ice Science Plan (Michel et al. 2019) and include an assessment of the ocean and sea ice physical, chemical and biological properties, biological assemblages and food webs within and under sea ice, carbon constituents and their cycling, and marine mammal distributions and habitat usage. Novel scientific findings

on MYI characteristics and communities (Campbell et al. 2022; Lange et al. 2019), food web interactions (Kohlbach et al. 2020), and marine mammals (Yukowski et al. 2019, Carlyle et al. 2021, 2025) from the MAP-Last Ice field campaigns already offer insights into this poorly understood ecosystem.

In this report, we present a summary of the sampling program undertaken during the 2019 spring field campaign, successfully fulfilling the five interconnected components proposed for this field program (Michel et al. 2019):

- Spatially-distributed multi-year sea ice habitat and productivity analysis;
- Seasonal characterization of sea ice and under-ice ecosystems;
- Continuous atmospheric, oceanographic and sea ice observations;
- Zooplankton, fish, and benthic organism observations and collection;
- Marine mammals and habitat surveys.

2.0 PROGRAM PARTICIPANTS

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3.0 DESCRIPTION OF THE ICE CAMP

An ice camp was set up in Black Cliffs Bay, North of Ellesmere Island (Fig. 2a), 9 km from Canadian Forces Station (CFS) Alert and was accessed daily by snowmobile. The camp was

establish on a FYI floe, at a distance of ca. 700 m from a MYI floe to allow for a comparison between both ice types. The site was carefully selected based on the following considerations:

- i) presence of floes of adequate size,
- ii) proximity of MYI and FYI,
- iii) stability of the ice in a region where mobile ice abounds, and
- iv) accessibility from the CFS Alert base

Two Weatherhaven tents were installed to accommodate scientific activities at camp (Fig. 3b). One tent, referred to as the Field Laboratory tent, was used for CTD (Conductivity, Temperature, Depth) profiling, water sampling and processing of sea ice and water biochemical samples. The second tent, referred to as the FYI ROV tent, was used as the Remotely Operated Vehicle (ROV) command center. Three smaller tents were installed next to the Weatherhaven tents; one used for the processing of samples for mercury analyses and the remaining two used for storage. A tent was also installed at the MYI site to be used as a second ROV command center (MYI ROV Tent; Fig. 3c). Sampling sites on FYI and MYI were accessed from the main ice camp by walking and by snowmobile, respectively (Fig 3a). An in-situ incubation site was established for each ice type, where in-situ primary production and under-ice light measurements were conducted.

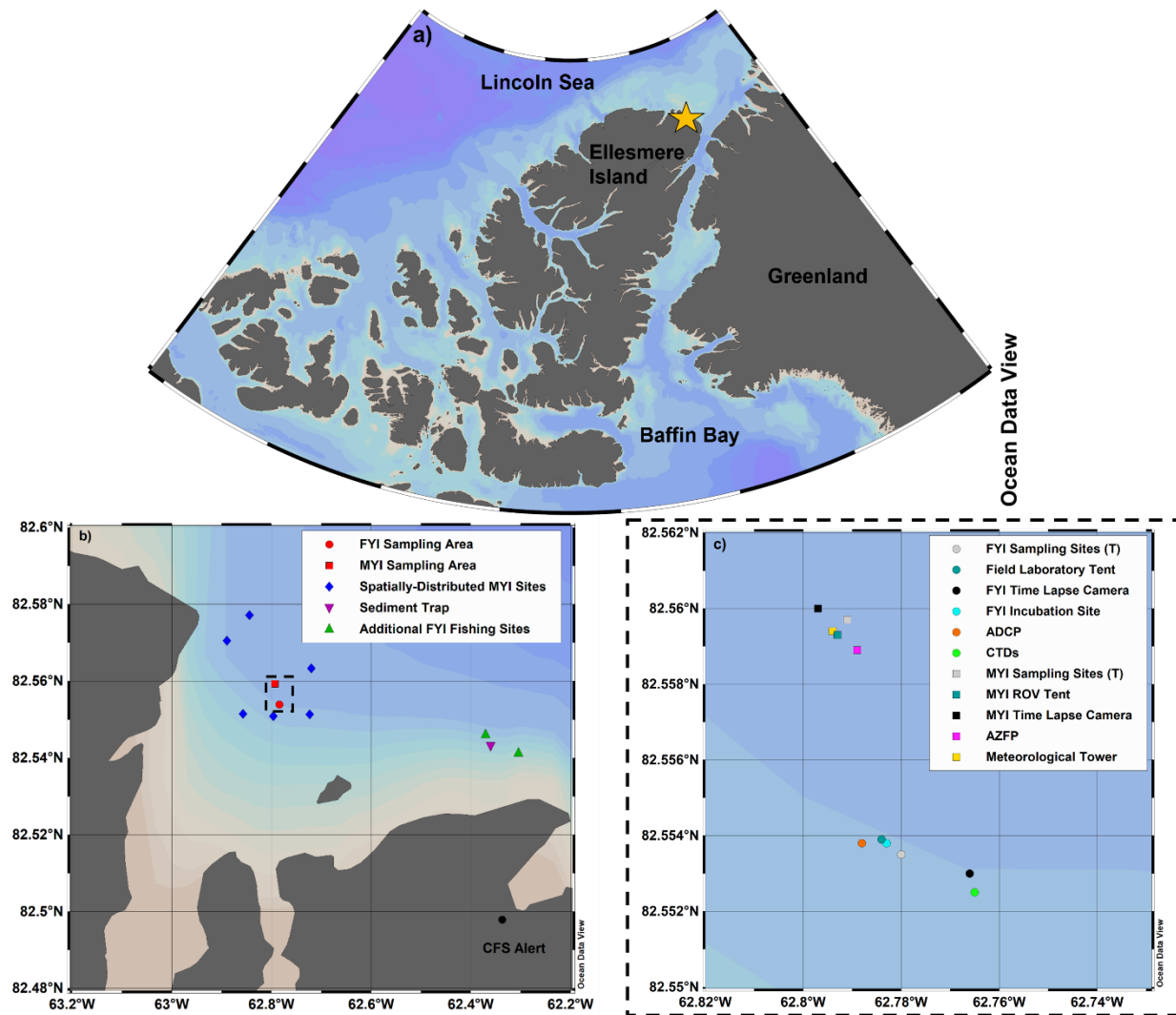


Figure 2. Location of a) the ice camp, indicated by the star, north of Ellesmere Island, b) inset showing sampling and sediment trap deployment sites and, c) zoomed image of the area outlined with dashed black line in (b) showing deployment location of continuously observing systems as well as sampling areas during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. FYI: first-year ice; MYI: multi-year ice; CFS Alert: Canadian Force Station Alert; ADCP: Acoustic Doppler Current Profiler; CTD: Conductivity, Temperature, Depth; ROV: Remotely Operated Vehicle AZFP: Acoustic Zooplankton Fish Profiler.

The extensive ecosystem-based field program was conducted between 1 April and 12 June 2019. A record of daily activities is provided in Appendix 1. All activities were conducted in line with the proposed Scientific Plan and following the Safety Plan described in Michel et al. (2019) as well as safety protocols at CFS Alert. The field program comprised a full suite of activities integrating regular collection and biochemical analysis of FYI, MYI, water column, and

zooplankton samples, daily CTD profiles, installation of continuous ocean, ice surface, and atmosphere observing systems, spatially-distributed sampling and characterization of the sea ice, snow and under-ice habitats. In addition to these core activities, we carried out:

- Under-ice fish sampling (Section 4.3);
- Remotely Operated Vehicle (ROV) dives to characterize the under-ice surface and the benthos (Section 4.6);
- Unmanned Aerial Vehicle (AUV) surveys exploring sea ice/snow cover variability (Section 4.7);
- Simulated *in situ* experiments to determine governing factors for primary production and assess microbial processes in this unique multi-year ice environment (Section 5.5);
- A spring marine mammal aerial survey to estimate abundances and habitat usage in Tuvaijuittuq (Section 4.8).

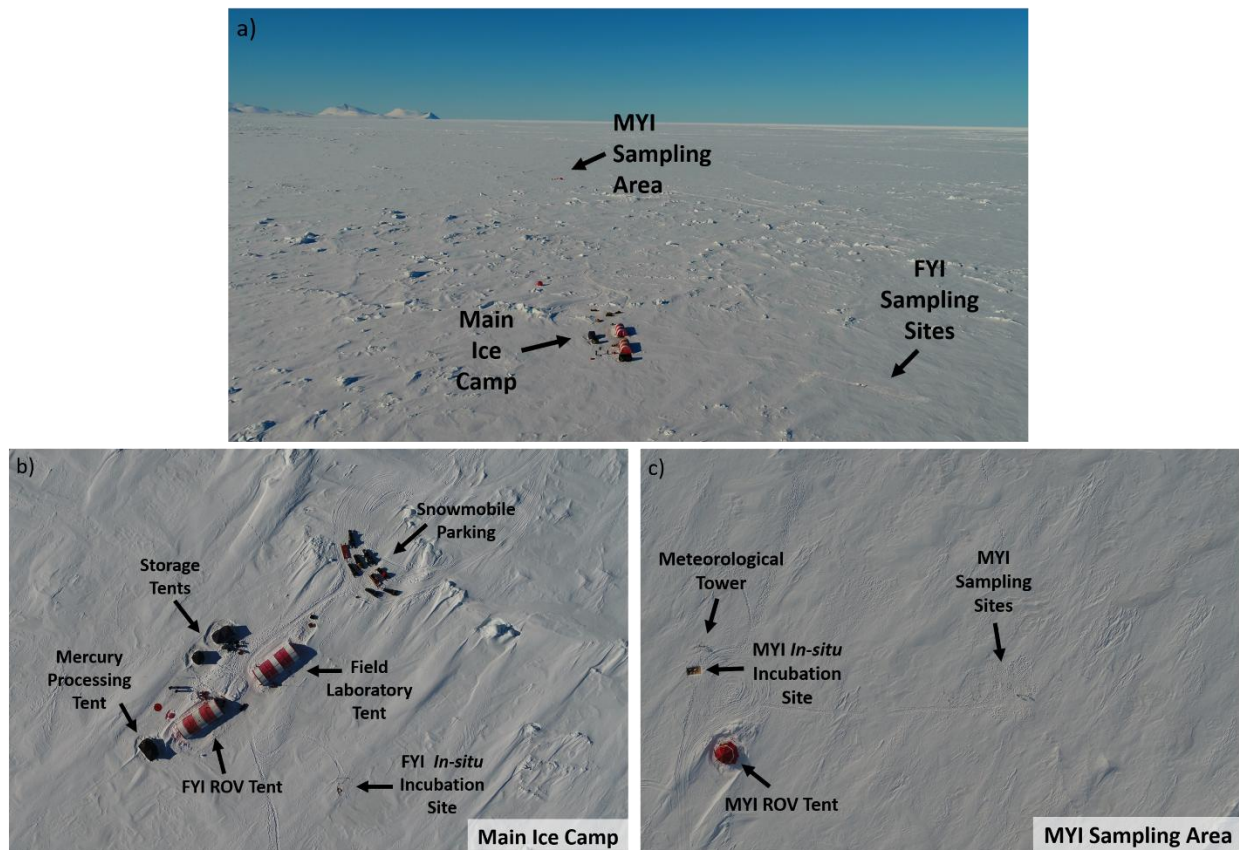


Figure 3. Aerial photos of the ice camp and sampling areas with a) overall view, b) view of the main ice camp on first-year ice (FYI) and adjacent storage and sampling sites, and c) view of the multi-year ice (MYI) sampling area during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Photos were taken with the Unmanned Aerial Vehicle (UAV). ROV: Remotely operated vehicle.

4.0 SAMPLING AND DATA COLLECTION

4.1 SEA ICE SAMPLING

Seasonal time-series sea ice core collection was carried out at the FYI and MYI sampling sites in 4-day intervals from 12 April to 27 May 2019, for a total of 12 time-series sampling events for each site. On one occasion, weather conditions precluded access to the ice and the sampling interval was 5-days (May 2-7). On each sampling day, sea ice cores were extracted using an ice corer (Mark II coring system, 9 cm core barrel internal diameter, Kovacs Enterprises; Fig. 4a) equipped with a Bosch power drill and head adapter for FYI and a Honda coring motor for MYI. Snow and ice thickness as well as freeboard height were measured at each core hole.

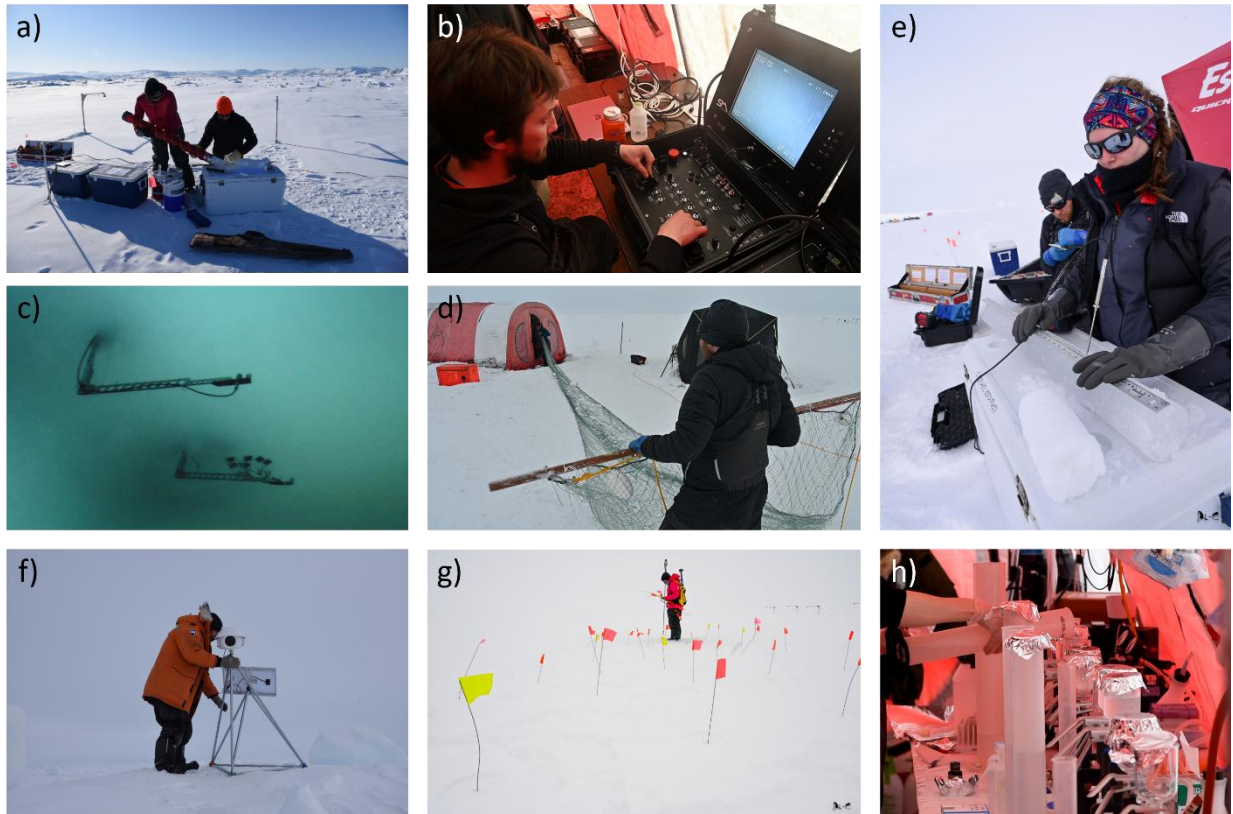


Figure 4. Sampling during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. a) Ice core sampling, b) Remotely operated vehicle (ROV) command center, c) primary production incubations and under-ice light sensor under first-year ice (FYI), d) trammel net deployment on FYI, e) temperature measurement of an ice core, f) installation of the FYI time lapse camera, g) snow thickness measurement for multi-year ice (MYI) experiment sampling, h) filtration setup in the field laboratory tent. Credits: a) & b) Fisheries and Oceans Canada (DFO); c) & f) S. Duerksen DFO, d) e), g) & h) P. Coupel, DFO.

A total of 10 cores were collected on each sampling day at each of the FYI and MYI sampling sites (see Table 1). Sea ice cores were measured, sectioned or processed (e.g., temperature core) on site immediately after extraction. A first core was used to measure sea ice temperature profiles.

A Testo 720 RTD Thermometer was used to measure temperature in a 2-mm diameter hole drilled to the center of the core with a Bosh drill (Fig. 4h). Temperature measurements were acquired every 10 cm along the total core length, starting at 5 cm from the snow-ice interface. All twelve seasonal MYI and six (every other sampling day) FYI cores used for temperature measurements were bagged and brought back to CFS Alert for sea ice texture and salinity analysis.

On regular time-series sampling days, three 10-cm core sections (top, middle and bottom horizons; Fig. 5) were cut from each core and kept for further analysis. The three sections from one extracted core were immediately transferred to sterile Whirl-pak bags for chemical analyses. The remaining eight cores were cut into sections and placed in sterile whirl-pak bags (top and middle) or clean thermal containers (bottom, pooled). Pooling of the core sections was necessary to obtain sufficient material to perform a series of biochemical analyses and was performed after melting for top and mid section, and upon collection for bottom sections.

On five regular time-series sampling days (11 to 27 May), one extra core was collected and the bottom core horizon (10-cm section) was melted in a Whirl-pak bag and kept for zooplankton identification. Furthermore, on five occasions (20, 28 April, 7, 15, 23 May; see Fig. 5, Table 1), additional sea ice horizons were collected for increased vertical resolution of biochemical variables. On these occasions, 10 cm sections were collected every 50-cm in addition to the top, mid and bottom sections, for a total of 4 to 6 horizons collected (Fig. 5). The seasonal time-series sampling strategy for FYI and MYI was accompanied by continuous snow thickness recordings at the FYI and MYI sampling sites, as well as regular water column sampling and autonomous observation systems (see Sections 4.2 and 4.4).

In addition, because of the known heterogeneity associated with MYI, the MAP-Last Ice sea ice sampling plan also included a spatial heterogeneity component. We sampled six spatially-distributed MYI sites on 23 April, 5, 15, 22 May, over a distance ranging from 0.3 to 2.7 km from the main ice camp (see Fig. 2b). Nine MYI cores were extracted at each site. The first core was used for temperature measurements as described above. All of the temperature cores were brought back to CFS Alert for ice texture and salinity analyses. The remaining eight cores were sectioned and 10-cm sections from the top, middle and bottom horizons were kept. Core sections from one core were individually kept in sterile Whirl-pak bags, for further chemical analyses. Other core sections were kept in sterile whirl-pak bags (top and middle) or clean thermal containers (bottom) for further processing and analysis. Pooling was performed as described for time-series sampling.

Additional cores were also collected for three *in-situ* simulated experiments carried out during the field program. A total of 60 cores were extracted for two nutrient enrichment experiments, one on FYI and one on MYI (30 cores each ice type), and 26 MYI cores were collected for a Dissolved Organic Matter (DOM) enrichment experiment. The bottom ice horizon (10-cm section) was collected and used for the nutrient enrichment experiments. For the DOM enrichment experiment, the middle and bottom ice horizons (10-cm sections) were collected and used.

A total of 390 ice cores were collected during the sampling season, of which 155 were FYI and 235 were MYI (Table 1). Sea ice thickness ranged from 1.40 to 1.78 m and from 1.30 to 3.05 m.

for FYI and MYI, respectively. Including all types of sea ice sampling (time-series, spatial distribution, experiments), a total of 1056 core sections, 404 from FYI and 652 from MYI, were processed for biochemical analysis during the field program.

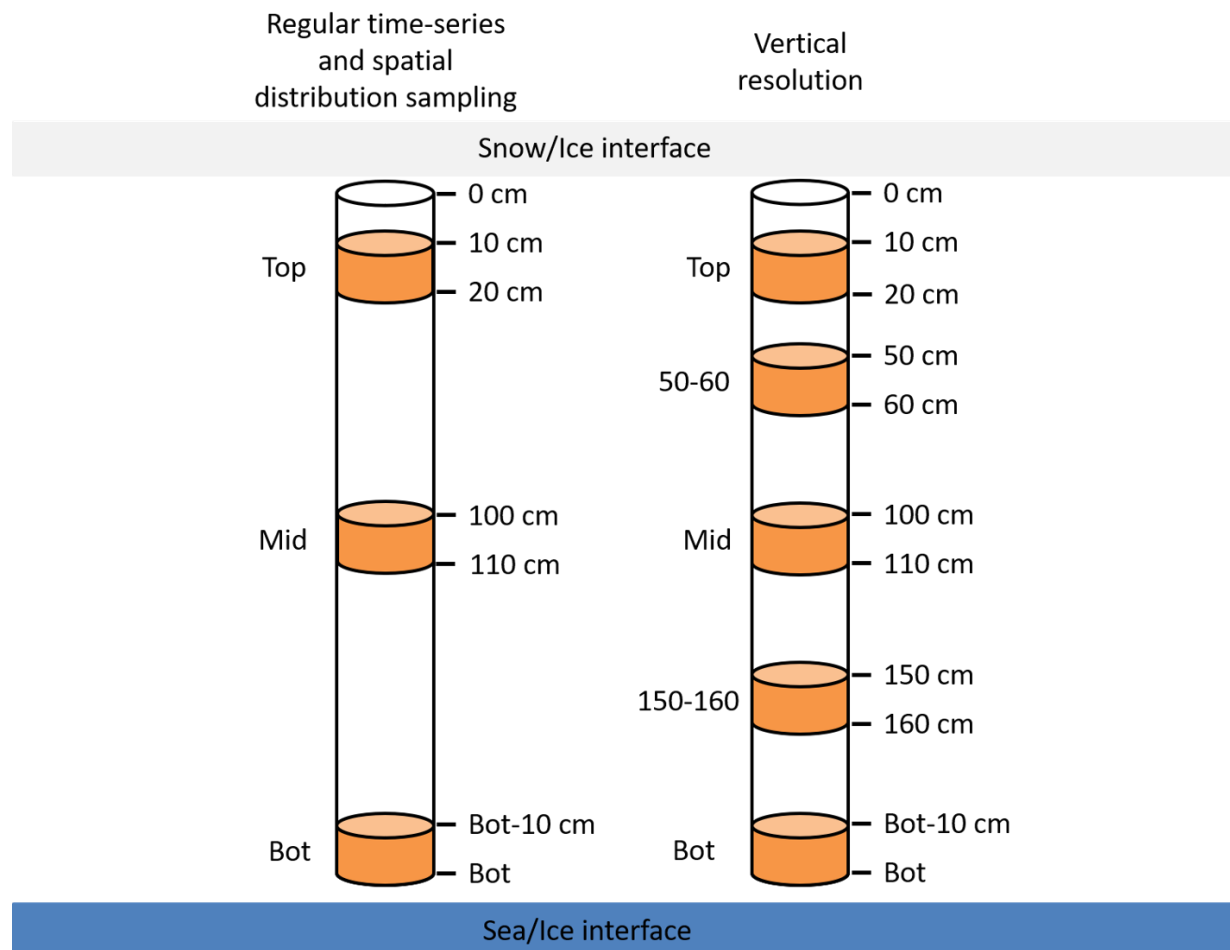


Figure 5. Schematic representation of top (Top), middle (Mid) and bottom (Bot) sea ice horizons sampled during regular time-series and vertical resolution sampling (left) and of additional horizons (vertical resolution, right) collected during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Orange shading represents the sampled sea ice horizons.

Table 1. Summary of first-year (FYI) and multi-year (MYI) ice sampling during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Top: 10-20 cm from the snow-ice interface, Middle (Mid): 100-110 cm from the snow-ice interface, Bottom (Bot): bottom 10 cm of the core from the ice-water interface. Every 50 cm also includes Top, Mid, Bot. Temp: Temperature; Biochem: Biochemical; Zoo: Zooplankton; Exp: Experiments.

Site ID	Ice type	Sampling Date	Number of cores				Total per site	Number of horizons (Biochem or Exp core)	Number of sections collected	Sampled horizons
			Temp	Biochem	Zoo	Exp				
T1	FYI	12-Apr	1	9			10	3	27	Top, Mid, Bot
T1	MYI	12-Apr	1	9			10	3	27	Top, Mid, Bot
T2	FYI	16-Apr	1	9			10	3	27	Top, Mid, Bot
T2	MYI	16-Apr	1	9			10	3	27	Top, Mid, Bot
FYI Exp	FYI	18-Apr				30	30	1	30	Bot
T3	FYI	20-Apr	1	9			10	4	36	Every 50 cm
T3	MYI	20-Apr	1	9			10	5	45	Every 50 cm
S1	MYI	23-Apr	1	8			9	3	24	Top, Mid, Bot
T4	FYI	24-Apr	1	9			10	3	27	Top, Mid, Bot
T4	MYI	24-Apr	1	9			10	3	27	Top, Mid, Bot
T5	FYI	28-Apr	1	9			10	4	36	Every 50 cm
T5	MYI	28-Apr	1	9			10	6	54	Every 50 cm
DOM Exp	MYI	01-May	1			25	26	2	50	Mid, Bot
T6	FYI	02-May	1	9			10	3	27	Top, Mid, Bot
T6	MYI	02-May	1	9			10	3	27	Top, Mid, Bot
S2	MYI	05-May	1	8			9	3	24	Top, Mid, Bot
S3	MYI	05-May	1	8			9	3	24	Top, Mid, Bot
T7	FYI	07-May	1	9			10	4	36	Every 50 cm
T7	MYI	07-May	1	9			10	4	36	Every 50 cm
S4	MYI	10-May	1	8			9	3	24	Top, Mid, Bot
S5	MYI	10-May	1	8			9	3	24	Top, Mid, Bot
T8	FYI	11-May	1	9	1		11	3	28	Top, Mid, Bot
T8	MYI	11-May	1	9	1		11	3	28	Top, Mid, Bot
MYI exp	MYI	14-May				30	30	1	30	Bot

T9	FYI	15-May	1	9	1	11	4	37	Every 50 cm
T9	MYI	15-May	1	9	1	11	5	46	Every 50 cm
T10	FYI	19-May	1	9	1	11	3	28	Top, Mid, Bot
T10	MYI	19-May	1	9	1	11	3	28	Top, Mid, Bot
S6	MYI	22-May	1	8		9	3	24	Top, Mid, Bot
T11	FYI	23-May	1	9	1	11	4	37	Every 50 cm
T11	MYI	23-May	1	9	1	11	6	55	Every 50 cm
T12	FYI	27-May	1	9	1	11	3	28	Top, Mid, Bot
T12	MYI	27-May	1	9	1	11	3	28	Top, Mid, Bot
Total						390	120	1056	
Total FYI						155	47	404	
Total MYI						235	73	652	

4.2 WATER COLUMN SAMPLING

The water depth at the ice camp, 153 m, was measured with a *Furuno* LCD Sounder FCV-620 on 5 April 2019. Water sampling and CTD profiles were conducted in a 1×1 m ice hole located in the Field Laboratory tent (Fig. 3b) using a portable winch equipped with a *EW-C-6* Electronic Wire Counter Module. A *Sea-Bird* SBE 19plus CTD was used for profiling, measuring water column temperature, conductivity, pressure and chlorophyll *a* (Chl *a*) fluorescence (WET Labs ECO-FLRTD). CTD casts were performed down to 140 m, at an approximate speed of 0.5 m s^{-1} , twice a day, every day between 10 April and 30 May at ca. 9:15 AM and 3:15 PM local time. Moreover, a 24-h CTD coverage was carried out from 1:15PM on 27 May to 3:45PM on 28 May, with CTD casts performed every hour. The downcast measurements were kept as processed data.

Sea water samples were collected at 4-day intervals between 13 April and 28 May, for a total of 12 sampling events (Table 2). Six depths were sampled (2, 10, 25, 50, 100, 140 m) using 5-L *Niskin* bottles and were immediately processed for further biochemical analyses. On one occasion, on 5 April, surface water (40 L) was collected using a bilge pump into 20 L dark carboys and was used for a phytoplankton experiment (described in section 5.4).

Zooplankton collection took place immediately after water column sampling for each time point. A total of four vertical zooplankton net tows were performed, two from 135 m to surface, one from 50 m to surface and one from 135 m to 50 m, at a speed of ca. 0.5 m s^{-1} using a $153 \mu\text{m}$ mesh zooplankton net (50 cm diameter). The first two tows (entire water column) were used for the determination of zooplankton fatty acid biomarkers and the two remaining tows were used for stratified zooplankton abundance and species composition (taxonomy). Samples for zooplankton abundance and taxonomy were preserved in buffered formalin (4% final concentration). For fatty acid biomarkers, individuals from target groups were immediately sorted and frozen at -80°C .

Water column samples were also collected for measurement of total, methyl and particulate mercury concentrations. For these analyses, 7-10 depths were sampled (variable depths) with a 2.5-L teflon coated *Niskin* bottle on four occasions (see Table 2). Additionally, a vertical zooplankton net tow was performed between 0 and 100 m at a speed of ca. 0.5 m s^{-1} using a $153 \mu\text{m}$ mesh zooplankton net (50 cm diameter), and the bulk samples were kept at either 4°C or -20°C for subsequent mercury analyses (Table 2).

Table 2. Summary of water and zooplankton sampling during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Samples were collected at the same location but different time points. N/A: not applicable.

Type of sampling	Sampling ID	Sampling Date	Number of Niskins collected	Sampling depths (m)	Number of zooplankton net tows	Depth range of zooplankton net tows (m)
Biochemical variables	T1	13-Apr	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T2	17-Apr	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T3	21-Apr	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T4	25-Apr	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T5	29-Apr	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T6	3-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T7	8-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T8	12-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T9	16-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T10	20-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T11	24-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
	T12	28-May	10	2, 10, 25, 50, 100, 140	4	0-135 (x2), 0-50, 50-135
Mercury		28-Apr	7	1, 2, 5, 10, 50, 100, 140	N/A	N/A
		30-Apr	10	2, 3, 5, 10, 15, 50, 100, 120, 130, 140	4	0-100
		5-May	8	2, 3, 5, 10, 50, 100, 120, 140	5	0-100
		11-May	8	2, 3, 5, 10, 50, 100, 120, 140	5	0-100
		19-May	0	N/A	5	0-100
Total:			153		67	

4.3 FISH SAMPLING

Fish sampling was carried out over a 9-day period between 11 and 20 May (Table 3). Two net types (crab traps, trammel net) were deployed from FYI and MYI while minnow traps were deployed from MYI only (Fig. 4e). The trammel net was 2.43 m wide and 30.48 m long, with an inner mesh size of 2.54 cm and an outer mesh size of 10.16 cm. Crab and minnow traps were deployed in arrays of multiple traps set at varying depths in the water column (e.g., seven traps set at 7 depths: bottom, 150m, 120m, 80m, 40m, 2m). Nets were deployed from the ROV tents for both ice types, except on 19 May, when equipment was deployed at additional FYI stations, closer to CFS Alert (Fig. 1b). Fish sampling nets were deployed for a period ranging from 16.75 to 70.25 hours.

Table 3. Summary of fish sampling during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. FYI: first-year ice; MYI: multi-year ice; N/A: not available.

Date In	Time In (local hh:mm)	Date Out	Time Out (local hh:mm)	Duration (hh:mm)	Ice Type	Net Type
11-May	15:45	12-May	10:19	18:21	MYI	Crab traps
11-May	16:30	11-May	N/A	N/A	FYI	Trammel
12-May	15:10	13-May	10:14	18:26	FYI	Crab traps
13-May	12:18	14-May	12:25	23:38	MYI	Crab traps
13-May	16:45	14-May	9:45	16:45	FYI	Trammel
14-May	11:06	15-May	10:13	22:48	FYI	Trammel
14-May	12:40	15-May	12:58	23:55	MYI	Crab traps
15-May	11:25	16-May	10:12	22:27	FYI	Trammel
15-May	13:19	18-May	11:48	70:16	MYI	Minnow traps
16-May	11:45	18-May	10:30	22:22	FYI	Trammel
18-May	12:12	21-May	10:43	22:13	MYI	Crab traps
18-May	16:15	19-May	N/A	N/A	FYI	Crab traps
18-May	16:21	19-May	N/A	N/A	FYI	Crab traps
19-May	14:26	20-May	18:38	19:04	FYI	Trammel
19-May	15:58	20-May	16:55	19:47	FYI	Trammel

4.4 CONTINUOUS ATMOSPHERIC, OCEANOGRAPHIC AND SEA ICE OBSERVATIONS

Seven continuously observing systems were deployed during the MAP-Last Ice 2019 spring field season, as listed in Table 4. The atmospheric observing system consisted of a solar-powered weather station equipped with a *Campbell Scientific* HMP45CF temperature and relative humidity probe, a *Young* wind monitor model 05103, a *Vaisala* CS106 barometric pressure sensor, two *LI-COR* LI-190 cosine irradiance air sensors and a *LI-COR* LI-192 cosine underwater irradiance

sensors were installed on MYI on 9 April and recorded data until 30 May. A *Campbell Scientific* CR10X measurement and control module was used for data logging. The atmospheric observing system provides records of integrated downwelling and upwelling surface photosynthetically active radiation (PAR; 400 – 700 nm), under-ice PAR, air temperature, relative humidity, wind speed and direction and barometric pressure at 5-min interval. In addition, continuous (5-min interval) measurements of surface downwelling, upwelling, and under-ice PAR at the FYI incubation site were obtained using two *LI-COR* LI-190 cosine irradiance air sensors and one *LI-COR* LI-192 cosine underwater irradiance sensor installed and operational from 9 April to 31 May, 2019.

Two *Sea-Bird* SBE 16plus CTDs, equipped with Wet-labs ECO-PAR sensor and Wet Labs Eco-Triplets FL3w sensor were moored on the same line, tethered to FYI, deployed at 3 m and 60 m. The CTDs were moored on 10 April and provided data at 5-min interval until they were recovered on 31 May.

A passive Persistent Organic Pollutants (POPs) sampler comprised of Ethylene-Vinyl Acetate (EVA) tape on a Teflon coated spider carrier was also deployed on 10 April at 3 m, at a location adjacent to the CTDs.

An Acoustic Doppler Current Profiler (ADCP, *Teledyne* Sentinel V100) was deployed downward facing, under FYI, at a depth of 3 m on 10 April and collected data until 29 May to measure under-ice currents. The ADCP used 1 m cells with a total depth of 100 m and a frequency of 300 kHz. Every 5 minutes, 1 ping was emitted for 30 seconds.

An Acoustic Zooplankton Fish Profiler (AZFP, *ASL Environmental Science*) with a multi-frequency transducer (125, 200 and 455 kHz) and a 38 kHz transducer was deployed downward facing, under MYI, at a depth of 3 m, from 10 April to 30 May.

Seven SR50A probes were installed on each FYI and MYI sampling site to record snow thickness, for a total of 14 probes deployed on 8 April. Two *Campbell Scientific* CR800 data loggers were used for logging data every 5 minutes. All probes were moved to a future coring site once during sampling season, the day ice cores were extracted at their original location. Measurements were recorded until recovery on 27 May.

Two time-lapse cameras, a *Pentax* K-1 Mark II and a *Canon* Rebel EOS T6i, set at a shooting interval of 5 minutes, were installed on FYI and MYI, respectively. Cameras were installed on FYI on 17 April (Fig. 4g) and on MYI on 30 April and were recovered on 26 May and 28 May, respectively. The cameras were installed with *Harbortronics* Solar Charger and a solar panel for battery autonomy. The time-lapse camera on MYI took more than 5300 pictures of the study site during 29 days. However, technical issues with the FYI time-lapse camera system caused malfunction after 22 April. The FYI time-lapse camera took 1321 pictures from 17 to 22 April.

On 15 April, a *Technicap* PPS 3-3 sediment trap was tentatively deployed. An unexpected event led to the loss of the trap during deployment, after equipment failure. The trap intended to collect

sinking particles over a period of one year, to collect information on primary and secondary producers phenology in the region.

Table 4. Summary of continuously observing systems during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. When more than one system/instrument was deployed, the amount is indicated in bracket, after the system/instrument name. Negative deployment depths are shown for systems deployed in the water; positive deployment depths are shown for systems deployed in the air. FYI: first-year ice; MYI: multi-year ice; PAR: Photosynthetically Active Radiation; CDOM: Colored Dissolved Organic Matter.

Type of observation	System	Ice type	Deployment date	Recovery date	Sampling frequency	Deployment depth (m)	Measurement	Model
Atmosphere/ Ocean	Meteorological Station	MYI	9-Apr	30-May	5 minutes	2.5	Downwelling PAR	LI-COR, LI-190
						2.5	Upwelling PAR	LI-COR, LI-190
						-3.5	Under-ice PAR	LI-COR, LI-192
						2.5	Air temperature	Campbell Scientific, HMP45CF
						2.5	Relative humidity	Campbell Scientific, HMP45CF
						3	Wind speed and direction	Young, 05103
						1	Barometric pressure	Vaisala, CS106
	PAR Sensors (3x)	FYI	9-Apr	31-May	5 minutes	2	Downwelling PAR	LI-COR, LI-190
						2	Upwelling PAR	LI-COR, LI-190
						-2	Under-ice PAR	LI-COR, LI-192
Ocean	Acoustic Doppler Current Profiler (ADCP)	FYI	7-Apr	31-May	5 minutes	-3	Under-ice current velocity and direction	Teledyne, Sentinel V100
	Acoustic Zooplankton and Fish Profiler (AZFP)	MYI	10-Apr	30-May	3 seconds	-3	Zooplankton and fish presence and abundance	ASL Environmental Science
	Conductivity, Temperature, Depth profiler (CTD) (2x)	FYI	10-Apr	31-May	30 minutes	-3, -60	Conductivity, Temperature, Depth	Sea-Bird, SBE 16plus
							PAR	Wet-labs, ECO-PAR sensor
							Fluorescence, CDOM	Wet Labs, Eco-Triplets FL3w
	Passive Persistent Organic Pollutants (POPs) sampler	FYI	10-Apr	31-May	N/A	-3	Chemical contaminants	
Snow/Ice surface	Snow Thickness probes (14x)	FYI (7x), MYI (7x)	8-Apr	27-May	5 minutes	1.5	Snow thickness	Campbell Scientific, SR50A
	Time Lapse Camera	FYI	17-Apr	26-May	5 minutes	1.5	Site pictures every 5 minutes	Pentax, K-1 Mark II
		MYI	30-Apr	28-May	5 minutes	1.5	Site pictures every 5 minutes	Canon, Rebel EOS T6i

4.5 SPATIALLY-DISTRIBUTED SNOW THICKNESS MEASUREMENTS

Spatially-distributed snow thickness measurements were conducted using a *Snow-Hydro* GPS-Magnaprobe between 1 April and 26 May (Fig. 4c). The probe was equipped with a *Campbell Scientific* CR800 data logger and a magneto-strictive rod measuring snow thickness between 0 m and 1.2 m. One measurement was taken every four steps (estimated range 1-3 m) along a grid (Area, Table 5) or along a path (Length, Table 5). Focused areas for snow measurements included, on 26 May, one area surveyed by the Unmanned Aerial Vehicle (AUV) a few hours prior to the snow thickness measurements, and twice during the field season, coverage of the FYI Time-lapse camera area. Grid measurements were performed on eight occasions, for a total of 18,496 m² covered. Linear measurements were performed on five occasions during the field season, for a total of 3.6 km. On occasions where both grid and linear measurements were recorded, the grid was performed at the ice sampling location, while the path followed the edge of the ice floe of this sampling location.

Table 5. Summary of spatially-distributed snow thickness measurements during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. FYI: first-year ice; MYI: multi-year ice; N/A: not applicable.

Site ID/Description	Ice type	Sampling Date	Area (m ²)	Length (m)	Number of measurements
MYI site selection	MYI	1-Apr	N/A	254	82
FYI Time-lapse camera	FYI	17-Apr	9458	592	748
S2	MYI	5-May	N/A	1155	380
S3	MYI	8-May	1190	N/A	259
S4	MYI	10-May	1086	N/A	185
S5	MYI	10-May	724	N/A	110
MYI Experiment site	MYI	14-May	39	N/A	50
FYI Time-lapse camera	FYI	21-May	3245	732	861
S6	MYI	22-May	543	891	460
UAV site	FYI	26-May	2211	N/A	394
Total:			18496	3624	3529

4.6 ROV OPERATIONS

Two ROVs were used to collect information on the under-ice and the sea-floor environment and fauna (Fig. 4d). A total of 24 dives were carried out during the sampling program (Table 6). Both ROVs were deployed through a 1 × 1 m hole in the ROV command tents set up on FYI and MYI (Fig. 2). The *Blue Robotics* BlueROV2 was equipped with an acrylic housing allowing operation down to 100 m, six thrusters (4 vectored, 2 vertical), 4 lumen subsea lights, one Newton subsea gripper, a ping sonar altimeter and an echosounder. The BlueROV2 was used exclusively for under-ice measurements. The *Seamor* Chinook ROV has a depth range of 300 m and was equipped

with a wired pendant controller, fiber optic tether, ultra-short baseline (USBL) dunking transducer, dual function gripper, double dot laser scaling system (6" gap for referencing), zoom camera and a *Tritech* echosounder. The Chinook ROV was used for under-ice, but also seafloor transects, to document the benthic ecosystem.

Unfortunately, the USBL transducer of the Chinook ROV only functioned for a short period of time. It stopped working just before the return to surface, at 34 m depth, on the second dive of the expedition, on May 9 and could not be repaired for the rest of the expedition. Light and temperature measurements were obtained with the Chinook ROV using a *RBR* Solo PAR and Duet TD probes, respectively and were performed under the ice or on the seafloor, under FYI or MYI (Table 6). GoPros were added to the ROVs on two occasions, one for each vehicle, to record additional footage.

Table 6. Summary of ROV operations during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. FYI: first-year ice; MYI: multi-year ice; PAR: Photosynthetically Active Radiation; TD – Temperature, Depth.

Date	Vehicle	Number of dive(s)	Location	Habitat visited	Additional instrument used
19-Apr	BlueROV2	1	FYI	Under-ice	
21-Apr	BlueROV2	2	FYI	Under-ice	
25-Apr	BlueROV2	1	FYI	Under-ice	
30-Apr	BlueROV2	1	FYI	Under-ice	
7-May	Chinook ROV	1	FYI	Seafloor	
8-May	Chinook ROV	1	FYI	Seafloor	
9-May	Chinook ROV	2	FYI	Under-ice, seafloor	
11-May	Chinook ROV	1	MYI	Under-ice	<i>RBR</i> Solo PAR with <i>LI-COR</i> LI-192
13-May	Chinook ROV	1	FYI	Under-ice, seafloor	<i>RBR</i> Solo PAR with <i>LI-COR</i> LI-192, <i>RBR</i> Duet TD
17-May	Chinook ROV	1	FYI	Seafloor	
21-May	BlueROV2	1	FYI	Under-ice	
22-May	BlueROV2	1	FYI	Under-ice	
	Chinook ROV	1	FYI	Seafloor	<i>RBR</i> Duet TD
23-May	BlueROV2	1	FYI	Under-ice	
24-May	Chinook ROV	1	FYI	Under-ice, seafloor	
25-May	Chinook ROV	1	FYI	Under-ice	<i>RBR</i> Solo PAR with <i>LI-COR</i> LI-192, <i>RBR</i> Duet TD
26-May	Chinook ROV	2	FYI	Under-ice, seafloor	
	Chinook ROV and BlueROV2	1	FYI	Under-ice	GoPros
28-May	BlueROV2	1	FYI	Under-ice	
	Chinook ROV	2	MYI	Seafloor	GoPros, <i>RBR</i> Solo PAR with <i>LI-COR</i> LI-192, <i>RBR</i> Duet TD
Total:		24			

4.7 UAV SURVEYS

Unmanned Aerial Vehicle (UAV) surveys were performed using an *InDRO Robotics* M210C RTK quadcopter UAV to characterize snow and sea ice surface variability in the study area. Operations were conducted in accordance with Transport Canada regulations. The UAV was flown in systematic overlapping grids (ca. 400×400 m), with visible camera (*DJI* Zenmuse X5S 15 mm model: FC6520). All surveys were planned and implemented using the flight planning software *DJI* GS Pro v. 2.0. Surveys were conducted on 12 occasions during the expedition (Table 7). On three occasions, multiple surveys were conducted on the same day (8, 21, 26 May). The visible imagery data were used to create orthorectified georeferenced images and 3-dimensional digital surface maps (DSM) of the snow and sea ice surface.

Table 7. Summary of UAV surveys during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. FYI: first-year ice; MYI: multi-year ice.

Date	Site ID	Number of images
16-Apr	FYI	66
17-Apr	MYI	349
29-Apr	FYI-MYI	1039
1-May	FYI	73
8-May	S2, FYI	125
9-May	S3	166
11-May	FYI	68
21-May	MYI-FYI, FYI	1354
22-May	S6	134
26-May	S2, FYI, FYI-MYI	856
27-May	FYI-MYI	248
29-May	FYI-MYI	458
Total:		4936

4.8 MARINE MAMMAL SURVEY

A marine mammal aerial survey to assess abundance, distribution and habitat usage in the larger offshore Tuvaijuittuq region was carried out using a Twin Otter aircraft mobilized from Polar Continental Shelf Program in Resolute Bay. A total of 51 survey lines, including 36 priority lines (Fig. 6 red lines) and 15 opportunistic lines (Fig. 6 black lines) were completed between 6 and 12 June, 2019, covering Nares Strait and the Lincoln Sea, east and north of Ellesmere Island, respectively (Fig. 6; Table 8). The Twin Otter was flying at a target speed and altitude of 110 knots and of 1000 feet (ca. 305 m), respectively. The aircraft was equipped with a Nikon D810 DSLR

camera with a 35 mm lens placed above a custom hole with mounting bracket on the belly of the plane. This placement allowed for the continuous collection of digital images of the area beneath the plane with a strip width of 312 m. A GPS unit mounted in the plane and Bluetooth-linked to the camera allowed for geo-referencing of all images collected along the transect lines. With transect lines spaced 5 km apart, the coverage of the aerial survey is estimated at 5% of the total study area. More than 38 000 pictures were taken along the survey transect lines during a total of 33.25 hours of flight time to complete the sampling plan.

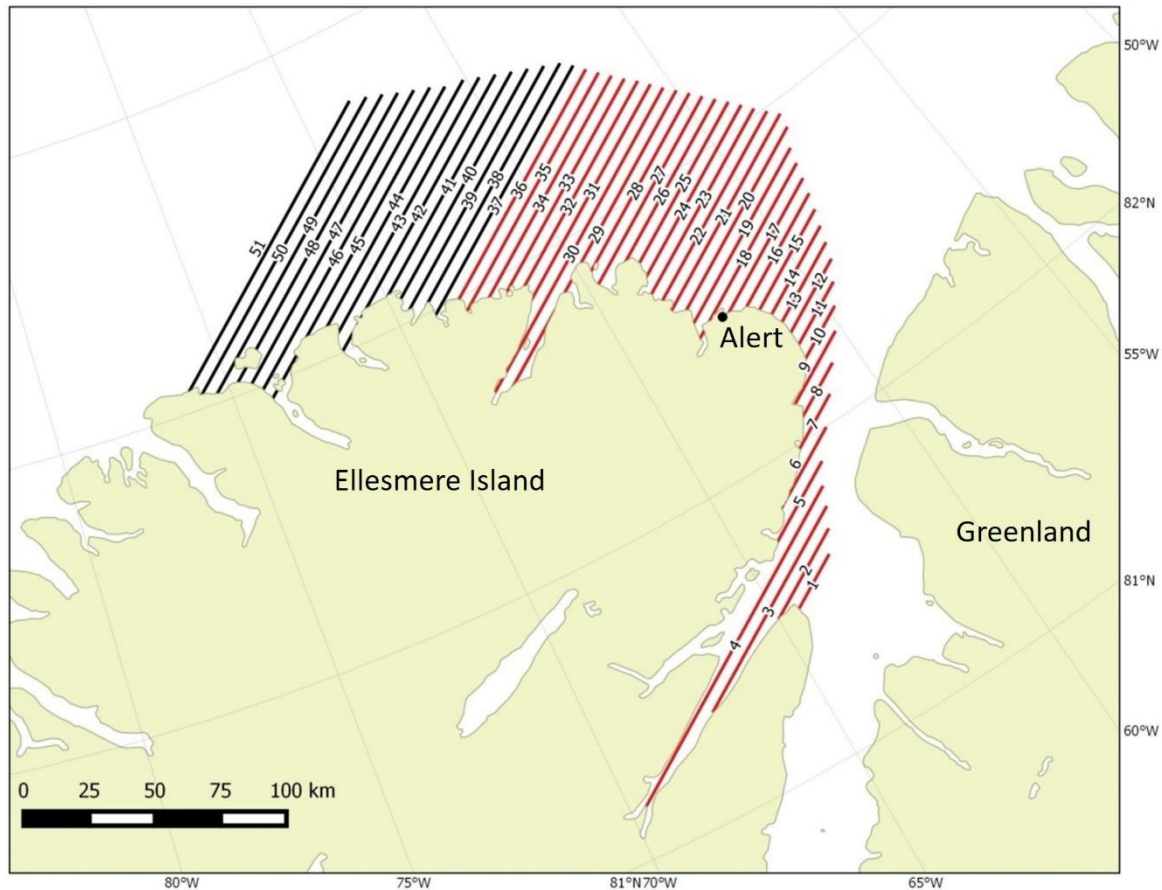


Figure 6. Location of the marine mammal aerial survey lines in Nares Strait and the Lincoln Sea, during the Multidisciplinary Arctic Program (MAP) – Last Ice, spring 2019. Red and black lines represent priority and opportunistic sampling lines, respectively.

Table 8. Summary of marine mammal aerial survey flights completed during the Multidisciplinary Arctic Program (MAP) – Last Ice aerial survey, spring 2019.

Date	Transects ID	Start (local hh:mm)	End (local hh:mm)	Length (km)
6-Jun	AL01-AL04	14:30	17:00	2.5
8-Jun	AL05-AL13	9:15	11:45	2.5
8-Jun	AL14-AL21	12:15	16:00	3.75
9-Jun	AL22-AL28	8:15	12:00	3.75
9-Jun	AL29-AL33	12:30	16:30	4
10-Jun	AL34-AL39	8:30	13:00	4.5
10-Jun	AL40-AL45	13:30	18:30	5
11-Jun	AL46-AL50	10:00	15:00	5
12-Jun	AL51	9:45	12:00	2.25
Total :				33.25

5.0 SAMPLE PROCESSING

Tables 10 and 11 provide an overview of measured variables for sea ice and water, respectively. Samples for biochemical analyses were immediately processed in the Field Laboratory tent upon collection for water and melting for sea ice. A total of four experiments were conducted during the field season, one focussing on phytoplankton, two on sea ice algae and one on sea ice microbial processes.

5.1 SEA ICE SAMPLES

Sea ice samples were melted in the dark, at room temperature either individually in a sterile Whirl-pak bag when no filtered sea water (FSW) was added to the core, or pooled in isothermal containers, when FSW was added. To produce FSW, surface water was collected in the Field Laboratory tent on the day of ice core collection, filtered through Nuclepore 0.2 µm pore size membrane and added to the ice core sections. Sea ice samples were processed for filtration and analysis as soon as completely melted, often 36 to 48 hours after collection. The addition of FSW was based on core horizon and/or target parameter (Table 9), at a ratio of 500 ml per core. Cores from the same horizon and ice type were pooled together in an isothermal container in order to obtain sufficient material for subsequent analyses (listed in Table 10), with the exception of one core sample per horizon. This core was melted without the addition of FSW regardless of its horizon and kept separately in a sterile Whirl-pak bag and subsampled for macro-nutrients ($\text{NO}_3 + \text{NO}_2$, PO_4 and $\text{Si}(\text{OH})_4$), dissolved organic carbon (DOC), bacterial and protist abundance by flow cytometry, salinity and oxygen stable isotope ($\delta^{18}\text{O}$) analyses. All sample volumes were measured, after which the bulk sample of pooled cores was screened through a 350 µm nitex mesh to remove any large grazers and processed for a series of biochemical analyses (see Table 10).

A shore laboratory alongside Environment and Climate Change Canada (ECCC) at CFS Alert (CFS Alert laboratory) was used for the fluorometric determination of Chl *a*, whereas all other biochemical samples were stored for later analysis at the Freshwater Institute in Winnipeg or other laboratories (see section 5.3 for protocols specific to each analysis). We also used the CFS Alert laboratory for simulated *in situ* experiments, including sample processing, and for equipment cleaning and maintenance.

Table 9. Summary of dilution of sea ice samples collected during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Addition, or not, of Filtered seawater (FSW) is shown for each variable according to the sea ice horizon sampled: Top, Middle (Mid), Bottom (Bot), Vertical (every 50 cm along the core length). DOC: Dissolved organic carbon, DN: Dissolved nitrogen, Sal: Salinity, $\delta^{18}\text{O}$: Ratio of Oxygen-18 isotope and Oxygen-16 isotope, FC: Flow cytometry, Chl *a* total: total chlorophyll *a*, POC: Particulate organic carbon, PN: Particulate nitrogen, PP: Primary production, FRRF: Fast Repetition Rate Fluorometry. Macro-nutrients include nitrate plus nitrite ($\text{NO}_3 + \text{NO}_2$), phosphate (PO_4) and silicate ($\text{Si}(\text{OH})_4$).

Analyses	No FSW addition	FSW addition
<u>Chemistry</u>		
Macro-nutrients	Top, Mid, Bot, Vertical	
DOC/DN	Top, Mid, Bot, Vertical	
Sal	Top, Mid, Bot, Vertical	
$\delta^{18}\text{O}$	Top, Mid, Bot, Vertical	
<u>Community structure</u>		
FC - Bacteria	Top, Mid, Bot, Vertical	
FC - Attached bacteria	Top, Mid, Vertical	Bot
FC - Protists	Top, Mid, Bot, Vertical	
FC - Viruses	Top, Mid, Bot, Vertical	
<u>Algal biomass</u>		
Chl <i>a</i> total	Top, Mid, Vertical	Mid ² , Bot
POC/PN	Top, Mid ¹ , Vertical	Mid ² , Bot
<u>Diversity</u>		
DNA	Top, Mid, Vertical	Bot
Taxonomy	Top, Mid, Vertical	Bot
<u>Food web biomarkers</u>		
Fatty acids	Top, Mid, Vertical	Bot
Stable isotopes	Top, Mid, Vertical	Bot
<u>Primary production</u>		
PP $^{13}\text{C}/^{15}\text{N}$	Top, Mid, Vertical	Mid ² , Bot
FRRF	Top, Mid, Vertical	Bot

¹Only for spatially distributed (S) sites

²Only for seasonal time-series samples

Table 10. Summary of biochemical analyses and replication performed for sea ice samples collected during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Number of replicates is shown for temporal and spatially distributed sites (site T1 to T12 and S1 to S6, respectively) and core horizons (Top, Middle (Mid), Bottom (Bot)). DOC: Dissolved organic carbon, DN: Dissolved nitrogen, Sal: Salinity, $\delta^{18}\text{O}$: Ratio of Oxygen-18 isotope and Oxygen-16 isotope, FC: Flow cytometry, Chl *a* total: total chlorophyll *a*, POC: Particulate organic carbon, PN: Particulate nitrogen, PP: Primary production, FRRF: Fast Repetition Rate Fluorometry . Macro-nutrients *include* nitrate plus nitrite ($\text{NO}_3 + \text{NO}_2$), phosphate (PO_4) and silicate ($\text{Si}(\text{OH})_4$).

Analyses	Sites T1 to T12			Odd T Sites ¹	Sites S1 to S6		
	Top	Mid	Bot	Additional sections	Top	Mid	Bot
<u>Chemistry</u>							
Macro-nutrients	2x	2x	2x	2x	2x	2x	2x
DOC/DN	2x	2x	2x	2x	2x	2x	2x
Sal	1x	1x	1x	1x	1x	1x	1x
δ ¹⁸ O	1x	1x	1x	1x	1x	1x	1x
<u>Community structure</u>							
FC - Bacteria	2x	2x	2x	2x	2x	2x	2x
FC - Attached bacteria	2x	2x	2x	2x	2x	2x	2x
FC - Protists	2x	2x	2x	2x	2x	2x	2x
FC - Viruses	2x	2x	2x	2x	2x	2x	2x
<u>Algal biomass</u>							
Chl <i>a</i> total	2x	2x	2x	2x	2x	2x	2x
POC/PN	2x	1x	2x	2x	2x	2x	2x
<u>Diversity</u>							
DNA	2x	1x	2x	2x	2x	2x	2x
Taxonomy	1x	1x	1x	1x	1x	1x	1x
<u>Food web biomarkers</u>							
Fatty acids	2x	2x	2x	2x	2x	2x	2x
Stable isotopes	2x	1x	2x	2x	2x	2x	2x
<u>Primary production</u>							
PP ¹³ C/ ¹⁵ N		2x	2x				
FRRF	1x	1x	1x	1x	1x	1x	1x

¹Excluding site T1

5.2 WATER SAMPLES

Upon collection of seawater samples with *Niskin* bottles, dissolved inorganic carbon (DIC) samples were drawn first, directly from the *Niskin* bottle (details on Section 5.3). Macro-nutrients, DOC and flow cytometry samples were then collected, also from the *Niskin* bottle with a 60 ml acid-washed syringe, after rinsing three times with sample water. The remaining water was pre-filtered through a 350 μm nitex mesh to remove large grazers, transferred to a clean carboy and

kept cool in the dark. All processing of samples, described in Table 11, was completed within four hours of collection.

Samples for mercury analysis were prepared in a separate mercury processing tent at the ice camp. Total mercury in water samples were collected in 40mL glass vials. Methyl Mercury was sampled into 125 PET bottles and were acidified with 1mL of ultratrace HCl and immediately placed in an opaque bag. Two litre water samples were collected in clean teflon bottles for particulate sampling. Filtrations for particulate mercury were undertaken at the Dr. Neil Trivett Global Atmosphere Watch Observatory Laboratory (GAW Lab) facility using a Nalgene polysulfone (PSF) filter holder and pre-combusted 47mm GFF filters. Filters were kept frozen until analysis. Zooplankton, total mercury, methyl mercury and particulate mercury filter samples were sent to Dr. Lars-Eric Heimbürger at the Mediterranean Institute of Oceanography for analysis. A duplicate of total mercury samples were analyzed at the Canada Centre for Inland Waters in Burlington, ON.

Table 11. Summary of biochemical analyses and replication performed for water samples during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Number of replicates is shown for the different variables and sampling depths. DIC: Dissolved inorganic carbon, TA: Total alkalinity, DOC: Dissolved organic carbon, DN: Dissolved nitrogen, Sal: Salinity, $\delta^{18}\text{O}$: Ratio of Oxygen-18 isotope and Oxygen-16 isotope, FC: Flow cytometry, Chl *a* total: total chlorophyll *a*, POC: Particulate organic carbon, PN: Particulate nitrogen, FRRF: Fast Repetition Rate Fluorometry. Macro-nutrients include nitrate plus nitrite ($\text{NO}_3 + \text{NO}_2$), phosphate (PO_4) and silicate ($\text{Si}(\text{OH})_4$).

Analyses	Sampling Depth (m)					
	2	10	25	50	100	140
<u>Chemistry</u>						
DIC/TA	1x	1x	1x	3x	1x	1x
Macro-nutrients	2x	2x	2x	2x	2x	2x
DOC/DN	2x	2x	2x	2x	2x	2x
Sal	1x	1x	1x	1x	1x	1x
$\delta^{18}\text{O}$	1x	1x	1x	1x	1x	1x
<u>Community structure</u>						
FC - Bacteria	2x	2x	2x	2x	2x	2x
FC - Attached bacteria	2x					
FC - Protist	2x	2x	2x	2x	2x	2x
FC - Virus	2x					
<u>Algal biomass</u>						
Chl <i>a</i> total	2x	2x	2x	2x	2x	
Chl <i>a</i> >5 μm	2x	2x	2x	2x	2x	
POC/PN	2x					
<u>Diversity</u>						
DNA	2x			2x		
Taxonomy	2x					
<u>Food web biomarkers</u>						
Fatty acids	2x					
Stable isotopes	2x					
<u>Primary production</u>						
FRRF	1x	1x	1x	1x		

5.3 LABORATORY ANALYSES

Chemistry

Dissolved Inorganic Carbon: Samples for DIC were collected directly from the *Niskin* bottles in clean 250 mL borosilicate glass reagent bottles with a tapered stopper, after abundant overflow. Precautions were taken to minimize air bubbles during filling, leaving a headspace of 1% of the

bottle's volume using a calibrated spacer. The samples were preserved with 50 μL of mercury chloride and tightly sealed with Apiezon M grease in the Field Laboratory tent. The glass stopper was secured with an elastic band and clamp, and the samples were stored at 4 °C in the dark until analysis. Samples were analyzed using a SOMMA sample handling system and a coulometer (UIC Inc.) following the protocol from Dickson et al. (2007) using Certified reference material seawater (CRMs; Scripps Oceanographic Institution) every 20 samples for calibration.

Macro-nutrients: Duplicate subsamples were filtered through pre-combusted 25 mm Whatman GF/F filters (450°C for 12 h) using an acid-washed syringe holder for macro-nutrient analysis (NO_3+NO_2 , PO_4 , $\text{Si}(\text{OH})_4$). Samples were kept in 15 mL acid washed (12-24 h soak in 10% HCl and rinsed with ultrapure water) Falcon polypropylene tubes, immediately frozen at -80°C and stored until further analysis using an Autoanalyzer 3 (Seal Analytical) following a method adapted from Grasshoff et al. (1999).

Dissolved Organic Carbon and Dissolved Nitrogen: Duplicate subsamples for DOC/Dissolved Nitrogen (DN) analysis were collected using the same method as macro-nutrients, and were kept in 20 mL Amber EPA glass vials with polypropylene caps and PTFE silicone septas. The vials, caps and septas were previously acid-washed (12-24 h soak in 10% HCl and rinsed with ultrapure water). The vials were also combusted overnight at 500°C. Samples were acidified with 100 μL of 50% H_3PO_4 and stored at 4 °C in the dark until analysis using a Shimadzu TOC-VCPN analyzer calibrated with potassium hydrogen phthalate in Milli-Q water. Results were consistently checked against low-carbon water and deep seawater reference water from the Certified Reference Material (CRM) from Hansell.

Salinity and Oxygen Isotopes: Salinity samples were collected in clean 125 mL clear HDPE bottles. Oxygen isotope ($\delta^{18}\text{O}$) samples were collected in 30 mL amber HDPE bottles or 5 mL clean cryovials, for water and sea ice samples, respectively. Samples were tightly sealed with electrical tape to avoid evaporation and stored at 4 °C in the dark until analysis. Salinity was determined with an Portasal (model 8410A) analyzer. The ratio of Oxygen-18 isotopes to Oxygen-16 isotopes ($\delta^{18}\text{O}$) was determined in a certified laboratory using an Isotope Ratio Mass Spectrometry (IRMS) technique and a Micromass Isoprime dual inlet Isotope Ratio Mass Spectrometer (Waters) according to the method described by Rosa et al. (2016). The method is also described in Pucko et al. (2023).

Community structure

Protist, bacteria and virus abundance by flow cytometry: The abundance of protist (picoeukaryotes: < 2 μm and nanoeukaryotes: 2–20 μm), free-living bacteria, virus and attached bacteria abundances were determined by flow cytometry. Duplicate 4 mL subsamples were fixed with 25% glutaraldehyde Grade I (0.1% final v/v concentration for photosynthetic eukaryote and free-living bacterial abundance and 0.5% final v/v concentration for viral abundance; Sigma-Aldrich G5882), stored and kept frozen at -80 °C until analysis by flow cytometry with a CytoFLEX Flow Cytometer (Beckman Coulter Inc.) following Belzile et al. 2008. For attached bacteria, duplicate 50 mL subsamples were filtered on 3 μm pore size Nuclepore membrane 25

mm diameter filters, placed in a 5 mL cryovial with 4mL of FSW, fixed and kept frozen at -80 °C until analysis.

Bacteria abundance by epifluorescence microscopy: Duplicate subsamples for bacteria enumeration were preserved with buffered formaldehyde (1% final concentration). The samples were kept in the dark until they were stained with 4, 6-diamidino-2-phenylindole (DAPI; 1 µg ml⁻¹ final concentration) and filtered onto 0.2 µm pore size black Nuclepore membrane filters following Sherr et al. 1993. Filters were mounted on a slide and kept at -80 °C until further analysis using epifluorescent microscopy.

Algal biomass

Size-fractionated chlorophyll *a*: Duplicate subsamples (25-250 mL) were filtered onto 25 mm Whatman GF/F filters and 5 µm Nuclepore membrane filters for determination total and >5 µm chl *a*, respectively. Fluorescence was measured at CFS Alert Laboratory using a Turner Designs 10-AU fluorometer after 24 to 36 h extraction in 10 ml of 90% acetone at 4°C in the dark, following Parsons et al. (1984). The fluorometer was calibrated prior to and upon return from the field expedition using pure *Anacystis nidulans* extract (Sigma).

Particulate Organic Carbon and Particulate Nitrogen: Subsamples for particulate organic carbon and particulate nitrogen (POC/PN) and stable isotope analyses were filtered onto pre-combusted 21 mm Whatman GF/F filters (450°C during 12 h), placed in acid-washed (12-24 h soak in 10% HCl) cryovials, immediately frozen and stored at -80 °C until analysis using a continuous-flow isotope ratio mass spectrometer (Thermo Electron Delta Advantage) in the continuous-flow mode (Thermo Electron ConFlo III) and an ECS 4010 Elemental Analyzer/ZeroBlank Autosampler (Costech Analytical Technologies). Blank filters were processed on each sampling day, then stored and analyzed as samples.

Diversity

DNA: Subsamples for DNA analysis were filtered onto sterile 47 mm 0.22 µm pore size cellulose (mixed cellulose ester) membrane filters, placed in sterile cryovials, immediately frozen and stored at -80°C until analysis.

Taxonomic Composition: Photosynthetic eukaryote abundance and taxonomic composition were determined on 250 mL subsamples from a water or pooled ice core sample, preserved with acidic Lugol's solution (final concentration of 0.4%; Parsons et al. 1984), and kept in the dark at 4 °C until analysis. An additional 250 mL water subsample was preserved with formaldehyde (final concentration of 0.4%), and kept in the dark at 4 °C until analysis. Identification was performed to the lowest taxonomic rank possible following the inverted microscope method (Lund et al., 1958). A minimum of 400 cells were counted.

Food web biomarkers

Fatty Acid: Subsamples for fatty acid analysis were filtered onto pre-combusted 47 mm Whatman GF/F filters (450°C for 12 h), placed in acid-washed (12-24 h soak in 10% HCl) cryovials,

immediately frozen and stored at -80°C until analysis. Blank filters were stored and analyzed as samples.

Primary production

Simulated In-Situ Primary Production: Stable isotope incubations were performed by filling three 500 mL clear polyethylene bottles with pooled ice samples of the mid and bottom ice horizons and by spiking each bottle with $^{15}\text{NO}_3$ solution (500 μM) and ^{13}C solution (20 g L^{-1}) to reach 10% of the *in situ* concentration. For every sample, one of the three bottles was filtered onto a 21 mm GF/F pre-combusted filter (450°C for 12 h) immediately after spiking. The other two samples were placed under their respective ice type using a mechanical arm (Fig. 4b). The samples were recovered after 24 h, kept in the dark until filtration onto 21 mm GF/F pre-combusted filters, typically within 1 h of sample recovery. All filters were frozen and stored at -80 °C until analysis. Transmitted PAR and PAR albedo were measured at the incubation sites immediately prior to and after the incubation period using a Li-Cor LI-1500 data logger, a LI-192 underwater PAR sensor and a LI-190 air cosine PAR sensor. PAR albedo was calculated as the ratio of upwelling to downwelling surface PAR. Transmitted PAR was calculated as the ratio of measured under-ice PAR to downwelling surface PAR.

Fast Repetition Rate Fluorometry: Algal community photosynthetic parameters and gross primary production estimates were determined on 2 mL subsamples using a FastOcean FRR (Fast Repetition Rate) fluorometer and the Act2Run software (Chelsea Technologies). After a minimum of 15 minutes acclimation in the dark, subsamples were exposed to irradiance from 0 to 2000 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ for 40 to 120 seconds, with three dark periods of 20 seconds. Total exposition lasted 21:40 minutes.

5.4 SEA ICE TEXTURE

We conducted cross-polarized texture analyses on six FYI cores and 18 MYI cores collected throughout the sampling period (see Table 1). Upon collection, complete FYI and MYI sea ice cores were bagged and brought back to a non-heated temporary shore laboratory. The cores were cut into 20 cm sections using a band saw whose blade was cleaned with ethanol and each section was further cut in half longitudinally to create two half cylinders. A thin (ca. 4 mm) slice of ice was cut from the flat side of one half cylinder for imaging in a cross-polarizing light box. The light box is composed of two perpendicular polarized filters and a 60 W incandescent light located at the bottom of the box. The box interior is designed to be completely opaque, thereby blocking any other source of light within the cross-polarizing compartment. A Nikon Z6 camera was primarily used to photograph each piece of ice, using a small opening at the top of the box. A Nikon D750 and a Panasonic DMC-FZ18 were also used on one occasion. The images were analyzed to identify and classify the ice into ice texture classes following Lange et al. (2015). Key features of the texture analyses included the identification of annual layers apparent by an abrupt shift in ice crystal structure.

5.5 SIMULATED *IN-SITU* EXPERIMENTS

Phytoplankton

This experiment was designed to evaluate the potential effect of leads on phytoplankton community structure and production. Surface water was collected on 5 April 2019, kept in a dark 20 L acid-washed carboys and brought back to the CFS Alert Laboratory within two hours of collection where it was prefiltered through a 350 μm Nitex mesh to remove large zooplankton grazers. Surface water subsamples were incubated in 500 mL bottles in a simulated *in-situ* incubator under two different light conditions simulating 1% and 50% surface irradiance using Lee filters. Temperature in the incubator was maintained between 2 and -2°C for the duration of the experiment, using a VWR 1156D circulating bath. Triplicate subsamples were randomly collected every second day throughout the experimental period of 12 days (Fig. 7), and further processed for a suite of analyses, namely: macro-nutrients (NO_2+NO_3 , PO_4 , $\text{Si}(\text{OH})_4$), DOC, bacterial, protists and viral abundance, total chl *a*, and photosynthetic parameters (Table 12). In addition, POC/PN, DNA, taxonomy and stable isotopes samples were collected at the beginning and end of the experiment. Salinity was measured throughout the duration of the experiment and $\delta^{18}\text{O}$ was measured at the beginning.

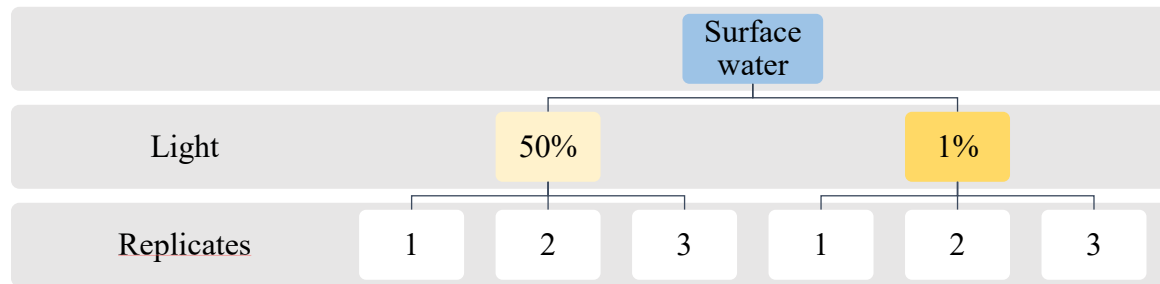


Figure 7. Schematic representation of phytoplankton experiments during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019.

Table 12. Overview of biochemical analyses and replication performed for phytoplankton experiment during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Number of replicates is shown for the different parameters and sampling times. DOC: Dissolved organic carbon, DN: Dissolved nitrogen, Sal: Salinity, $\delta^{18}\text{O}$: Ratio of Oxygen-18 isotope and Oxygen-16 isotope, FC: Flow cytometry, Chl *a* total: total chlorophyll *a*, POC: Particulate organic carbon, PN: Particulate nitrogen, FRRF: Fast Repetition Rate Fluorometry. Macro-nutrients are nitrate plus nitrite ($\text{NO}_3 + \text{NO}_2$), phosphate (PO_4) and silicate ($\text{Si}(\text{OH})_4$).

Analyses/Day	0 ¹	2	4	6	8	10	12
<u>Chemistry</u>							
Macro-nutrients	3x	3x	3x	3x	3x	3x	3x
DOC/DN	3x	3x	3x	3x	3x	3x	3x
Salinity	1x	1x ²	1x ²	1x ²	1x ²	1x ²	1x ²
$\delta^{18}\text{O}$	1x						
<u>Community structure</u>							
FC – Bacteria ³	3x	3x	3x	3x	3x	3x	3x
FC – Protists ³	3x	3x	3x	3x	3x	3x	3x
FC – Virus ³	3x	3x	3x	3x	3x	3x	3x
<u>Algal biomass</u>							
Chl <i>a</i> total	3x	3x	3x	3x	3x	3x	3x
POC/PN	1x						1x
<u>Diversity</u>							
DNA	2x						2x
Taxonomy	1x						1x
<u>Food web biomarkers</u>							
Stable isotopes	1x						1x
<u>Primary production</u>							
FRRF	1x	1x	1x	1x	1x	1x	1x

¹Analyses on pooled sample

²With hand-held salinometer

³Duplicate subsamples were collected for each of the three bottles

Nutrient enrichment

We investigated the response of the FYI and MYI sea ice algal communities to different macro-nutrient concentrations with two enrichment experiments. A total of 60 ice cores (30 FYI and 30 MYI) were extracted on 18 April and 14 May respectively, and used for the nutrient-enrichment experiments. The bottom 10 cm section of each core was cut and they were brought back to the CFS Alert laboratory in 7 L isothermal containers within two hours of collection. Bottom core sections were prepared with addition of surface FSW collected on the same day as core extraction in the same way as for the time-series and spatial distribution sampling (see Section 5.1). For each

ice type, the bottom core sections melted with addition of FSW were pooled, spiked for nutrient enrichment, and split into subsamples. Three nutrient enrichment treatments were used during this experiment, i.e., addition of nitrate (+N), of silicate (+Si) and of both nitrate and silicate (+N+Si), at final target concentrations of 12 μM for nitrate and 16.5 μM for silicate. These concentrations were determined based on nutrient concentrations measured at depth in the region during the MAP-Last Ice spring 2018 expedition.

FYI and MYI subsamples and controls without nutrient addition were incubated in 125 mL polycarbonate bottles in a temperature-controlled simulated *in-situ* incubator as described above. Controls, without addition of nutrients, was exposed to two different ice-appropriate light conditions ($2.24 \pm 0.96 \mu\text{mol photon m}^{-2} \text{s}^{-1}$; $20.81 \pm 2.60 \mu\text{mol photon m}^{-2} \text{s}^{-1}$), with the lower irradiance representative of the under-ice irradiance value at the time of sampling. Subsamples with nutrient enrichment were only incubated under the higher irradiance to avoid light limitation (Fig. 8). Triplicate subsamples and controls randomly collected every second day throughout the experimental period of 14 and 16 days, for FYI and MYI respectively, were processed for analysis of macro-nutrients (NO_3+NO_2 , PO_4 , $\text{Si}(\text{OH})_4$), DOC, abundance of bacteria, protists and viruses, total chl *a*, and photosynthetic parameters (see Table 13). Further analyses for POC/PN, DNA, taxonomy, stable isotopes, salinity were carried out prior to nutrient enrichment, at day 10 and at the end of the experiment. Delta (δ)¹⁸O was also measured prior to nutrient enrichment and at the end of the experiments.

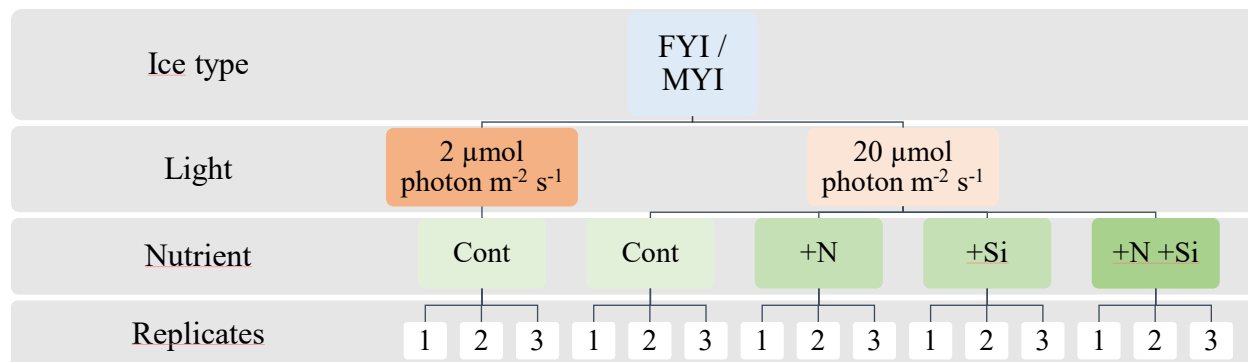


Figure 8. Schematic representation of nutrient enrichment experiments during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019.

Table 13. Overview of biochemical analyses and replication performed for first-year sea ice (FYI) and multi-year sea ice (MYI) experiments during the Multidisciplinary Arctic Program (MAP) – Last Ice field campaign, spring 2019. Number of replicates is shown for the different parameters and sampling times. DOC: Dissolved organic carbon, DN: Dissolved nitrogen, Sal: Salinity, $\delta^{18}\text{O}$: Ratio of Oxygen-18 isotope and Oxygen-16 isotope, FC: Flow cytometry, Chl *a* total: total chlorophyll *a*, POC: Particulate organic carbon, PN: Particulate nitrogen, FRRF: Fast Repetition Rate Fluorometry. Macro-nutrients are nitrate plus nitrite ($\text{NO}_3 + \text{NO}_2$), phosphate (PO_4) and silicate ($\text{Si}(\text{OH})_4$).

Analyses/Day	FYI								MYI							
	0	2	4	6	8	10	12	14	0	4	6	8	10	12	14	16
<u>Chemistry</u>																
Macro-nutrients	3x ¹	3x	3x	3x	3x	3x	3x	3x	3x ¹	3x	3x	3x	3x	3x	3x	3x
DOC/DN	3x ¹	3x	3x	3x	3x	3x	3x	3x	3x ¹	3x	3x	3x	3x	3x	3x	3x
Sal	1x					1x ⁴		1x ⁴	1x				1x ⁴			1x ⁴
$\delta^{18}\text{O}$	1x								1x							
<u>Community structure</u>																
FC – Bacteria ³	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x
FC – Protists ³	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x
FC – Virus ³	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x	3x
<u>Algal biomass</u>																
Chl <i>a</i> total	3x ²	3x	3x	3x	3x	3x	3x	3x	3x ²	3x	3x	3x	3x	3x	3x	3x
POC/PN	1x					1x		1x	1x				1x			1x
<u>Diversity</u>																
DNA	1x					1x		1x	1x				1x			1x
Taxonomy	1x					1x		1x	1x				1x			1x
<u>Food web biomarkers</u>																
Stable isotopes	1x					1x		1x	1x				1x			1x
<u>Primary production</u>																
FRRF	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x	1x

¹Analyses subsampled after nutrient addition, for each treatment

²Triplicate subsamples collected on the pool sample, before nutrient addition and one subsample collected on each nutrient treatment

³Duplicate subsamples were collected for each of the three bottles

⁴With hand-held salinometer

Sea ice DOM enrichment

This experiment follows from an earlier publication (Underwood et al., 2019) showing that FYI DOM addition to surface waters causes significant changes in under-ice bacterioplankton community abundance, production, and composition. Here, we tested the response of the under-ice bacterioplankton community to MYI DOM addition. Sea ice DOM from bottom and middle sections of MYI cores was isolated via filtration through pre-combusted 47 mm GF/F filters. Each DOM fraction was added to surface seawater collected at the field station on the day of the start of the experiment (3 May). The response of the surface water bacterioplankton community to the two sea ice DOM fractions was evaluated over a period of 10 days (240 h). The experimental set up included two experimental conditions with addition of sea ice DOM from the bottom or middle MYI horizon to surface water pre-filtered through 3 μm membranes, and three controls. Two controls tested for the addition of DOM in the absence of the surface water bacterioplankton community, and one control tested for surface water microbial communities with no addition of DOM. All experimental conditions and controls were performed in triplicate, in a temperature-controlled incubator connected to a VWR 1156D circulating bath. The incubator temperature, maintained at ca. -1.7°C , was continuously monitored during the duration of the experiment using HOBO TidbiT v2 temperature data loggers. To avoid osmotic shock effects, salinity of all samples was standardised by the addition of sterile saline. Triplicate samples were collected at 48-h interval over the 240 h experimental period. Upon collection, samples were immediately processed for the following series of analyses: dissolved organic nitrogen (DON) and dissolved organic carbon (DOC), macro-nutrients (NO_3+NO_2 , PO_4 , $\text{Si}(\text{OH})_4$), bacterial abundance (flow cytometry), bacterial community composition (genomics), phytoplankton community composition (nano- and micro-eukaryotes; flow cytometry), and salinity. All equipment used in this experiment was acid-washed and sterile gloves were worn at all times to prevent contamination during DOM fractionation and handling of samples.

6.0 LOGISTICAL OVERVIEW

Sea ice conditions around CFS Alert were safe and allowed for a successful field campaign in March, April and May, 2019. Multiple snowfalls during spring allowed the snowmobile trails from CFS Alert to our ice camp to remain in good conditions. Military operations at the base requiring multiple aircraft flights per day lead us to avoid using the airfield and use alternate snowmobile routes during the first three weeks of the expedition. Both routes (18.5 km compared to 14 km) were flagged to ensure safe travel. The longer route allowed us to come back from the ice camp even when an aircraft would be flying in/out and provided an alternate route in the event that the shorter route would become unusable. For safety considerations, we considered it mandatory to have an alternate route from the ice camp to the base promptly established and flagged upon camp setup.

The rough MYI topography offshore of CFS Alert was definitely a challenge when snowmobiling, limiting travel speed and therefore extending daily travel time, up to 45 minutes one-way to/from

the ice camp. Site selection for the FYI and MYI sampling areas is largely dependant on the spatial distribution and size of the floes. In 2019, the FYI and MYI sampling areas were ca. 700 m apart from each other requiring snowmobile usage to travel between sites, resulting in longer sampling time at MYI site. The distance was however manageable and, contingent upon research activities, we would recommend a distance of ca. 1 km or less between main sampling areas whenever possible.

A total of three weather days, 26 April, 6 and 17 May, prevented access to and operations on the ice during the expedition. These days were used to process texture cores, salinity samples and for data entry. One additional weather day, on 7 June, 2019 prevented the marine mammals aerial surveys to be conducted, but contingency was sufficient to have the survey completed within the allocated time.

Several species of wildlife, including lemmings, wolves and polar bears, were encountered at the ice camp or on the way to/from the ice camp. Lemmings were a minor concern as they could only potentially damage cables from instruments at the camp, which did not happen. Lemmings encountered at the ice camp were generally in poor physical condition. Wolves, in particular a couple with gestating female, were encountered at the ice camp or at spatial distribution sampling site on four occasions. Wolf tracks were also seen on many occasions around the camp upon arrival in the morning, indicating that these animals were visiting the ice camp during the night. No damage was observed. During the day, wolves stole personal equipment (gloves and back pack) to drop it further away; the equipment was successfully recovered by snowmobile. On one occasion, a wolf damaged a Toughbook field computer used to upload observation site data. The computer worked with some hiccups for the remainder of the expedition. Safety procedures in place were adequate for the prevention of dangerous encounters with wolves. In the field, when wolves approached the camp, our team calmly retreated to observe them safely from a distance and work resumed once the wolves had left the sampling site. No polar bears were encountered at camp. Polar bears were observed on four occasions during the snowmobile drive between the ice camp and CFS Alert. On each occasion, the polar bear(s) retreated quickly once becoming aware of the snowmobiles presence. Polar bear tracks were also observed along the snowmobile route at three occasions. Arctic fox tracks were observed once at the camp. The regular observations of “land-based” mammals at the ice camp is interesting from a scientific perspective as it reflects the importance of the land-sea ice continuum in Tuvaijuittuq.

The Department of National Defense (DND) provided outstanding support to the entire project, with tremendous support regarding accommodation, meals and aircraft operations. We received noticeable logistical support from the Defense Research and Development Canada (DRDC) personnel at the base and at the ice camp. Notably, DRDC provided remarkable support for snowmobile maintenance and repairs, arranging after-hour meals, drilling large sampling and mooring holes, setting up the Weatherhaven tents, and acting as main communication link between CFS Alert and science personnel at camp. During the field season, the MAP – Last Ice team reached a maximum of nine members, including eight science personnel and one DRDC employee.

A total of 11 science personnel and 3 DRDC employees joined the expedition. Snowmobile availability was not an issue during this expedition. However, cold conditions in the first days of the expedition created problems with some of the hauling snowmobiles, slowing equipment transfer to the camp. Communication with the base using a HF radio was generally smooth and efficient, except on a few occasions where multiple attempts were required to inform DRDC of our return to the base. Improvement of the radio system would facilitate a more reliable communication between the field camp and the base. Given the importance of reliable communication between the field camp and the base, perhaps this is an area for improvement.

Partners at ECCC also provided invaluable support for the project, including a variety of tasks at the ice camp, laboratory and sample storage space, and administrative aspects of life at CFS Alert.

7.0 ACKNOWLEDGEMENT

The Multidisciplinary Arctic Program (MAP) – Last Ice program would have not been possible without the strong support from northern communities and the direct support from the Resolute Bay Hunters and Trappers Association. Special thanks go to the Polar Continental Shelf Program (PCSP) and to the team in Resolute for their invaluable logistic support, including lodging, transportation to/from CFS Alert, and transportation of fuel to CFS Alert for MAP-Last Ice. The project would not have been possible without their outstanding logistical support and expertise. The support from Defense Research and Development Canada (DRDC) was invaluable to the realization of this field program and we extend special thanks to Chris Browne, Joel Higgins and Mike Simms. We also thank Environment and Climate Change Canada (ECCC) for essential logistical support before and during the expedition. We thank Kenn Borek Air Ltd and crew Kelsey, Hugh and Cody for the Twin Otter aircraft operation during the marine mammal aerial surveys. Last, but not least, we thank the Department of National Defense (DND) at CFS Alert and all CFS Alert personnel who contributed in various ways to the success of this sampling campaign, especially Major Peter Kleinschmidt, Alt. Commanding Officer (CO), Major Melany Lepage, Commanding Officer (CO) and Master Warrant Officer Andrew Sargent, Station Warrant Officer (SWO). This project was funded by Fisheries and Oceans Canada.

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APPENDIX. LOGBOOK – MAIN ACTIVITIES

Date	Time (local)	Activities
3/25/2019		Arrival at CFS Alert: S. Duerksen (DFO)
		Inventory of equipment
	16:00	Briefing by the Commanding Officer (CO) and Station Warrant Officer (SWO) on CFS Alert base operation
3/26/2019		Inventory of equipment
3/27/2019		Arrival at CFS Alert: B. Lange (DFO), J. Charette (DFO), P. Tremblay (DFO), R. Hussherr (DFO)
	16:00	Briefing by the Commanding Officer (CO) and Station Warrant Officer (SWO) on CFS Alert base operation
	19:00	Team meeting
3/28/2019	8:00	Familiarization tour of CFS Alert and completion of checklist
	9:00	Inventory of equipment
	13:00	CFS Alert laboratory and experiment setup : Installation
3/29/2019	9:30	Sea ice reconnaissance survey
	12:00	CFS Alert laboratory and experiment setup : Installation
3/30/2019	9:00	CFS Alert laboratory and experiment setup : Installation
	9:30	FYI site selection
	2:30	Trail flagging
3/31/2019	9:30	MYI site selection
	9:00	MiliQ unit : setup
	13:00	FRRF: setup
4/1/2019	9:15	Mobilization of equipment to the ice camp
	11:00	Site of tents and moorings: Selection of exact location
	11:30	Storage tent : Installation
	12:45	Mobilization of equipment to the ice camp
	16:30	Drilling sea ice: Field laboratory tent hole on FYI
4/2/2019	9:15	Mobilization of equipment to the ice camp
	10:45	Drilling sea ice: Field laboratory and ROV tent holes on FYI with hot water drill
	13:00	Mobilization of equipment to the ice camp
4/3/2019	9:00	Mobilization of equipment to the ice camp
	9:00	CFS Alert laboratory and experiment setup : Installation
	13:00	Texture core setup : Installation
4/4/2019	9:00	Mobilization of equipment to the ice camp
	10:30	Field Laboratory tent (Wheatherhaven): Installation
	18:00	Mobilization of equipment to the ice camp

4/5/2019	10:00	ROV tent (Wheatherhaven): Installation
	12:15	Phytoplankton experiment: Sampling
	16:30	Starting and sampling: Phyto experiment (T0)
4/6/2019	10:00	Field laboratory: Installation
	10:00	Drilling sea ice: incubation hole on MYI
	12:30	Drilling sea ice: AZFP and ROV holes on MYI
4/7/2019	9:00	Various work at CFS Alert laboratory
	13:00	Field laboratory : Installation (end)
	13:00	Snow History sensors: Programing
	18:00	ADCP: Deployment
	19:20	Sampling: Phyto experiment (T2)
4/8/2019	10:00	Snow History sensors: Deployment
	17:00	Drilling sea ice: FYI Incubation hole
4/9/2019	10:00	Meteorological station (MYI) and light sensor (FYI) : Installation
	19:20	Sampling: Phyto experiment (T4)
4/10/2019	9:00	Mobilization of equipment to the ice camp
	10:00	AZFP and moored CTDs: Preparation
	13:00	AZFP: Deployment
	18:30	Moored CTDs and microplastic sampler: Deployment
	19:50	Daily CTD profile
4/11/2019	10:15	Preparation for sampling
	10:42	Daily CTD profile
	14:49	Daily CTD profile
	19:00	Sampling: Phyto experiment (T6)
4/12/2019	10:15	Preparation for first day of ice sampling
	10:16	Daily CTD profile
	11:15	Coring: T1-FYI (10 cores)
	14:30	Coring: T1-MYI (10 cores)
4/13/2019	9:52	Daily CTD profile
	11:40	Sampling: Niskin bottles deployment for biochemical analyses of water column (T1 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	12:10	Processing: Water column
	14:55	Sampling: Zooplankton net tow for biochemical analyses (T1 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	18:02	Daily CTD profile
	19:15	Sampling: Phyto experiment (T8)
4/14/2019	12:48	Daily CTD profile
	13:40	Processing: Ice core (T1, May 12 th)
	16:11	Primary Production incubation FYI (T1): Start
	17:00	Primary Production incubation MYI (T1): Start
4/15/2019	9:00	Sediment trap: Preparation (drilling hole, hauling equipment)
	14:00	Sediment trap: Deployment

	16:15	Primary Production incubation FYI (T1): End
	16:34	Primary Production incubation MYI (T1): End
	16:48	Daily CTD profile
	19:25	Sampling: Phyto experiment (T10)
4/16/2019	10:00	Coring: T2-FYI (10 cores)
	10:04	Daily CTD profile
	12:45	Coring: T2-MYI (10 cores)
	14:45	Drone flight (FYI)
4/17/2019	9:56	Daily CTD profile
	11:05	Sampling: Niskin bottles deployment for biochemical analyses of water column (T2 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	12:55	Time lapse camera (FYI): Deployment
	13:30	Processing: Water column
	14:00	Sampling: Zooplankton net tow for biochemical analyses (T2 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	15:00	Drone flight (MYI)
	16:00	Snow thickness survey (FYI)
	16:43	Daily CTD profile
	19:30	Sampling: Phyto experiment (T12) - End of experiment
4/18/2019	9:34	Daily CTD profile
	11:00	Coring: FYI Experiment (30 cores)
	12:25	Primary Production incubation FYI (T2): Start
	13:35	Primary Production incubation MYI (T2): Start
	14:00	Processing: Ice core (T2, May 16 th)
		Departure from CFS Alert: B Lange (DFO)
4/19/2019	8:30	Preparation: FYI experiment
	12:18	Primary Production incubation FYI (T2): End
	13:38	Primary Production incubation MYI (T2): End
	14:30	ROV dive (1; UI)
	14:48	Daily CTD profile
	19:00	Starting and sampling: FYI experiment (T0)
4/20/2019	9:33	Daily CTD profile
	10:30	Coring: T3-FYI with vertical sampling (10 cores)
	13:45	Coring: T3-MYI with vertical sampling (10 cores)
	17:05	Daily CTD profile
4/21/2019	9:22	Daily CTD profile
	10:15	Sampling: Niskin bottles deployment for biochemical analyses of water column (T3 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	11:30	Processing: Water column
	12:30	Sampling: Zooplankton net tow for biochemical analyses (T3 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	13:00	ROV dive (2; UI)

	15:23	Daily CTD profile
	19:10	Sampling: FYI experiment (T2)
4/22/2019	9:45	Daily CTD profile
	10:30	Visit at the ice camp: Padre
	11:00	Processing: Ice core (T3, May 20th)
	13:31	Primary Production incubation FYI (T3): Start
	14:04	Primary Production incubation MYI (T3): Start
	15:35	Daily CTD profile
4/23/2019	9:35	Daily CTD profile
	10:30	Coring: S1 (9 cores)
	14:05	Primary Production incubation FYI (T3): End
	14:24	Primary Production incubation MYI (T3): End
	15:10	Daily CTD profile
	19:10	Sampling: FYI experiment (T4)
4/24/2019	9:33	Daily CTD profile
	10:00	Coring: T4-FYI (10 cores)
	12:55	Coring: T4-MYI (10 cores)
	15:51	Daily CTD profile
4/25/2019	9:03	Daily CTD profile
	9:45	Sampling: Niskin bottles deployment for biochemical analyses of water column (T4 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	10:20	Processing: Ice core (S1, April 23 rd)
	12:00	Processing: Water column
	12:50	Sampling: Zooplankton net tow for biochemical analyses (T4 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	15:48	Daily CTD profile
	16:15	ROV dive (1; UI)
	19:00	Sampling: FYI experiment (T6)
4/26/2019		Weather day – Could not access ice camp
	9:00	Data entry
	10:00	Texture core : T1 FYI
	10:30	Fire alarm practice at CFS Alert
4/27/2019	9:01	Daily CTD profile
	10:00	Processing: Ice core (T4, April 24 th)
	11:39	Primary Production incubation FYI (T4): Start
	12:06	Primary Production incubation MYI (T4): Start
	13:00	Visit at the ice camp: CO
	16:03	Daily CTD profile
	19:00	Sampling: FYI experiment (T8)
	19:30	Texture core : T1 MYI
4/28/2019	8:52	Daily CTD profile
	9:10	Coring: T5-FYI with vertical sampling (10 cores)

	N/A	Sampling: Niskin bottles deployment for mercury analyses of water column (7; 1, 2, 5, 10, 50, 100, 140 m)
	11:20	Primary Production incubation FYI (T4): End
	12:05	Coring: T5-MYI with vertical sampling (10 cores)
	13:05	Primary Production incubation MYI (T4): End
	15:43	Daily CTD profile
	19:30	Texture core : T2 MYI
4/29/2019	9:06	Daily CTD profile
	9:35	Sampling: Niskin bottles deployment for biochemical analyses of water column (T5 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	10:45	Drone flight (FYI)
	11:30	Processing: Water column
	12:03	Sampling: Zooplankton net tow for biochemical analyses (T5 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	13:15	Drone flight (MYI-FYI)
	15:10	Daily CTD profile
	19:10	Sampling: FYI experiment (T10)
4/30/2019	9:03	Daily CTD profile
	10:00	Processing: Ice core (T5, April 28th)
	11:58	ROV dive (1; UI)
	N/A	Sampling: Niskin bottles deployment for mercury analyses of water column (10; 2, 3, 5, 10, 15, 50, 100, 120, 130, 140 m)
	13:34	Primary Production incubation FYI (T5): Start
	14:10	Primary Production incubation MYI (T5): Start
	14:27	Time lapse camera (MYI): Deployment
	N/A	Sampling: Zooplankton net tow for mercury analyses (4; 100-0)
	16:38	Daily CTD profile
	Arrival at CFS Alert: C. Michel (DFO), P. Coupel (DFO)	
5/1/2019	9:16	Daily CTD profile
	10:00	Coring: DOM Experiment (25 cores, MYI)
	13:20	Primary Production incubation FYI (T5): End
	14:00	Drone flight (FYI)
	14:10	Primary Production incubation MYI (T5): End
	16:14	Daily CTD profile
	20:00	Sampling: FYI experiment (T12)
	Arrival at CFS Alert: C. Duffaud (DFO), C. Carlyle (DFO), G. Underwood (University of Essex), J. Ingram (DRDC)	
	Departure from CFS Alert: R. Hussherr (DFO), C. Brown (DRDC)	
5/2/2019	9:29	Daily CTD profile
	9:50	Coring: T6-FYI (10 cores)
	12:45	Coring: T6-MYI (10 cores)
	15:31	Daily CTD profile
	19:00	DOM Experiment: preparation

	19:30	Texture core: T3 MYI
5/3/2019	9:17	Daily CTD profile
	9:40	Sampling: Niskin bottles deployment for biochemical analyses of water column (T6 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	12:30	Processing: Water column
	12:37	Sampling: Zooplankton net tow for biochemical analyses (T6 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	15:34	Daily CTD profile
	19:00	Sampling: FYI experiment (T14) - End of experiment
	20:00	Starting and sampling: DOM experiment (T0)
5/4/2019	9:22	Daily CTD profile
	12:15	Processing: Ice core (T6, May 4th)
	12:20	Primary Production incubation FYI (T6): Start
	12:55	Primary Production incubation MYI (T6): Start
	13:00	Coring: Mercury core
	15:45	Scouting for spatial sampling
	15:51	Daily CTD profile
	19:45	Texture core: T4 MYI
5/5/2019	8:59	Daily CTD profile
	9:50	Coring: S2 (9 cores)
	10:00	Snow thickness survey (S2)
	12:27	Primary Production incubation FYI (T6): End
	12:54	Primary Production incubation MYI (T6): End
	N/A	Sampling: Niskin bottles deployment for mercury analyses of water column (8; 2, 3, 5, 10, 50, 100, 120, 140 m)
	13:56	Coring: S3 (9 cores)
	N/A	Sampling: Zooplankton net tow for mercury analyses (5; 100-0)
	16:12	Daily CTD profile
	19:30	Texture core: T5 MYI
5/6/2019		Sampling: DOM experiment (T1)
		Weather day – Could not access ice camp
	9:30	Data entry
	10:00	Texture core: S1
	13:00	Texture core: T6 MYI
5/7/2019	9:31	Daily CTD profile
	9:45	Coring: T7-FYI with vertical sampling (10 cores)
	12:55	Coring: T7-MYI with vertical sampling (10 cores)
	14:30	ROV dive (1; sea floor)
	14:41	Daily CTD profile
5/8/2019		Sampling: DOM experiment (T2)
	9:29	Daily CTD profile
	10:10	Sampling: Niskin bottles deployment for biochemical analyses of water column (T7 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)

	11:30	Processing: Ice core (S2, S3, May 5 th)
	11:40	Sampling: Zooplankton net tow for biochemical analyses (T7 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	12:45	UAV flight (2; FYI, S2)
	12:50	ROV dive (1; sea floor)
	13:00	Processing: Water column
	13:25	Snow thickness survey (S3)
	16:56	Daily CTD profile
		Departure from CFS Alert: C. Michel (DFO)
5/9/2019	9:23	Daily CTD profile
	11:20	UAV flight (1;FYI)
	12:30	Primary Production incubation FYI (T7): Start
	13:00	Primary Production incubation MYI (T7): Start
	13:20	Processing: Ice core (T7, May 7 th)
	13:45	ROV dive (2; UI, sea floor)
	16:11	Daily CTD profile
		Sampling: DOM experiment
		Arrival at CFS Alert: S. Atchison (DFO)
5/10/2019	9:28	Daily CTD profile
	10:30	Coring: S4 (9 cores)
	10:45	Snow thickness survey (S4)
	13:00	Primary Production incubation FYI (T7): End
	13:20	Primary Production incubation MYI (T7): End
	13:50	Coring: S5 (9 cores)
	14:00	Snow thickness survey (S5)
	16:14	Daily CTD profile
	19:30	Texture core: S5
5/11/2019	8:56	Daily CTD profile
	9:05	Coring: T8-FYI (11 cores)
	N/A	Sampling: Niskin bottles deployment for mercury analyses of water column (8; 2, 3, 5, 10, 50, 100, 120, 140 m)
	12:45	Coring: T8-MYI (11 cores)
	13:05	Snow thickness survey (Scouting for MYI experiment sampling site)
	N/A	Sampling: Zooplankton net tow for mercury analyses (5; 100-0)
	14:00	ROV dive (1; UI; MYI)
	14:26	Daily CTD profile
	15:00	UAV flight (1; FYI)
	15:45	Fishing: Crab traps (MYI), trammel net (FYI) : In
	16:45	Fishing: Trammel net (FYI): Out
	19:00	Texture core: T7 MYI, T8 MYI
		Sampling: DOM experiment (T4)
5/12/2019	9:19	Daily CTD profile

	9:35	Processing: Ice core (S2, S3, May 5 th)
	9:50	Sampling: Niskin bottles deployment for biochemical analyses of water column (T8 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	N/A	Fishing: Crab traps (MYI) : Out
	11:15	Sampling: Zooplankton net tow for biochemical analyses (T8 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	11:30	Processing: Water column
	15:10	Fishing: Crab traps (FYI) : In
	17:00	Daily CTD profile
	19:30	Texture core: S2, S3
5/13/2019	9:10	Daily CTD profile
	9:36	Fishing: Crab traps (FYI) : Out
	9:50	Processing: Ice core (T8, May 11 th)
	12:18	Fishing: Crab traps (MYI): In
	12:20	Primary Production incubation FYI (T8): Start
	12:32	Primary Production incubation MYI (T8): Start
	14:10	ROV dive (1; Sea floor)
	15:57	Daily CTD profile
	16:45	Fishing: Trammel net (FYI) : In
		Sampling: DOM experiment (T5) - End of experiment
5/14/2019	9:07	Daily CTD profile
	9:30	Fishing: Trammel net (FYI) : Out/In
	10:00	Coring: MYI Experiment (30 cores)
	11:56	Fishing: Crab traps (MYI): Out/In
	13:45	Primary Production incubation FYI (T8): End
	13:30	Daily CTD profile
	14:15	Primary Production incubation MYI (T8): End
	19:00	Texture core: S4
5/15/2019	9:30	Daily CTD profile
	9:45	Coring: T9-FYI with vertical sampling (11 cores)
	9:54	Fishing: Trammel net (FYI) : Out/In
	12:20	Coring: T9-MYI with vertical sampling (11 cores)
	12:35	Fishing: Crab traps (MYI): Out
	13:19	Fishing: Minnow traps (MYI): In
	15:07	Daily CTD profile
		Departure from CFS Alert: G. Underwood (University of Essex)
5/16/2019	9:21	Daily CTD profile
	9:35	Processing: Ice core (S2, S3, May 5 th)
	9:50	Sampling: Niskin bottles deployment for biochemical analyses of water column (T9 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	9:52	Fishing: Trammel net (FYI) : Out/In
	11:05	Processing: Water column

	11:10	Sampling: Zooplankton net tow for biochemical analyses (T9 Zoo; 2; 135-50, 50-0)
	12:23	Daily CTD profile
	15:30	Texture core: T3 FYI, T9 MYI
	19:00	Starting and sampling: MYI experiment (T0)
5/17/2019		Weather day – Could not access ice camp
	10:50	ROV dive (1; Sea floor)
	13:00	Texture core: T5 FYI, T7 FYI
	14:30	Data entry
5/18/2019	9:34	Daily CTD profile
	10:07	Fishing: Trammel net (FYI) : Out
	10:52	Sampling: Zooplankton net tow for biochemical analyses (T9 Zoo; 2; 135-0)
	11:35	Fishing: Minnow trap (MYI): Out
	12:12	Fishing: Crab traps (MYI): In
	12:45	Processing: Ice core (T9, May 15th)
	14:00	Primary Production incubation FYI (T9): Start
	14:05	Primary Production incubation MYI (T9): Start
	14:10	ROV dive (1; Sea floor)
	15:06	Daily CTD profile
	16:15	Fishing: Crab traps (FYI): In
5/19/2019	9:34	Daily CTD profile
	10:00	Coring: T10-FYI (11 cores)
	N/A	Fishing: Crab traps (FYI) : Out
	12:15	Coring: T10-MYI (11 cores)
	N/A	Sampling: Zooplankton net tow for mercury analyses (5; 100-0)
	14:00	Primary Production incubation FYI (T9): End
	14:05	Primary Production incubation MYI (T9): End
	14:26	Fishing: Trammel nets (FYI): In
	14:42	Daily CTD profile
	19:30	Texture core: T9 FYI
5/20/2019	9:24	Daily CTD profile
	9:30	Fishing: Trammel nets (FYI) : Out
	10:00	Sampling: Niskin bottles deployment for biochemical analyses of water column (T10 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	11:19	Sampling: Zooplankton net tow for biochemical analyses (T10 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	12:20	Processing: Water column
	15:20	Daily CTD profile
	19:10	Sampling: MYI experiment (T4)
	19:30	Texture core: T10 MYI
5/21/2019	9:24	Daily CTD profile
	10:00	Drone flight (MYI-FYI, FYI)

	10:25	Fishing: Crab traps (MYI) : Out
	11:00	Visit of the SWO
	11:30	ROV dive (1; UI)
	12:08	Primary Production incubation FYI (T10): Start
	12:40	Primary Production incubation MYI (T10): Start
	13:00	Processing: Ice core (T10, May 19th)
	13:30	Snow thickness survey (FYI)
	15:01	Daily CTD profile
5/22/2019	9:15	Daily CTD profile
	10:20	Coring: S6 (9 cores)
	10:30	Snow thickness survey (S6)
	12:16	Primary Production incubation FYI (T10): End
	12:40	Primary Production incubation MYI (T10): End
	14:00	ROV dive (2; UI, sea floor)
	15:25	Drone flight (S6)
	16:05	Daily CTD profile
	19:00	Sampling: MYI experiment (T6)
		Departure from CFS Alert: S. Atchison (DFO)
5/23/2019	9:10	Daily CTD profile
	9:20	Coring: T11-FYI with vertical sampling (11 cores)
	11:45	Coring: T11-MYI with vertical sampling (11 cores)
	14:50	ROV dive (1; UI)
	13:55	Daily CTD profile
5/24/2019	8:59	Daily CTD profile
	9:40	Sampling: Niskin bottles deployment for biochemical analyses of water column (T11 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	10:51	Sampling: Zooplankton net tow for biochemical analyses (T11 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	11:00	Processing: Water column
	14:09	ROV dive (1; UI and sea floor)
	14:57	Daily CTD profile
	19:00	Sampling: MYI experiment (T8)
5/25/2019	9:23	Daily CTD profile
	11:30	Processing: Ice core (T11, May 23rd)
	12:05	Primary Production incubation FYI (T11): Start
	12:17	Primary Production incubation MYI (T11): Start
	14:35	ROV dive (1; UI)
	15:51	Daily CTD profile
	19:30	Texture core: S6
5/26/2019	9:34	Daily CTD profile
	10:30	ROV dive (3; UI, sea floor, UI tandem)
	11:00	Time lapse camera (FYI): Recovery

	12:05	Primary Production incubation FYI (T11): End
	12:20	Primary Production incubation MYI (T11): End
	13:35	Drone flight (S2, FYI, FYI-MYI)
	14:19	Daily CTD profile
	14:45	Snow thickness survey (FYI)
	15:00	Visit of the CO, SWO and Bell Hop
	19:10	Sampling: MYI experiment (T10)
	19:30	Texture core: T11 MYI
5/27/2019	9:14	Daily CTD profile
	9:20	Coring: T12-FYI (10 cores)
	11:10	Coring: T12-MYI (11 cores)
	13:05	Drone flight (FYI-MYI)
	13:15	Daily CTD profile: Beginning of the hourly cast over 24 hours
	15:00	Snow History sensor (FYI): Recovery
	19:30	Texture core: T11 FYI
5/28/2019	9:30	Sampling: Niskin bottles deployment for biochemical analyses of water column (T12 WC; 10; 4 x 2, 10, 25, 50 x 2, 100, 140 m)
	10:00	Snow History sensor (MYI): Recovery
	10:30	Time lapse camera (MYI): Recovery
	10:58	Sampling: Zooplankton net tow for biochemical analyses (T12 Zoo; 4; 135-0 x 2, 135-50, 50-0)
	11:00	Processing: Water column
	14:09	ROV dive (2; UI;MYI, sea floor)
	15:48	Daily CTD profile
	20:00	Sampling: MYI experiment (T12)
5/29/2019	9:28	Daily CTD profile
	10:00	Drone flight (FYI-MYI)
	12:26	Primary Production incubation FYI (T12): Start
	12:45	Primary Production incubation MYI (T12): Start
	13:45	Processing: Ice core (T12, May 27th)
	15:58	Daily CTD profile
	19:30	Texture core: S6
		Arrival at CFS Alert: C. Brown (DRDC)
		Departure from CFS Alert: P. Coupel (DFO), C. Duffaud (DFO)
5/30/2019	9:55	Daily CTD profile
	10:00	Demobilization: Ice camp
	12:41	Primary Production incubation FYI (T12): End
	13:00	AZFP: Recovery
	13:05	Primary Production incubation MYI (T12): End
	14:19	Daily CTD profile
	16:00	Meteorological station (MYI) : Recovery
	19:00	Sampling: MYI experiment (T14)

5/31/2019	9:30	Demobilization: Ice camp
	12:02	Light sensor (FYI), : Recovery
	13:11	Moored CTDs and microplastic sampler: Recovery
	14:30	ADCP: Recovery
6/1/2019	9:30	Demobilization: Ice camp
	18:30	Sampling: MYI experiment (T16) - End of experiment
6/2/2019		Inventory and packing
6/3/2019		Inventory and packing
6/4/2019		Inventory and packing
6/5/2019		Inventory and packing
		Arrival at CFS Alert: U. Amarualik (DFO), M. Galicia (DFO), plane crew
6/6/2019		Inventory and packing
	9:30	Texture core: T12 MYI
	14:30	Aerial survey: 4 lines (AL01-AL04)
		Data entry and exploration
6/7/2019		Weather day – Could not fly
		Inventory and packing
		Data entry and exploration
6/8/2019	9:15	Aerial survey: 17 lines (AL05-AL21)
		Data exploration
6/9/2019	8:15	Aerial survey: 12 lines (AL22-AL33)
		Data exploration
6/10/2019	8:30	Aerial survey: 12 lines (AL 34-AL45)
		Data exploration
6/11/2019	10:00	Aerial survey: 5 lines (AL46-AL50)
6/12/2019	9:45	Aerial survey: 1 line (AL51)
		Departure from CFS Alert: J. Charette (DFO), S. Duerksen (DFO), P. Tremblay (DFO), C. Brown (DRDC), J. Ingram (DRDC)
		Departure from CFS Alert: U. Amarualik (DFO), C. Carlyle (DFO), M. Galicia (DFO), plane crew