Cambridge Bay 2022

BREATHE Field Report

In collaboration with ECV-Ice & BEPSII

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OUTLINE

SECTION 1 – SUMMARY OF PARTICIPANTS & INTRODUCTION

Table 1. Summary of participants, affiliations, and responsibilities during the field campaign

Field Personnel	Position	Affiliation	Field Responsibilities
Karley Campbell	BREATHE project lead; Associate Professor	UiT	-Sensor deployments -Biogeochemical analyses
Janina Osanen	MSc student	UiT	-Radiative transfer -Filtration
Rosalie McKay	PhD Student	UiT	-Laboratory incubations
Fowsia Ahmed	PhD Student	UM	-sea ice chl *a* fluorescence
Bruno Delille	Professor	University of Liege	-*In situ* incubations -CO_2 team
Odile Crabeck	Researcher	University of Liege	-Winkler oxygen -In situ incubations -CO_2 team
Sophia Muller	PhD Student	University of Liege Max Plank Institute	-Stable isotopes of nutrients
Brent Else	Campaign Lead	University of Calgary	-Underwater eddy covariance
Nicole Johnson	BSc Student	University of Calgary	-CO_2 team
Kyle Simpson	Researcher	Department Fisheries & Oceans Canada	-Peepers / CO_2 team
Diaki Nomura	Professor	University of Hokaido	-CO_2 team -CTD casts
Manami Tozawa	MSc Student	University of Hokaido	-genetic analysis
Taichi	MSc student	University of Hokaido	-CO_2 team
Naoya Kanna	Associate Professor	University of Tokyo	-CTD -trace metals

The sea ice campaign took place between 27 April and 4 June, 2022. Researchers were based at the Canadian High Arctic Research Station (CHARS) and visited the sea ice approximately every other day. Two locations were chosen for deployment of biogeochemical sensors due to their contrasting sub-ice turbulence regimes (*see* Dalman et al. 2019), and they were routinely visited throughout the campaign for collection of samples. The sites are referred to as Poly 1 and R2.

Site Poly 1 – 68.99°N 105.84°W– high turbulence regime

Site R2 – 69.02°N 105.36°W – low turbulence regime

A total of seven sample cycles were completed during the campaign, with a given sample cycle lasting four days and comprising of the following:

Table 2. Example activities on a sample cycle

Day 1	Poly 1 site visit Poly 1 processing of water column
Day 2	Poly 1 sample processing
Day 3	R2 site visit R2 processing of water column
Day 4	R2 sample processing

Sample cycles are labeled as *CBX 2022*. During the campaign there was one storm day on 23 June where sampling/processing was not completed.

The campaign summarised in this report focuses on objectives of the RCN-BREATHE project and primary production inter-comparison of the SCOR working group ECV-Ice. Here, the nutrient regimes of two contrasting locations of sub-ice turbulence were characterised, as was the resultant impact on sea ice biogeochemistry. Within ECV-Ice, BREATHE project members completed measurements of production using oxygen optodes and winkler titration as a contribution to the method inter-comparison. Other methods of incubation facilitated by Bruno Delille include: *in situ* stable isotope (with and without the addition of seawater), POC accumulation, and O_2-Argon.

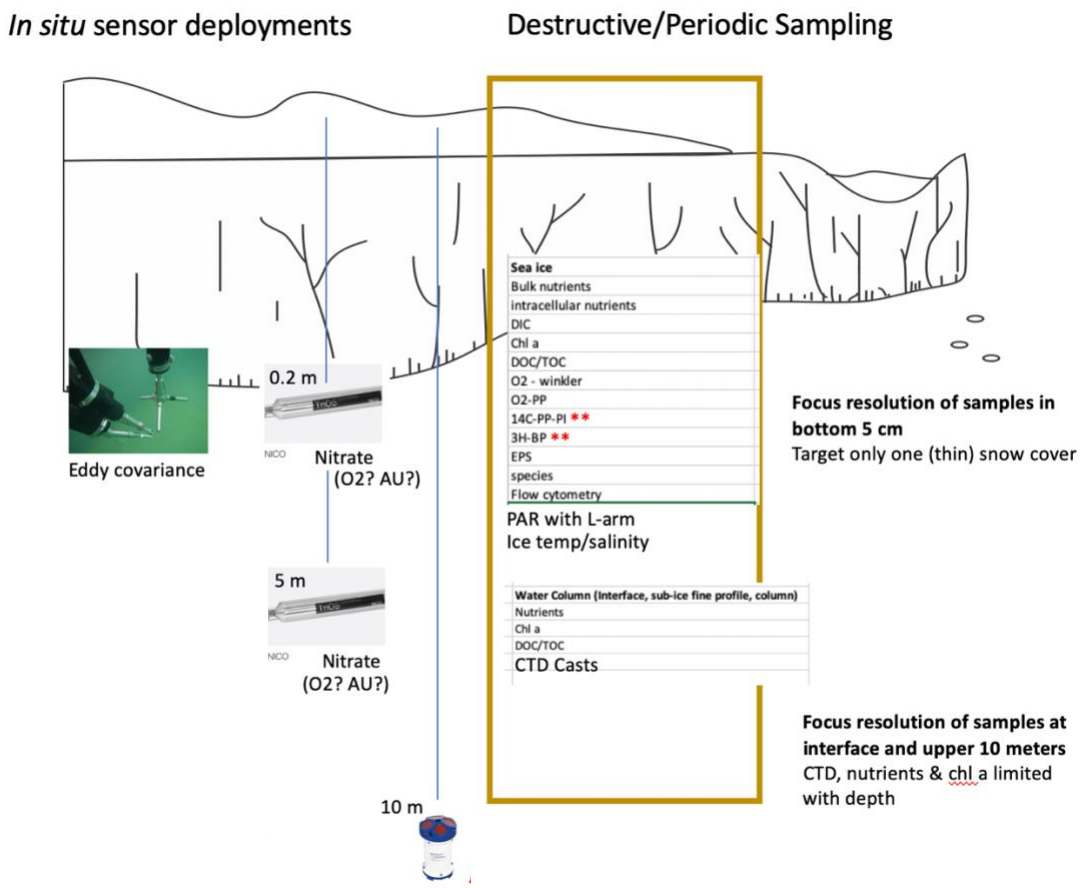

Figure 1 Summary of instrument deployments and planned sampling – completed at each of the two stations. See Section 2 for additional information on deployed sensors and Section 4 for information on destructive sampling.

SECTION 2 – INSTRUMENT DEPLOYMENTS

Table 3 Summary of sensors deployed (i.e. installed to log data) at each of the sampling locations. See also Figure 1 schematic.

Sample Site	Instrument	Description	Date of Deployment & Recovery	Comments
Poly 1	Aquadop (UM)	Nortek 600khz Z-cell 10 m below interface facing upwards	1 May @ 13:00 / 28 May (unknown time; afternoon)	35 kg weight used on tether
	Underwater Eddy covariance (UC)	Nortek Vektor & Rockland Microsquid	11 -29 May	
	OPUS Nitrate (UiT)	Two sensors; 20 cm (04922 7372) 5 m (049 22 7376)	30 April / 28 May	
	HOBO PAR (UiT & NPI)	Three sensors; interface (213 498 82) 1 m depth (104 73169) 1 m above snow surface (213 498 77)	30 April @ 16:00 / 28 May (unknown time in afternoon)	Bear attacks at station killed surface HOBO early-on in fieldwork
R2	Aquadop Z-cell (UM)	Nortek 600khz Z-cell 10 m below interface facing upwards	1 May @ 14:30 / 1 June (unknown time in morning)	20 kg weight used on tether
	Underwater Eddy covariance (UC)	Nortek Vektor & Rockland Microsquid	9-30 May	Issues throughout fieldwork with battery supply
	OPUS Nitrate (UiT)	Two sensors; 20 cm (049 22 7374) 5 m (049 22 7375)	1 May / 30 May	20 cm sensor cable cut during recovery; last download not made
	HOBO PAR (UiT & NPOI)	Three sensors; interface (21349883) 1 m depth (10608018) 1 m above snow surface (21349878)	1 May @ 16:15 / 1 June (unknown time in morning)	

All data are saved onto K Campbell rugged external drive (orange). Exceptions include the eddy covariance backed up by Brent Else and optode data backed up by Rosalie McKay.

Aquadop. instruments were programmed for profile interval of 60s, 15 cells, cell sizes of 1 and z-cell of 0.5. A trial was made on April 30th @ Poly 1 to assess functionality of the instrument. Data were successfully retrieved after deployment onto B Else Panasonic.

Underwater eddy covariance. All oxygen electrodes were damaged at the time of instrument recovery. The system at R2 was also not functional (except the microsquid) for a majority of the field season due to issues with powering the system. The most consistent data were taken within the last 10 days of sampling.

Nitrate. Sensors were downloaded during every site visit. Problems with sensor logging occurred due to the strong draw of G2 interface boxes on car battery powering them. As a result, it is expected that there are periods of no data. The 20 cm sensor at R2 was especially problematic as the routine loss of power wiped the operation file. This was successfully reloaded on 17 May. The same sensor was severed during recovery and thus CB7 data were not recovered. All other sensors were downloaded as one file prior to shipping. *Throughout the field season all sensors logged absorption but did not calculate nitrate concentrations.*

PAR. A light tether was deployed for each site. It consisted of three HOBO sensors attached to rope-chain, logging surface temperature and integrated PAR. HOBO data were downloaded following recovery. Approximately three snow depths around the tether were recorded during site visits, with the exception of CB7.

CTD. Casts to 50 m depth were done by team Japan. These largely took place at the same time as coring and water sample collection.

SECTION 3 – SAMPLE COLLECTION & ANALYSES

Light. Upon selection of the sample site each field day, two 10" auger holes were drilled for PAR measurement. The first hole was the site of coring following light measurements, while the 2nd hole was kept undisturbed for continuous light measurements throughout daily sampling. The LICOR data logger was used to measure the upwelling (2π), downwelling (2π) and under ice (4π) PAR, while hyperspectral irradiance measurements were simultaneously taken. Spectral irradiance measurements (W m^{-2} nm^{-1}) were taken with a Ramses TRIOS ACC spectral radiometer (Trios GmbH, Rastede, Germany) with a cosine receptor with a wavelength range from 350 to 920 nm and a resolution of 3.3 nm.

The under ice (4π) PAR and hyperspectral sensor were mounted on an under-ice arm, which allowed the sensors to be pivoted in an upright position directly below the ice, approximately one meter from the auger hole. The measurements were taken towards the sun to minimise the effect of the auger hole. At the coring site, five measurements were taken for under ice PAR, while approximately four hyperspectral measurements were logged. The under-ice arm was then moved to the undisturbed auger hole, where the hyperspectral sensor was left to log every 2 min for the duration of sampling (approximately 1,5 h).

Time of day and weather conditions were documented during all light measurements.

SEA ICE CORES.

BREATHE pooled cores. The top, mid and bottom 5 cm section of three cores were combined at Poly 1 and R2 for the respective pooled samples. The middle section was determined by dividing the total thickness by 2 and selecting the centre 5 cm. At R2, five cores were taken for the pooled bottom sample to provide sufficient volume for *in situ* incubations of the ECV-ice inter-comparison.

Core sections were transported in cooler jugs to CHARS and diluted by 3x their volume (bottom 5 cm) or by estimating the brine channel salinity and calculating an approximate dilution using laboratory brine (filtered dissolved Giant Value or Sifto Brand table salt in milliQ water, no nutrients were added). Salinity for the bottom dilutions were measured in the lab with a portable salinity meter. The salinity of the mid and top sections were outside the range of the instrument and samples were stored in the fridge for analysis at UiT.

Samples of the bottom sections were taken for taxonomy, chl *a*, POC/N, nutrients, EPS, HPLC, flow cytometry (algal, bacterial and viral), DOC, DIC and Winkler oxygen (Table 4). The top and mid sections BREATHE cores were subsampled for taxonomy, chl *a*, POC/N, algal/bacterial flow cytometry. Samples (50 ml) were added to 1 ml concentrated F2 in incubation flasks for the top, mid and bottom sections of Poly 1 and R2 for potential culturing in UiT laboratories.

Salinity for the brine in the mid and upper sea ice sections was estimated using the following equations:

$S_{brine} = \frac{1000}{(1-\frac{54.11}{T_{ice}})}$ with T in °C for T > -8.2°C

$S_{brine} = \frac{(62.3 - 10.31 \bullet T_{ice})}{(1.0624 - 0.01031 \bullet T_{ice})}$ with T in °C for T < -8.2°C

Then brine was added to approximate salinity according to:

$$C_{dilution} = \frac{C_1 V_1 + C_2 V_2}{V_1 + V_2}$$

Table 4 Summary of parameters sampled on sea ice core samples, the chemicals used in their preservation or analysis, and the means of sample storage. Sea ice samples are designated as either bottom 5 cm pooled ice (B5), mid (M5) or top 5 cm (T5) diluted melt ice, scrape (SCR), or vacuum sealed bag (V). The number of replicates is indicated by "#" and S (singlet), D (duplicate) or T (triplicate).

Nutrients/O_2/DIC/flow cytometry. Three cores were collected for these analyses. The bottom 10 cm was sectioned at 2.5 cm resolution before vacuum sealing on-site with Cabellas brand plastic bags. Following melt, subsamples were taken for nutrients, DIC, O2, Flow cytometry

Variable	#	Filter	Container	Sample	Storage
chl *a*	D	GF/F [25mm]	Scintillation vials; 10 ml **90% acetone**	B5/M5/T5/SCR	4°C; dark
HPLC	S	GF/F [25 mm]	Foil pocket [label before put filter in]	B5	-80°C
Nutrients (Extra)	D	**Burnt** GF/F [25mm]; Swinnex	15 ml Falcon tube; Parafilm	V/B5/M5/T	-20°C
Nutrients (Intra)	D + B	**Burnt** GF/F [25mm]; Hot milliq	Collect in 50 ml Falcon tube; decant to 15 ml Falcon tube; Parafilm	SCR	-20°C
DOC/N	D	**Burnt** GF/F [25mm]; Swinnex	30 ml amber vial, 1 cm below top; **250 µl 2N HCl**; Parafilm	V	4°C; dark
POC/N	S + B	**Burnt** GF/F [25mm];	Burnt oil pocket [label before put filter in]	B5/M5/T5	-20°C
DIC	D	None	Exetainer; **20 µl $HgCl_2$**	V	4°C; dark
EPS	S	0.4 µm Polycarbonate [25mm];	Foil pocket [label before put filter in]	B5/M5/T5	-20°C
Taxa	S	None; 60 ml syringe	60 ml amber bottle; **240 µl**	B5/M5/T5	4°C; dark
FC	D or T	none	Cryovial & **25% Gluteraldehyde** x2 2**0 µl** x1 **100 µl** (virus)	B5/M5/T5 (x2) V (x3)	-80°C
Winkler	T	None	Exetainer; **20 µl $HgCl_2$**	V	4°C; dark

(algal, bacterial and viral; viral samples not taken for mid or top sections) and winkler-based oxygen. Samples of these sections were also provided to Sofia Muller for stable isotopic

analysis. The pre-determined mid and upper sections (see BREATHE cores above) of one core was also placed into whirlpack bags for undiluted melt and determination of upper column nutrients.

Subsamples for O_2 and DIC were taken using exetainers, in duplicate for DIC and in triplicate for O_2. Samples were spiked with 20 ul $HgCl_2$ and stored at room temperature (in darkness) prior to transport (DIC to UC for analysis) or measurement (winkler O_2 completed at CHARS).

Subsamples for flow cytometry were taken in triplicate within 5 ml cryovials. A more concentrated spike of glutaraldehyde was used in vials designated for viral analysis (Table 4).

Temperature/salinity core. At each coring sample site, a temperature/salinity core was taken approximately between 12:00-13:00 local time. The temperature was measured at the top of the core, then 5cm, 15cm, 25cm and so on from the top section of the core. The core was then sectioned in to 10cm segments and stored in numbered boxes. Once the top portion of the core was processed, the bottom section would be removed from the ice and the temperature taken from the bottom, then 2.5cm, 5cm, 7.5cm, 10cm, 15cm, 20cm, 25cm, 35cm, 45cm and so on. The bottom 10cm were then sectioned at 2.5cm resolution, then 5cm resolution from 10 to 30cm, then 10cm resolution from 30cm onwards and stored in numbered boxes. Following melt, salinities were recorded using the portable salinity meter.

Intracellular nutrient scrape. Taken as the last core, approximately 1 cm of the bottom ice was removed using a stainless-steel knife directly into a Nalgene containing 1L filtered sea water. Upon return to CHARS, this sample was used to measure intracellular nutrients and chl *a*.

Chl *a* core. A full core was taken for chl *a* measurement once for each site, CB3 R2 and CB4 Poly 1. The core was sectioned at 2.5 cm resolution from the bottom to 10cm, the remainder of the core was sectioned at 10 cm resolution. Following 1-3x volume diluted melt with FSW, samples were filtered for chl *a* and salinity was measured.

WATER COLUMN.

Following completion of coring, water samples were taken using the 2nd auger hole (see above). A 1L Niskin sampler or 2L (Hydrobios) water sampler were used for deeper depths (bottom, 25m, 5m). Whereas a peristaltic pump was used for the interface water, 20cm and 1m depths. 2 casts (samplers) were taken per depth, Nalgene containers were rinsed 3x with the sampled water before filling. Samples were kept in a dark cooler for transport. Samples for chl *a* and nutrients were taken for each depth. For the interface, POC, DOC, DIC, Winkler oxygen and flow cytometry were also taken.

The chl *a* data was measured on Turner Designs Trilogy fluorometer and recorded by Fowzia Ahmed or Rosalie McKay. Filters were frozen from the first sample cycle CB1 and post-incubation for optodes until additional acetone was obtained. Filters were frozen for just over 4 weeks (CB1) to a few hours (final optode incubation CB7 R2). Filters were removed from freezer

for 30min-1hr to warm to room temperature, then muddled in 10ml acetone and left to extract in a dark fridge overnight. The liquid was poured into borosilicate tubes, avoiding pouring in fibers as no centrifuge was available.
File: Chlorophyll_CBay2022.xlsx

SECTION 4 - PRODUCTION INCUBATIONS & ECV-ICE INTER-COMPARISON

Oxygen Optode Incubations. Following melt of the BREATHE cores described in Section 4, samples were loaded into optode bottles using a peristaltic pump fitted with a nitex filter to remove grazers. Bottles were filled with no headspace and a magnetic stir bar. They were then loaded in to darkened chambers to equilibrate with the set temperature (circulator setting -3.5°C with chamber temperatures -0.5°C to -2.0°C) for a few hours. Incubations were then started by inserting a manually calibrated Firesting optode into each bottle and exposing the chambers to light. The Oxygen logger system was then set to "log to file" and saved to the computer tower.

The PI chambers were arranged around one LED lamp at the front of both chambers. All samples for these experiments were obtained from the bottom ice sections. The Profile chambers were arranged with one LED lamp at the front of both chambers, with LED strip lights along the sides and aluminium foil used to reflect light at the front of the chambers to increase the light. The PAR ranged from 30µmol/s at the back of these chambers to 300µmol/s at the front. It was difficult to obtain a PAR of zero for the black bottles near the front of these chambers but they could not be put at the back due to warmer temperature fluctuations there. Consider painting/tinfoil wrapping these bottles then wrapping with electric tape in the future. A light bottle and a dark bottle for the mid and top sections were placed in these chambers (along with Winkler incubations, see below). The bottom incubations were not necessary as these wavelengths are covered within the PI chambers.

File: Folder name Cambridge Bay 2022, each incubation is saved under the Firesting system name, sample cycle, site, and date. Eg. 2022 CB1 R2 may 6 blue PvsI high irr
This is saved to the lab computer tower, Rosalie´s UiT OneDrive and Rosalie´s black portable hard drive (Sintef).

Data for the optode systems and chl *a* are named Optode Overview.xlsx, Optode chl a filter volumes.xlsx, and Chlorophyll_CBay2022.xlsx. This is saved to Rosalie´s UiT OneDrive and Rosalie´s UiT Mac.

Winkler Oxygen Incubations. In addition to the above incubations, an airtight light and dark bottle were filled with bottom melt. They were incubated along with the optode incubations and then transferred to 3x 15ml exetainers and spiked with 20µl $HgCl_2$ for later Winkler titration. At the time of filling bottles, a T_0 sample was also taken to fill and spike 3x exetainers. This is a parameter of the ECV-ice intercomparison and will be compared to the optode

measurements simultaneously taken. ^{14}C primary production and Bacterial production were also planned for the intercomparison but not able to be carried out.
**there were highly variable results noted for these incubations, a stir bar was added to the CB7 R2 Winkler incubations to see if stirring would improve accuracy.*

Winkler Titrations. Interface water samples taken for determination of O_2 were collected in glass, air-tight containers without head space. As soon as possible the samples were transferred into exetainer vials and spiked with 20 ul HgCl2. Samples were analysed in the field (i.e. within 2 weeks) via winkler titration method. This was completed by either Odile Crabeck, Bruno Delille or Karley Campbell.