6. ECOSYSTEM SCIENCE

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A comprehensive summary of the ecosystem measurements during all 5 cruise legs will be published in the *Special Feature: The Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC)* of the scientific journal *Elementa: Science of the Anthropocene* (https://online.ucpress.edu/elementa/collection/269/Special-Feature-The-Multidisciplinary-Drifting)

6.1 ECOSYSTEM SCIENCE: ZOOPLANKTON ECOLOGY AND BIOLOGY

Objectives

The objectives for the zooplankton studies are included in the following overall Ecosystem Team objectives:

1. Characterize the spatial distribution of sympagic and planktonic biomass (e.g., ice algae, phytoplankton, microbes, micro-, meso- and macrozooplankton) and determine their biodiversity. Quantify the energy flow and elemental (C, N, O, P) and compound specific (e.g. amino acids, fatty acids, sterols, highly-branched isoprenoids) cycles in the ice/ocean ecosystem. Special focus will be on the energy flow and the elemental and compound-specific cycles within the sea ice and pelagic communities, and the linkages between the two communities through the quantification of important biological rate processes. Important processes include primary production (new and regenerated), microbial respiration and remineralization, micro-zooplankton feeding and growth, and mesozooplankton feeding, respiration, growth, and reproduction.
2. Determine standing stocks and distributions of microorganisms and animals in relation to physical conditions (ice, stratification, water masses, etc.) to evaluate

the physical-biological interactions that impact production, pelagic retention and vertical export.

3. Determine nutrient fluxes, organismal abundance and biomass of important components of the ecosystem (e.g. ice algae, phytoplankton, zooplankton). Relate these properties to behavioral (e.g. vertical depth preferences and diel or ontogenic vertical migration) and life history (e.g. reproductive timing and overwintering strategies) patterns.

Work at Sea

Sampling Schedule:

We began zooplankton sampling for Leg 5 on August 17, 2020 with the first of 2 CTD/ Multinet transect stations on the way to the North Pole (PS122/5-59_63: 88°17.688 N; 34°45.239 W; PS122/5-59_74: 88°56.121 N; 35°53.130 W). We arrived at the new floe in the eastern part of the Nansen Basin (88°01.963 N; 108°51.849 E) on the 21st of August 2020 and left exactly one month later (= 4 weeks of sampling). During Leg 5, we had a late start opening the CTD hole (25th of August) and lost it again on two occasions over the following weekends. Therefore we used ice holes on the floe at several occasions – first the Ocean City hole (25th August), then the ROV hole (31st August) and finally the PPS sampling site (1st Sept., 8th Sept., 15th and 18th of Sept.). These sampling events were carried out with the 60 cm ringnet and comprised 3-4 double-vertical tows down to 75m and back to surface. Ice holes next to the ship were usually prepared in time for mid-week CTD and net sampling. CTD sampling was usually on Wednesday and Thursday and the net sampling was spread over Wednesday, Thursday and Friday. Three ROV sampling events occurred on a Saturday, the fourth was cancelled due to ROV site demobilisation before departing from the floe.

Weather/ Polar bear:

Generally, temperatures hovered around 0 °C. The lowest temperatures we experienced were about -10°C, but usually we didn't have problems with net/ cod-end freezing when sampling from the ship. In contrast, when sampling from the ice, the cod-end did occasionally contain ice which compromised the catch. We tried to avoid this by only opening the net below the surface, keeping the surface water as much as possible ice-free and filling the cod-end with subsurface water of higher salinity. No sampling event was lost to bad weather, but one ROV net sampling had to be abandoned due to polar bear sightings.

Sampling Gear:

General:

All sampling gear were lowered from the surface and raised vertically from the designated sampling depth at a speed of 0.5m/s. Upon reaching the surface, nets were rinsed with surface seawater via a hose. The cod-ends were removed on deck. For samples that were to be preserved immediately without pre-sorting (Multinet and 53-µm ring net), the cod-

ends were rinsed into small 1-L Kautex jars and placed into a cooler. For samples to be processed for biochemical, genetic variables, or experiments the cod-end was diluted in 3 or 4, 4-L jars that were half-filled with surface seawater and then placed in the cooler. If a gut DNA subsample was to be taken (150-µm ring nets), the cod-end was first rinsed into a large beaker and subsampled with a small 150-µm mesh and the mesh rinsed into a sample container with 96% ETOH. The remainder of the sample was then distributed between the large jars. The cooler was then brought into the ship for further processing.

Multinet Midi (5 nets, 150-µm, 0.25 m^2, 2000-1000-500-200-50-0 meter sample depths): Multinet samples were collected from the 5 depth strata at weekly intervals to determine the meso/macrozooplankton abundance, community composition, and vertical distribution. The samples were preserved in 4% formaldehyde for later analysis.

Ring Nets (53-µm, 0.25 m^2; 150-µm, 0.28 m^2; 150-µm, 1m^2; and 1000-µm, 1m^2): Four different ring nets were deployed during Leg 5: The smaller 53-µm mesh net collected large microzooplankton and small mesozooplankton in the upper 200 meters; the smaller 150-µm net collected meso- and macrozooplankton from ice holes at the floe; the large 150-µm net collected meso- and macrozooplankton in two separate depth intervals (2000-200 and 200-0 m); the 1000-µm net was used to collect large meso- and macrozooplankton from the upper 1000m. An opening/closing mechanism with mechanical messenger was used to close the net at 200 m for the 2000-200 m net haul. The 53- and 1000-µm nets were preserved in 4% formaldehyde for later enumeration at home laboratories, and the remainder of the 150-µm net was frozen at -80 °C after individual specimens were picked for various parameters (see below) so samples could be used for later biochemical and genetic analysis. Target species were pre-sorted from both the 150- and 1000-µm nets for biochemical and genetic analysis (see meta-data sheets for details), and subsamples were occasionally taken from the 150-µm net for gut DNA analysis.

ROV Net (150- and 10-µm nets; 0, 10, and 50 m sample depths): The under-ice zooplankton community was studied in cooperation with the ROV team of the ICE group (see ROV section 4.5). The ROV net consisted of a large 150-µm net bag and a small phytoplankton/gypsum net (10-µm mesh size). Plastic lamellas on top of the net frame were used to scrape organisms off of the underside of the sea ice. During leg 5, we observed the presence of platelet ice at the bottom of the ice. Collecting platelets together with the zooplankton catch resulted in damaging the organisms. We thus decided to dive close to the ice, but without scraping the bottom of the ice in order to preserve the catch in better condition. Samples were preserved in 4% formaldehyde after pre-sorting target organisms for biochemical and genetic variables. Occasional extra net samples were taken for gut DNA.

LOKI (Lightframe On-sight Key species Investigation): The LOKI, an optical plankton recorder, was deployed on a weekly basis to 1000 m. The LOKI was equipped with a 150-µm net to concentrate the plankton and a high-resolution camera taking up to 18 pictures sec^{-1}. The underwater computer unit of the LOKI system immediately detected zooplankton organisms and particles in the pictures and saved clippings of these objects. In addition, a set of sensors is usually measuring depth, water temperature, conductivity, oxygen and fluorescence, which will allow us to relate zooplankton distributions to the environmental conditions. Unfortunately, during Leg 5 the conductivity sensor did not provide any data. The failure of sensor recording could be back-dated to the 11th of July, which coincides with the time where the LOKI computer was exchanged during Leg 4. It was concluded that there is a problem with the HJ-Sensor, which could not be solved on board. While we were able to download the data from the first 2 LOKI events, at a later time, we were unable to access the LOKI computer via the external computer. Therefore data will have to be extracted from the LOKI computer when back at the lab in Bremerhaven.

To study diurnal differences in animals' vertical distribution, the last three LOKI hauls were taken at three consecutive days but different times of the day (9 am, 1 pm and 4 pm). These time points were selected to fit with the crews' deck working hours.

Biochemical and Genetic Variables:

Prior to preservation/freezing, the 150-µm, 1000-µm, and ROV net tow collections were pre-sorted for biochemical and genetic variables of target zooplankton species following protocols provided by the project PIs. After sorting out a portion of the collection for rate process measurements (egg production, feeding, and/or respiration rates) in the environmental room, if needed, the catch was brought to the zooplankton lab where it was concentrated and poured into a sample tray that was kept over ice. Large animals (e.g. Amphipods, gelatinous zooplankton, chaetognaths) were sorted to species by eye, while smaller zooplankton (e.g. copepods) were sorted to species/life stage under a dissecting microscope. The Core project variables included trophic biomarkers (lipid class composition, fatty acid composition, bulk stable isotope composition, compound-specific stable isotope composition of fatty acids, highly branched isoprenoids) and carbon and nitrogen (CN) content. Target animals were also sorted for project variables including: energy content, gut content, digestive enzymes and transcriptomics. All animals sorted for trophic biomarkers, CN content, digestive enzymes, and transcriptomics were photographed prior to transferring to sample containers. All other animals were transferred directly to the sample containers without photographs. All samples were processed, preserved or frozen following the sampling protocol for the given variable. In addition, subsamples were taken from the surface, and on occasion the deep 150-µm ring net, and a dedicated ROV net, and preserved immediately in 96% ETOH for gut DNA content of target zooplankton species.

Rate Process Studies (respiration, reproduction, and feeding):

Rate process studies were conducted in continuous low light, between -0.5 and 0.5 °C in the environmental chamber.

Respiration rates were determined for target zooplankton species/life stages collected from different depth horizons with an Optode oxygen measurement system. Measurements were taken every 12 hours for 2 to 3 days. Seven experiments were conducted with groups of three to ten target organisms, depending on size, each measured in triplicate along with controls. At the termination of the experiment, all animals were photographed and saved for CN determination.

Egg production rates were determined for adult females of the copepod *Calanus glacialis* in short-term, 3-day incubations. Two separate experiments with 30 females each were conducted during Leg 2, Egg production rates were monitored daily for individual females. At the termination of the experiments the females were photographed and saved for CN measurements..

Zooplankton Feeding Rates were determined in five experiments using standard bottle incubation techniques. Up to two separate treatments were run in each experiment: ambient water from the surface and ambient water enriched with ice algae. The incubations were conducted on a plankton wheel in the environmental chamber (at -0.5 to 0.5 °C) in continuous, low, light for 24-48 hours. Groups of up to four separate target species/life stages were incubated in triplicate along with controls and 20% dilutions to estimate microzooplankton grazing. At the start and end of the incubations samples were taken for fractionated chlorophyll (total and <5 µm) and microplankton analysis so that feeding rates on size-fractionated-chlorophyll and microzooplankton could be determined. At the termination, all animals were photographed and saved for CN analysis.

Preliminary (expected) Results

All samples will be processed and analysed at the home laboratories. The number of deployments for each sampling gear, the number of samples taken for each variable, and the total number of rate process measurements have been summarized in Tables 6.1.1, 6.1.2, and 6.1.3.

Table 6.1.1. Zooplankton sampling gear, targeted depth horizons, date of sampling, event ID and total number of hauls for each piece of sampling gear during Leg 5.

	MN	RN150 200-0m	RN150 1000-200m	RN1000 1000-0m	RN53 200-0m	RN150 100-0m	RN150 75-0m	ROV150 0m	ROV150 10m	LOKI	POM
17/8/20	59-63										59-62
18/8/20	59-74										59-72
19/8/20											
20/8/20											
21/8/20											
22/8/20											59-200 59-223
23/8/20											
24/8/20											
25/8/20							59-265				59-265
26/8/20	59-284										59-274
27/8/20				59-312							59-305 59-306
28/8/20	59-338				59-340					59-337	
29/8/20									59-369		
30/8/20											
31/8/20							60-18				60-16
1/9/20							60-66				60-3
2/9/20											
3/9/20	60-71	60-68									60-69
4/9/20			60-90	60-104	60-113						
5/9/20								60-167	60-167		60-167 60-224
6/9/20											
7/9/20											61-3
8/9/20							61-69				
9/9/20											
10/9/20	61-124	61-123		61-133						61-125	
11/9/20		61-164	61-164		61-160						61-161
12/9/20						61-191 61-192 61-196 61-197		61-200	61-200		61-189
13/9/20											61-211
14/9/20	62-11									62-9	
15/9/20						62-37	62-68			62-36	
16/9/20	62-71	62-73			62-74	62-72 62-73				62-75	62-66
17/9/20				62-90							62-91
18/9/20			62-118				62-158				
19/9/20											
20/9/20											
21/9/20											
24/9/20	63-48										63-48 63-35
25/9/20	63-58										63-53
28/9/20	63-109										64-2
Total	**11**	**4**	**3**	**4**	**4**	**7**	**6**	**2**	**3**	**5**	

Table 6.1.2. Summary of the core and project sample variables collected for individual species/ life stages.

Variable	Core/Project	Samples	Number of Animals	Number of Filters
Individual Species/Stage Measurements				
Carbon and Nitrogen	Core	1625	2001	
Trophic Biomarkers	Core/Project	443	4306	67
Energy/Gut Content	Project	28	478	
Enzymes	Project	112	1126	
Gut prey-DNA	Project	14	~	
ARJEL Project	Project	169	194	
Total		**2377**	**8105**	
Photographs	Core/Project	2547		

Table 6.1.3. Zooplankton rate processes. The number of experiments and the total number of samples/bottles incubated for each type of process measurement are shown.

Experiments	Number	Incubations
Respiration	7	84
Reproduction	2	60
Feeding	5	75

Data management

All data are handled, documented, archived and published following the MOSAiC data policy (see APPENDIX). All data will be subject to the MOSAiC data policy, and therefore, deposited in the MCS and relevant public open access data repositories upon publication.

6.2 THE CARBON UPTAKE BY THE ARCTIC OCEAN

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Objectives

This project focuses on the carbon cycle within the surface Arctic Ocean with special attention to rapid changes at the end of the summer season and the onset of annual continuous freeze-up of the Arctic. The objectives during PS122/5 are:

1. To study the drivers of the seasonal changes in the inorganic carbon chemistry of the Arctic Ocean surface waters and to capture biogeochemical processes that occur at small time scales.
2. To quantify the CO_2 flux during the transition period between summer and winter in the Arctic Ocean, as well as to understand how air-sea CO_2 exchange varies throughout the year and how it may change in the future. This includes air-sea CO_2 exchange in the heterogeneous landscape of the high Arctic, including leads and melt ponds.

The main variables of interest are dissolved inorganic carbon (DIC) and total alkalinity (TA). During PS122/5, main scientific activities for this project included collecting DIC/TA samples. Time and spatial resolution were chosen high enough to constrain the processes occurring during this time period, especially during the switch of the energy budget. Another carbon system variable that has been measured and will be studied in more detail is the partial pressure of CO_2 (pCO_2).

Work at sea

In terms of work on board, the main scientific activities within this project were to collect dissolved inorganic carbon (DIC) and total alkalinity (TA) samples. These sea water samples are typically collected in 250 mL or 500 mL borosilicate bottles (as opposed to glass bottles that can lead to silicate contamination and thereby affect the TA measurements). DIC and TA can be analysed from the same sample. These laboratory analyses will be done on land by various involved institutes, Hokkaido University and UEA. In order to preserve the samples, they were fixed with mercuric chloride ($HgCl_2$) and sealed with grease to make the bottles gas-tight. The collection and fixing of the samples was done according to SOP 1 (Dickson et al., 2007), respectively. DIC/TA samples were stored at 4°C or at room temperature. Depending on their final destination, they will be

transported at either of these two temperatures. The analysis on land will be done according to SOP 2 for DIC and SOP 3b for TA (Dickson et al., 2007), consistent with the DIC/TA analyses done for all previous PS122 legs. For samples that will be analysed at the University of East Anglia, the Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA 3C; Mintrop, 2004) will be used. This includes coulometric titration and photometric detection for DIC and potentiometric titration for TA analysis. Samples that are destined for Hokkaido University will be similarly analysed with coulometry for DIC (Johnson et al., 1985). The TA of these samples will be determined with the single point titration method (Culberson et al., 1970).

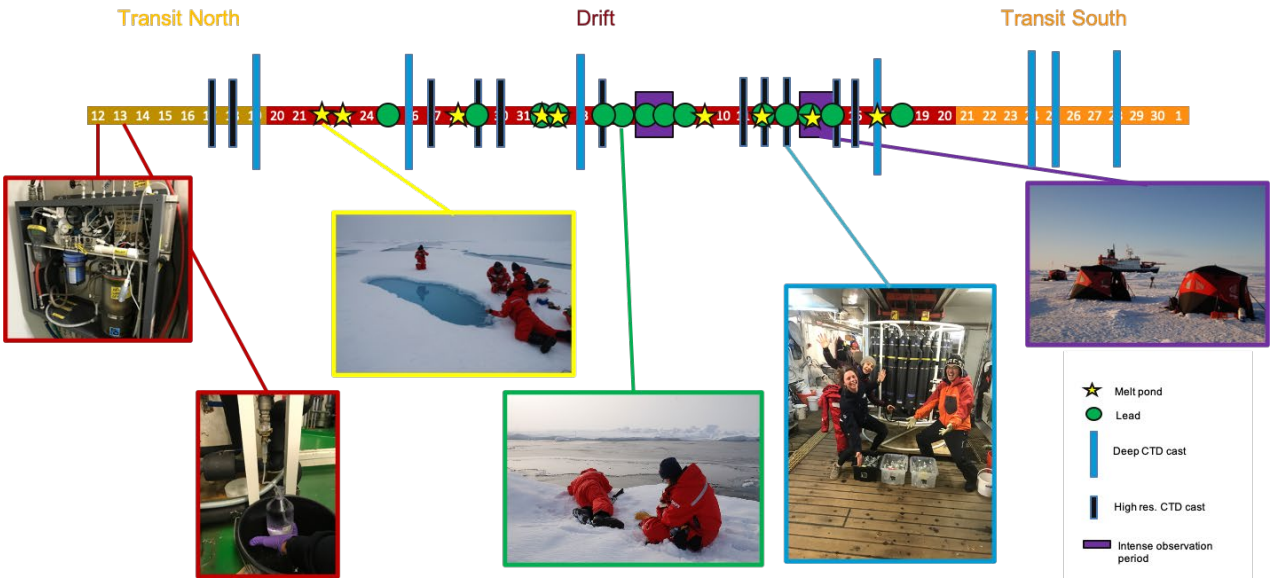


Fig. 6.2.1: Visual overview of different DIC/TA sampling events during PS122/5.

The three main components of this project are here summarised under “Underway sampling”, “High resolution casts”, and “Intercomparison cast”. Work on leads is covered in Chapter 8.4 and contributions to melt pond work is covered in Chapter 8.3.

Underway sampling

Polarstern houses a General Oceanics (GO) pCO_2 analyser, which continuously measures the partial pressure of CO_2 (pCO_2) from an inlet at 11 m depth. To complement this data set, we collected DIC/TA samples from the exact same inlet and pipe system (Figure 6.2.2). The water was collected from a tap between the pump and the GO pCO_2 analyser. Underway DIC/TA samples were collected between the 13th of August and the 1st of October 2020. The sampling time resolution was increased during ship transit times, i.e. going north to find a new MOSAiC floe and going south towards Svalbard, as we were covering a lot of distance relatively rapidly. During the drift along the floe (between the 20nd of August and the 20th of September), samples were collected at irregular intervals. In total, 86 DIC/TA samples were taken from the underway system, all of which were

accompanied by primary organic and primary inorganic nutrient samples, which are required for the quantification of the TA (Table XX).

Fig. 6.2.2: Sampling from the underway system next to the GO pCO_2 analyser.

Parts of the pCO_2 data set will be missing due to a variety of issues that occurred during PS122/5. These are listed below:

- Ice in the pipes. This temporarily automatically stopped the flow of sea water through the system, including the GO pCO_2 analyser. Flow was re-established as soon as possible afterwards.
- Organisms in the pipes. During the transit north, amphipods (and once even a small polar cod) would occasionally get stuck in the tubing that we used to collect our samples. The amphipods were brought to members of the zooplankton sub-group of Team ECO. Organisms were removed and the tubing was rinsed with MQ water before attempting to collect the DIC/TA sample again.
- Pump malfunctioning (e.g. 22-23 September 2020) and subsequent pump replacement.

During transit north and south, we had the opportunity to collect DIC/TA samples from a number of CTD casts (Table 6.2.1). These will complement and provide more context to the underway study by giving more information on the vertical water column profiles at various points of the expedition track.

Tab. 6.2.1: Device operation IDs of the CTD casts done on the transit north (^{N}) and the transit south (^{S}) of PS122/5, before and after the floe drifting period, respectively. The casts done on the transit north went down to 1000 m only due to time constraints. The casts done on the transit south went down to the bottom of the ocean.

Device Operation ID	Date	Number of depth horizons
^{N}PS122/5_59-62	2020-08-17	17
^{N}PS122/5_59-72	2020-08-18	17
^{S}PS122/5_63-35	2020-09-24	13
^{S}PS122/5_63-53	2020-09-25	13
^{S}PS122/5_63-111	2020-09-28	13

High resolution casts

DIC/TA samples are taken from all weekly deep CTD casts as part of the core ECO program (Table 6.2.3). In addition to these, samples were also collected from a total of six high resolution casts that were operated by members of Team Ocean during the drift along the floe (Table 6.2.2). These casts went down to 2000 or 1000 m depth and the Niskin bottles were closed at depth horizons at a higher vertical resolution in the upper 200-300 m (see Figure 6.2.3 as an example of a high resolution CTD cast during PS122/5) than typically done for other CTD casts. Casts were operated as often as possible and were mainly dependent on the availability of a hydro hole adjacent to the starboard side of the working deck. DIC/TA samples were collected from all depth horizons on the “shallow” casts (i.e. up to 1000 or 2000 m depth). A replicate sample was taken at one of the deepest sampled depth horizons for each cast.

Tab. 6.2.2: Device operation IDs of the high resolution CTD casts done during the PS122/5 drifting period along the floe down to 1000 or 2000 m depth.

Device Operation ID	Date	Number of depth horizons
PS122/5_59-357	2020-08-29	14
PS122/5_59-363	2020-08-30	22
PS122/5_60-89	2020-09-04	23
PS122/5_61-189	2020-09-12	12
PS122/5_62-38	2020-09-15	24
PS122/5_62-66	2020-09-16	24

Tab. 6.2.3: Device operation IDs for all deep CTD casts done during the drift period along the floe during PS122/5.

Device Operation ID	Date	Number of depth horizons
PS122/5_59-149	2020-08-19	6
PS122/5_59-274	2020-08-26	18
PS122/5_59-306	2020-08-27	18
PS122/5_60-69	2020-09-03	17
PS122/5_61-161	2020-09-11	16
PS122/5_62-91	2020-09-17	16

Date/time (UTC):	16.9.2020
Operator:	SACAN
Max depth (M):	3000 m
Device operation ID:	PS122/5_62-66

NISKIN	Desired depth (m)	Actual depth (m)	Feature	ECO Overflow DIC	BGC Overflow O2/Ar discrete	OCEAN Overflow Salinity	BGC Rinses 18O	ECO Rinses Nuts	ECO Rinses DOC	ECO Rinses CDOM	ECO Rinses Light micro	ECO Rinses FOM	ECO Rinses Chl a	MethOx DNA.	Total volume (L)
1	2000			2		4		0,2				0,1			6,3
2	1000			1				0,2				0,1			1,3
3	750			1				0,2				0,1			1,3
4	500			1				0,2				0,1			1,3
5	400			1				0,2				0,1			1,3
6	300		Tmax	1				0,2				0,1			1,3
7	280		Shallow oxy min	1				0,2				0,1			1,3
8	200			1				0,2	0,2	0,2		0,1			1,7
9	150			1				0,2				0,1			1,3
10	100			1				0,2	0,2	0,2	0,3	0,1	2		4
11	90			1				0,2				0,1			1,3
12	80			1				0,2				0,1			1,3
13	70			1				0,2				0,1			1,3
14	60			1				0,2				0,1			1,3
15	50			1				0,2	0,2	0,2		0,1			3,7
16	42		extra shallow oxy min	1				0,2			0,3	0,1			1,6
17	35			1				0,2				0,1			1,3
18	30			1				0,2				0,1			1,3
19	25			1				0,2				0,1			1,3
20	20			1				0,2				0,1			1,3
21	17		Chl max	1				0,2	0,2	0,2	0,3	0,1	2		4
22	10			1				0,2	0,2	0,2	0,3	0,1	2		4
23	5			1				0,2				0,1			1,3
24	2			1				0,2	0,2	0,2		0,1	2		3,7

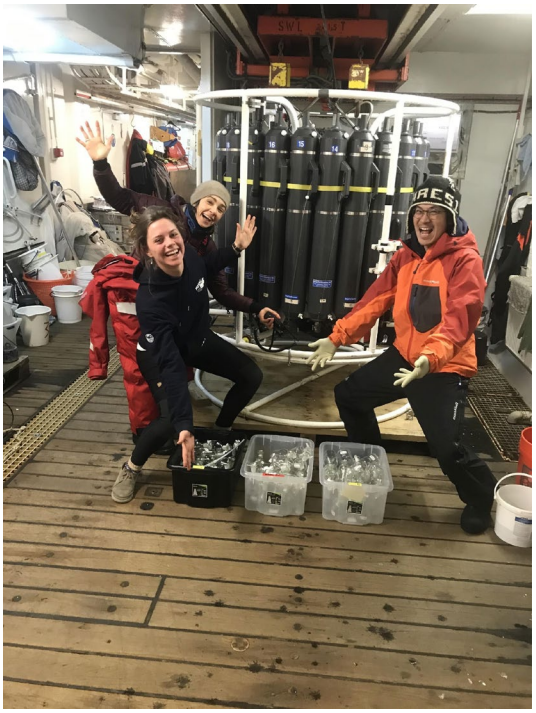
If no observable Chl max, fire bottles at 20 m

Fig. 6.2.3: An example of a cast sheet for a high resolution CTD cast during PS122/5.

Intercomparison cast

DIC and TA are core parameters of the ECO Team program for MOSAiC. The samples collected for the core time series are distributed over various institutions for laboratory analysis, using the VINDTA system or methods similar to those incorporated into the VINDTA. All analyses follow the relevant SOPs (mainly SOP 2 for DIC SOP 3b for TA) as described in Dickson et al. (2007). However, small differences or necessary deviations from the protocol – or simply the instruments themselves – might lead to differences in the analytical results. In order to check this and to be able to account for it, the Carbonate Chemistry sub-group of Team ECO plan to do an intercomparison study. For this, we deployed a DIC/TA intercomparison CTD cast during PS122/5. The sampling strategy was to collect five 250 mL DIC/TA samples per depth horizon, for a total of three depth horizons. One intercomparison "set" should be dedicated to each analytical instrument (as opposed to each analytical institution) that has been scheduled to analyse a fraction of the DIC/TA samples of PS122 (Table 6.2.4). The institutions involved are UiT, AWI, UEA, and Hokkaido University. UEA has two available VINDTAs. The decision to collect five samples per depth horizon per VINDTA was based on enhancing the statistical quality of the intercomparisons. The chosen depth horizons were 2000, 1000, and 275 m. The gradient depth is typically very minimal for DIC and TA at 2000 and 1000 m, which is why

these depths seemed suitable for the objective of this CTD cast. All decisions described here had been discussed within the carbonate chemistry sub-group of Team ECO prior to the start of PS122/5. Further, it was decided to include the depth at which Atlantic Water is found (identified by the temperature maximum), which turned out to be at 275 m at the time the cast was deployed. The DIC/TA intercomparison CTD cast was done on the 13th of September 2020 (PS122/5_61_211). All samples from the same depth horizon were collected by the same person in order to reduce any variability caused by sampling. The poisoning of the samples was done immediately after collection of all samples by two people, but following the exact same protocol as for all other PS122 DIC/TA samples i.e. according to SOP 1 (Dickson et al., 2007) (Figure 6.2.4). Seven Niskin bottles were closed per depth horizon. As many DIC/TA samples (per depth horizon) were collected from a single Niskin bottle. Remaining samples were collected from the subsequent Niskin bottle. One set of nutrient samples (including primary organic and primary inorganic nutrients) were collected per depth horizon for the purpose of accurately determining TA later during data processing. The samples per depth horizon will be distributed randomly among each VINDTA (five each). This has already been done for the samples dedicated to Hokkaido University, as these could be shipped to Japan immediately at the end of the expedition. The others will be distributed and shipped from AWI after the expedition.



a)

b)

Fig. 6.2.4: a) About to collect the samples for the DIC/TA intercomparison study. b) The borosilicate glass bottles used for the collection of the DIC/TA intercomparison samples.

Tab. 6.2.4: Number and allocation of DIC/TA intercomparison samples between all involved laboratories. Note that the number of involved analytical facilities might change at a later date.

Institution with VINDTA	Depth horizon [m]	Number of samples	Sample IDs	Distributed?
UiT	2000	5	Tbd	No.
	1000	5	Tbd	No.
	275	5	Tbd	No.
AWI	2000	5	Tbd	No.
	1000	5	Tbd	No.
	275	5	Tbd	No.
UEA (VINDTA 1)	2000	5	Tbd	No.
	1000	5	Tbd	No.
	275	5	Tbd	No.
UEA (VINDTA 2)	2000	5	Tbd	No.
	1000	5	Tbd	No.
	275	5	Tbd	No.
Hokkaido University	2000	5	1062, 1064, 1069, 1074, 1083	Yes, at end of PS122/5.
	1000	5	1088, 1095, 1099, 1102, 1110	Yes, at end of PS122/5.
	275	5	1113, 1124, 1127, 1129, 1131	Yes, at end of PS122/5.

Preliminary (expected) results

The DIC/TA samples were fixed on board to preserve the state of the carbon system variables and will be analysed on land. Any preliminary results are therefore limited in this report. However, preliminary results of the vertical salinity CTD profiles in the top 100 m during the drift indicate substantial variability through time (Figure 6.2.5). As DIC and TA are closely related to salinity, we expect a similar amount of variability in the carbon system variables.

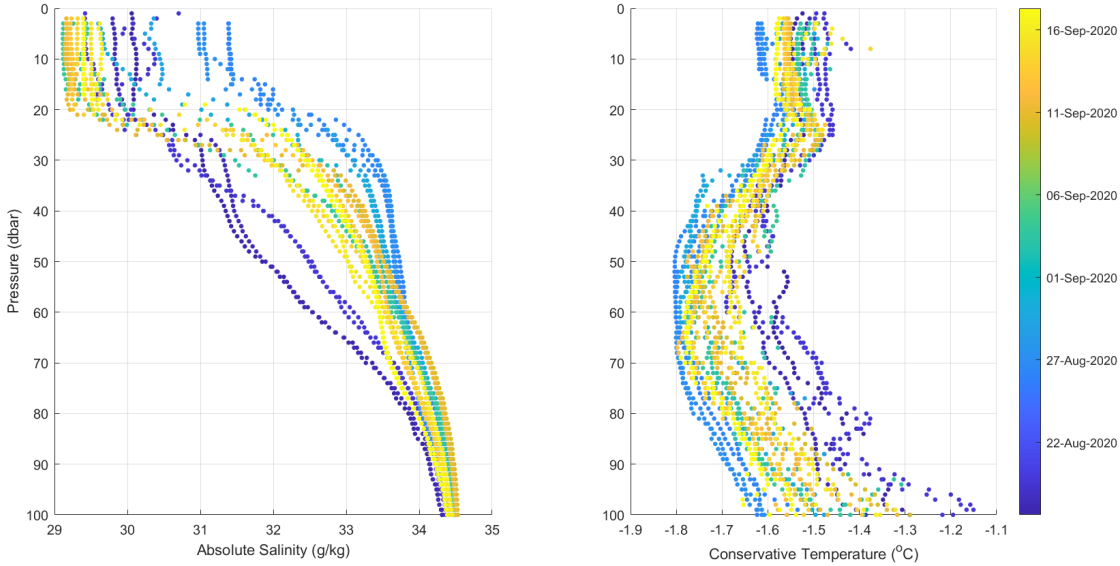


Fig. 6.2.5: Salinity (left) and temperature (right) vertical profiles of the upper 100 m from all CTD casts operated during the drift along the floe on PS122/5. Figure made by Salar Karam (Team OCEAN). The colourbar indicates time during the drifting period.

Data management

All data are handled, documented, archived and published following the MOSAiC data policy (see APPENDIX). The pCO_2 data is processed by the responsible people at the AWI and will be uploaded onto PANGAEA upon completion. The DIC/TA results from the laboratory analyses on land will be made available on PANGAEA upon completion of analyses by the respective institutions. This includes the DIC/TA samples collected from the underway system of *Polarstern*, the high resolution CTD casts, the deep CTD casts, and the intercomparison CTD cast.

References

Culberson, C. H. (1970). Seawater alkalinity determination by the pH method. *J. mar. Res.*, *28*, 15-21.

Dickson, A. G., C. Sabine, and J. R. Christian (2007), Guide to Best Practices for Ocean CO_2 Measurements, PICES Spec. Publ., vol. 3, 191 pp., North Pacific Mar. Sci. Organ., Sidney, Canada.

Johnson, K. M., King, A. E., & Sieburth, J. M. (1985). Coulometric TCO2 analyses for marine studies; an introduction. *Marine Chemistry*, *16*(1), 61-82.

Mintrop, L. (2004) VINDTA, Versatile Instrument for the Determination of Titration Alkalinity. Manual for versions 3S and 3C. Version 2.0. MARine ANalytics and DAta (MARIANDA), Kiel, Germany, 45 pp

6.3 QUANTIFYING MICROBIAL CONTROLS ON THE ANNUAL CYCLE OF METHANE AND OXYGEN WITHIN THE ULTRA-OLIGOTROPHIC CENTRAL ARCTIC (JOINT WITH BGC

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Background and objectives

The ocean is a source (Damm et al., 2010; Karl et al., 2008) and biological sink (Reeburgh, 2007) of methane (CH_4); together with carbon dioxide (CO_2) these greenhouse gases (GHG) are keystone compounds in the Arctic climate system. CH_4 and Oxygen (O_2) fluxes are closely tied to biological and physical drivers, such as phytoplankton blooms (Meskhidze & Nenes, 2006; Repeta et al., 2016) and, in the Arctic, sea ice cover (Yokouchi et al., 2013). Therefore, this project aims to identify the primary features triggering the production and consumption of CH_4 and CO_2 in an effort to establish the metabolic balance of O_2 and CH_4 in the oligotrophic Central Arctic. The microbial oxidation rate of CH_4 was investigated to assess the potential for microbial oxidation/production in this region. Such microbial activities control the migration of these GHG into the atmosphere, highlighting the importance of such investigations at the ice-water interface and in association with data from the water column underneath. During Leg 5, we measured the rates of net community production (NCP), methane oxidation and production, and bacterial respiration (BR) in seawater, from the air-ice interface to deep bottom water. These measurements, together with the ones from the previous legs, will be used to functionally constrain metabolic processes in two regional models of the Arctic and to produce model-based budgets of methane and net community production for the central Arctic.

The objectives for Leg 5 were:

- Conduct continuous and discrete sampling for microbial community structure (16S/18S rRNA gene analysis) in the water column to pair with continuous and discrete measurements of NCP.
- Conduct approximately bi-weekly measurements of BR (bacterial and phytoplankton abundance, bacterial production, and primary production will be provided for these same samples by ECO core measurements)
- Collect samples for experimentally deriving methane oxidation/production rates using elevated methane in select incubations as well as T_0 samples for microbial community structure, gene expression, and oxidation potential.
- These data will then be used to identify patterns of expression for genes involved in methanotrophy by using metatranscriptomics to identify genes differentially expressed under high methane conditions.

- Through modeling, we will identify the microbial taxa and physicochemical conditions that best predict the key ecosystem functions of methane production, methane oxidation, BR, CR, BP, NCP, nitrification, and DMS production

Field work

The following tables (6.3.1 and 6.3.2) summarize the samples collected during Leg 5 12/08/2020-12/10/2020.

Table 6.3.1. Core project sample collection

Sample type	Frequency	Purpose	Total # of samples
Underway seawater (see table X.X.X)	daily	DNA filtration	51
CTD seawater at 6-13 horizons (At least: PSW, chlmax, 100 m, T_{max}, 500 m, 1500 m, O_2 min, 10 m above bottom)	weekly	DNA filtration	86
CTD seawater at 3-4 horizons (PSW, Chl_{max}, T_{max}, 10 m above bottom)	weekly	RNA filtration	13
CTD seawater at 3-4 horizons (Duplicates: PSW, Chl_{max}, T_{max}, 10 m above bottom)	weekly	CH_4 incubations	28
CTD seawater at 2-3 horizons (Triplicates: PSW, Chl_{max}, and T_{max})	weekly	respiration (DO)	15
TOTAL:			278

**PSW = Polar surface water*

Table 6.3.2. Opportunistic sample collection to capture freeze-up processes and co-locate measurements during cross-cutting multi-team activities

Sample Environment	Frequency	Purpose	Total # of samples
Meltpond water	Opportunistic	DNA filtration	34
Meltpond Ice	Opportunistic	DNA filtration	2
Seawater from the surface/ice interface collected at Eco-Lodge (section xx)	Opportunistic	DNA filtration	11

Seawater from the surface/ice interface collected at Eco-Lodge (section xx)	Opportunistic	Respiration (DO)	12
Leads	Opportunistic	CH_4 incubations	3
Leads	Opportunistic	DNA filtration	29
Leads	Opportunistic	RNA filtration	5
Leads	Opportunistic	Respiration (DO)	3
Ice core/experiment for DMS/DMSP analysis	Weekly	DNA filtration	103
Biomass beneath freshwater lens (from leads or pumped directly from under ice)	Opportunistic	Potential culture stock, preserved in glycerol/ enriched sample stored at 0ºC, frozen sea water	12
Biomass from new ice formation	Opportunistic	Potential culture stock, preserved in glycerol/ enriched sample stored at 0ºC , frozen seawater	6
TOTAL:			82

Lab work

DNA and RNA filtration required filtering 500 mL – 1000 mL of seawater from either the underway system or CTD rosette and approximately 250 – 500 mL of ice melt, meltpond water, or lead water. Filter volumes dependent on biomass present and melted ice volume available. 1 mL of DNA/RNA shield buffer solution added to samples tagged for potential metatranscriptomic analysis. Filters stored at –80°C for future extraction and 16s/18s rRNA gene amplicon sequencing (analysis not conducted on board).

The methods established on Legs 3 and 4 (see chapter X.X. and X.X) for respiration experiments using the handheld PyroScience FireSting GO2 and dissolved oxygen optical sensor spots were refined for several successful respiration incubations on Leg 5 from the CTD rosette. Additionally, samples were collected from oxygen minimum stratification features seen in the upper 1m of lead sites and two *in-situ* light/dark incubations were deployed directly under the ice at the Eco-lodge incubation site near Ocean City during cross-cutting 36 hr intensive observation cycles. From each triplicate set of BOD bottles, dissolved oxygen concentrations were monitored between 24 hr (*in-situ*) and 2 weeks post final capping (incubated at 1C on board) to capture draw-down rates and processes.

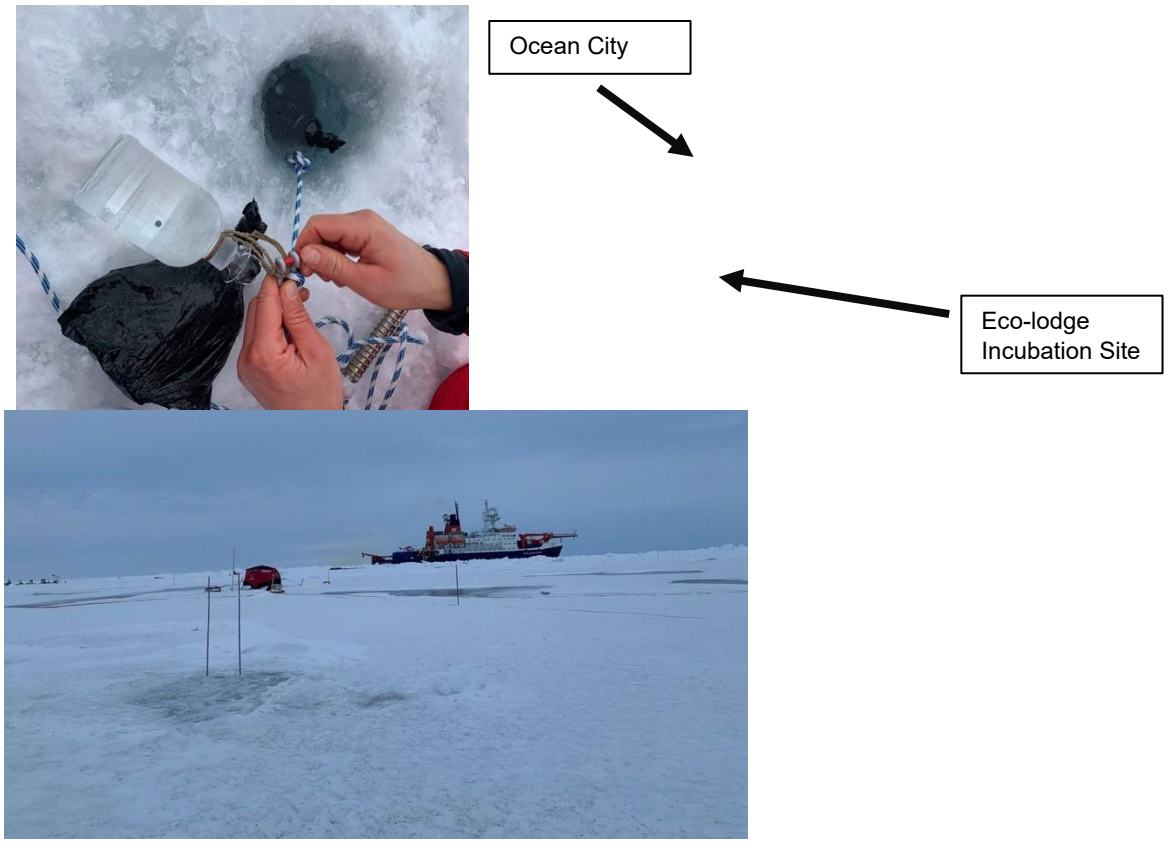

Figure 6.3.1: In-situ light/dark community respiration measurements under the ice at Eco-lodge

(photo: Emelia Chamberlain)

During the Leg 4/5 transition, the Picarro Cavity Ring Down Spectrometer used for CH_4/CO_2 analysis on board (see PS122.4 section X.X for work-program explanation) experienced calibration issues following a SSIM sampling port blockage. After major troubleshooting on-board, it was determined use of the instrument should be suspended until help from land was available. All real-time measurements of *in-situ* seawater, sea ice and freshwater [CH_4] and [CO_2] with stable isotope ratios were suspended on Leg 5. However, seawater and lead samples were still collected to assess the microbial potential for methane oxidation. Samples were collected in muti-layer foil bags (capacity 1000 mL and 3000mL, Restek, Bellfonte, Pennsylvania, U.S.A.) and processed with hydrocarbon-free air (100 mL for experimental bags and 50 mL for the discrete samples). The experimental samples were spiked with 12 mL of methane standard „1005“, 500ppmv and -70 permil and stored in a water bath at 0-1°C until analysis on land.

The following Table 6.3.3 lists all methane incubation samples and associated device operations collected on Leg 5 for this later processing.

Table 6.3.*3. Methane incubation samples*

Bag Num	Sample ID	Date collection	Device operation
177	20200827_PS_N11	2020-08-27	PS122/5_59-306 CTD_SBE9plus_321
178	20200827_PS_N11	2020-08-27	PS122/5_59-306 CTD_SBE9plus_321
179	20200827_PS_N20	2020-08-27	PS122/5_59-306 CTD_SBE9plus_321
180	20200827_PS_N20	2020-08-27	PS122/5_59-306 CTD_SBE9plus_321
181	20200903_PS_N12_A	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
182	20200903_PS_N12_B	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
183	20200903_PS_N20_A	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
184	20200903_PS_N20_B	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
185	20200903_PS_N23_A	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
186	20200903_PS_N23_B	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
187	20200903_PS_N1_A	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
188	20200903_PS_N1_B	2020-09-03	PS122/5_60-69 CTD_SBE9plus_321
189	20200904_ROVlead_10cm	2020-09-04	PS122/5_60-130 peristaltic_pump
190	20200904_ROVlead_52cm	2020-09-04	PS122/5_60-130 peristaltic_pump
191	20200904_ROVlead_100cm	2020-09-04	PS122/5_60-130 peristaltic_pump
192	20200911_PS_N1_A	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
193	20200911_PS_N1_B	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
194	20200911_PS_N10_A	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
195	20200911_PS_N10_B	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
196	20200911_PS_N19_A	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
197	20200911_PS_N19_B	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
198	20200911_PS_N24_A	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
199	20200911_PS_N24_B	2020-09-11	PS122/5_61-161 CTD_SBE9plus_321
200	20200917_PS_N1_A	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
201	20200917_PS_N1_B	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
202	20200917_PS_N10_A	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
203	20200917_PS_N10_B	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
204	20200917_PS_N16_A	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
205	20200917_PS_N16_B	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321

206	20200917_PS_N19_A	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321
207	20200917_PS_N19_B	2020-09-17	PS122/5_62-91 CTD_SBE9plus_321

Additionally, biological oxygen supersaturation ($\Delta(O_2/Ar)$) was measured continuously by a Membrane Inlet Mass Spectrometeter (MIMS) provided by Sebastian Rokitta (AWI) as part of the ECO core sampling program (see section X.X for details). In addition to continuous operation, discrete bottle samples from CTD casts, direct under-ice water, lead surveys, and melt ponds (see Table 6.3.4) were analyzed. On Leg 5, an emphasis was placed on opportunistic samples collected from a variety of surface melt-layer environments during the transition to the freeze up period, as well as increasing the temporal frequency and vertical resolution from CTD casts. This included high frequency sampling during cross-cutting intensive observation cycles (see section X.X). These samples were often paired with samples collected for Dissolved Inorganic Carbon/Alkalinity (see section X.X). From these measurements, we expect to develop a stronger understanding of how net community production (based on high-resolution O_2/Ar measurements) relate to community structure, sea ice and light conditions, and nutrient supply, as well as the variability in physical and biological controls of CO_2 and O_2. To capture how NCP is related to microbial community structure in time and space, water was collected from the ships underway system daily and filtered for Cholorophyll-a and totDNA (Table 6.3.X). All discrete bottle measurements were additionally paired with samples collected for microbial community structure analysis (Table 6.3.1 and 6.3.2). During Leg 5, the MIMS was operated onboard by Emelia Chamberlain.

Table 6.3.4. Device operations from which discrete seawater samples for O_2/Ar were taken and analyzed

Date	Device operation	Device Short Name	Environment	Total # of bottles
2020-08-17	PS122/5_59-62	CTD_SBE9plus_321	Water Column	6
2020-08-18	PS122/5_59-72	CTD_SBE9plus_321	Water Column	6
2020-08-22	PS122/5_59-200	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-201	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-202	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-203	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-207	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-208	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-209	peristaltic_pump	Meltpond	1
2020-08-22	PS122/5_59-210	peristaltic_pump	Meltpond	1
2020-08-25	PS122/5_59-290	peristaltic_pump	Lead	3
2020-08-26	PS122/5_59-274	CTD_SBE9plus_321	Water Column	10
2020-08-27	PS122/5_59-306	CTD_SBE9plus_321	Water Column	6
2020-08-29	PS122/5_59-389	peristaltic_pump	Lead	3
2020-08-29	PS122/5_59-392	peristaltic_pump	Lead	3

2020-08-29	PS122/5_59-357	CTD_SBE9plus_321	Water Column	4
2020-09-02	PS122/5_60-133	peristaltic_pump	Lead	4
2020-09-02	PS122/5_60-61	peristaltic_pump	Meltpond	5
2020-09-03	PS122/5_60-69	CTD_SBE9plus_321	Water Column	10
2020-09-04	PS122/5_60-130	peristaltic_pump	Lead	4
2020-09-06	PS122/5_60-202	peristaltic_pump	Lead	1
2020-09-06	PS122/5_60-234	peristaltic_pump	Under Ice	1
2020-09-06	PS122/5_60-232	peristaltic_pump	Under Ice	1
2020-09-06	PS122/5_60-239	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_60-242	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-71	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-74	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-77	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-80	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-84	peristaltic_pump	Under Ice	1
2020-09-07	PS122/5_61-86	peristaltic_pump	Under Ice	1
2020-09-11	PS122/5_61-161	CTD_SBE9plus_321	Water Column	12
2020-09-12	PS122/5_61-278	water_sampler	Lead	1
2020-09-12	PS122/5_61-205	peristaltic_pump	Meltpond	4
2020-09-15	PS122/5_62-38	CTD_SBE9plus_321	Water Column	12
2020-09-15	PS122/5_62-238	peristaltic_pump	Under Ice	5
2020-09-17	PS122/5_62-117	peristaltic_pump	Meltpond	2
2020-09-17	PS122/5_62-91	CTD_SBE9plus_321	Water Column	10
2020-09-25	PS122/5_63-53	CTD_SBE9plus_321	Water Column	10
Total:				**139**

Data management

All data are handled, documented, archived and published following the MOSAiC data policy (see APPENDIX). Data are stored on the MCS and will be stored at the Arctic Data Centre, following the agreement between NSF and the MOSAiC Project lead. DOIs will be communicated to PANGAEA for later access via the future MOSAiC Data Portal. Exceptions will to be documented in written agreements between the data provider and the MOSAiC Project Board and data manager.

References

Damm, E., Helmke, E., Thoms, S., Schauer, U., Nöthig, E., Bakker, K., and Kiene, R.P. (2010). Methane production in aerobic oligotrophic surface water in the central Arctic Ocean. Biogeosciences 7, 1099–1108.

Karl, D.M., Beversdorf, L., Björkman, K.M., Church, M.J., Martinez, A., and Delong, E.F. (2008). Aerobic production of methane in the sea. Nat. Geosci. 1, 473–478.

Meskhidze, N., and Nenes, A. (2006). Phytoplankton and cloudiness in the Southern Ocean. Science 314, 1419–1423.

Reeburgh, W.S. (2007). Oceanic Methane Biogeochemistry. Chem. Rev. 107, 486–513.

Repeta, D.J, Ferrón, S, Sosa, O.A., Johnson, C.G., Repeta, L.D., Acker, M., DeLong E.F. and Karl, D.M. (2016). Marine methane paradox explained by bacterial degradation of dissolved organic matter. Nature Geosciences. Vol. 9, 884-887.

Yokouchi, Y., Inoue, J., and Toom-Sauntry, D. (2013). Distribution of natural halocarbons in marine boundary air over the Arctic Ocean. Geophys. Res. Lett. 40, 4086–4091.

6.4 COLLECTIONOF PARTICLES UNDER ARCTIC ICE

?[1] [1]?

Objectives

NOT AVAILABLE

Work at sea

Under-ice samples were collected during MOSAiC Leg5 cruise in the central Arctic from August 26 to September 15, 2020. An in-situ automatic pump McLane phytoplankton sampler (PPS; serial number 12697-01, McLane; USA) was deployed at depth of 11 m (same as intake depth of underway seawater) to collect suspended particles. The PPS site at the floating ice was shown in Fig. 1. 4-6 L seawater was filtered through combusted GF/F filters under different pre-set sample parameters of the PPS (Table 1).

Figure 1 The pictures of the McLane phytoplankton sampler before the deployment (left pallet) and after the deployment (right pallet).

Table 1: The pre-set sample parameters of the McLane phytoplankton sampler during MOSAiC Leg 5

Date 2020/8/26-2020/9/7		
Initial flow rate	[ml/min]	200
Minimum flow rate	[ml/min]	150
Sample volume	[ml]	4000
Time limit	[minutes]	27
Flushing water volume	[ml]	100
Date 2020/9/7-2020/9/15		
Initial flow rate	[ml/min]	200
Minimum flow rate	[ml/min]	150
Sample volume	[ml]	6000
Time limit	[minutes]	27
Flushing water volume	[ml]	100

A 20-days collection of under-ice particles was conducted with the deployment and recovery of the PPS with a 3-days interval during the period. Besides, a 24-hours continuous collection of particles was conducted after a high wind event on 7 to 8 September, 2020 (Fig. 2). A total number of 192 filters were collected. Stable carbon isotope and elemental C/N ratios, HPLC pigments, humid acid, DNA and key biomarkers will measure in lab onshore.

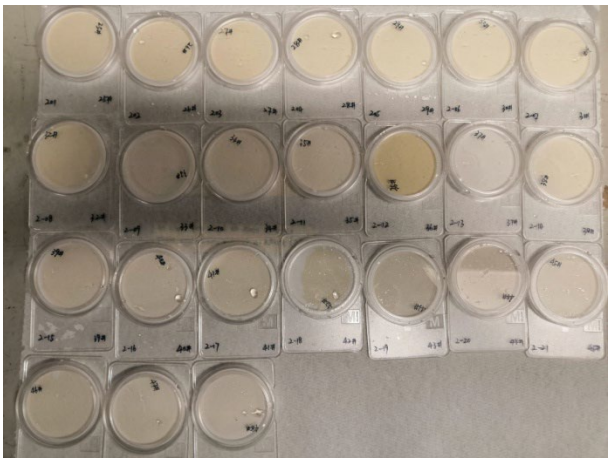

Figure 2: The membrane filters acquired by the McLane phytoplankton samplers in one deployment.

Expected and preliminary results

NOT AVAILABLE

Data management

NOT AVAILABLE

References

NOT AVAILABLE

6.5 UNCOVERING THE LARGEST BLIND SPOT ON THE MAP OF THE WORLD'S FISH STOCKS: MESOPELAGIC FISH AND THEIR ROLE IN THE CENTRAL ARCTIC OCEAN FOOD WEB

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A. Svensson[3] (not onboard), N. Hildebrandt[2] (not onboard), G. Castellani[2] (not onboard), S. Sakinan[4] (not onboard), K. Schmidt[5] (onboard)

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Grant-No. Dnr-2019-154 (Swedish Polar Research Secretariat SPRS)

Objectives

No scientific data exists for pelagic fish populations in the Central Arctic Ocean (CAO), i.e. the deep basins outside the continental shelves. In the EFICA (European Fisheries Inventory in the Central Arctic Ocean) project we target fish in the water column from the surface down to ca. 800 m of depth. Our goal is to answer the following research questions: (1) Do pelagic fish occur in the CAO?, (2) To which species and populations do they belong?, (3) What are their numbers and biomass along the MOSAiC drift transect?, (4) What is their role in the CAO pelagic food web?, (5) What are their migration patterns?, and (6) How are the existing populations expected to change with further climate warming? Since the *Polarstern* is drifting with the ice, MOSAiC offers the possibility to collect a unique acoustic data set with one year of measurements targeting fish while crossing the CAO. Such data collection is impossible to achieve when an ice-breaker is moving through the ice because of the noise. We will also mine the MOSAiC genomic data sets for fish genes to answer the EFICA project's research questions.

Work at sea

General

During Leg 5 of MOSAiC, Katrin Schmidt was on board *Polarstern* and followed the sampling routines established during Leg 1-4. Leg 5 work at sea followed directly on from Leg 4 on the 12th of August 2020.

Hydroacoustics

During Leg 5 of MOSAiC the EK80 and EK60 settings were the same as for the end of Leg 4, so the instruments ran with frequencies of 38 kHz (GPT, CW mode), 70 kHz (WBT, LFM and CW mode, and 200 kHz (GPT, LFM and CW mode) for the EK80 and 18 kHz and 120 kHz for the EK60 (GPT, CW mode). The mode of the 70 kHz transducer and 200 kHz transducer of the EK80 were manually swopped between LFM and CY mode every 24 hours.

During Leg 5 few events have caused a disturbance in the data. On the transit North and South, moving through thick ice interfered with the acoustic signals. The new floe was rather small and therefore other acoustic intruments were operated in close vicinity of the ship. At the floe, the multibeam of the ROV caused another interference. Problem was the small size of the floe and the close vicinity of the ROV hut (<300 m away from the ship). However, as the ROV was only operated during 2-3 days of the week, there were many hours where EK60 and EK80 recording produced good data. Team OCEAN deployed one ADCP about 250m away from the ship, but this happened only 2 weeks before the end of our time at the floe and interference seemed to be minor.

Fish sampling

During Leg 5, the procedure defined as standard during Leg 1 was followed through the entire period, with few exceptions. One long line has been deployed at the end of the first week at the floe, targeting the mesopelagic area (i.e., between 200 and 400 m depth). Unfortunately, there was no fish caught despite what seemed like a strong 'fish signal' at the echo sounder. There were no further longline deployments due to the concern of other teams about potential entangling with their equipment or the ships CTD. However, over the course of Leg 5, 5 polar cod were sampled by off-chance or unintentionally. One polar cod came from the underway seawater system (still in very good conditions), three were caught at the ice hole of Ocean City (thanks to Mario Hoppmann) and one by an ice corer. All these fish where measured, weight and dissected according to protocol (fin clip, stomach, hindgut, gonads, liver, muscle, otoliths, and remaining fish) and preserved at -80, -20, in Dietrich solution or Ethanol for further analysis at home.

Environmental DNA

During the entire Leg 5, we used the large CTD rosette to take water samples for DNA and RNA metagenomics analyses, see the part of this chapter dealing with the MOSAiC ECO Core Program. Within the EFICA project, we will mine the large metagenomic data sets that will be created by the MOSAiC Eco-omics group for fish and zooplankton genes.

Preliminary (expected) results

Altogether, ca. 2 TB of hydroacoustic data were collected during Leg 5 of MOSAiC. A scattering layer of living organisms was always observed in the Atlantic water layer of the CAO, but with varying density and varying vertical distribution. The organisms in the fish size range (>-45 dB) had at the floe often very high densities.

Data management

The data have been submitted to the MOSAiC Central Data Storage (MCS).

References

No references.

Objectives

Sampling for 18S metabarcoding accomplished during MOSAiC Leg5 is part of the overall MOSAiC molecular time series, which aims to link taxonomic and functional diversity of Arctic marine microbes over the complete annual cycle to elucidate differences in the functional background of Arctic marine microbial communities during seasonal succession. The resulting information is the basis to identify key phenotypic traits underpinning the role of microbial communities in maintaining Arctic marine ecosystem processes, functionality and services during different periods of the year.

Work at sea

Automated sampling for 18S metabarcoding

Marine pelagic microbial distribution and community composition is a function of ambient environmental conditions, displaying high spatial heterogeneity or "patchiness", and

temporal variability. On one hand the cruise track of RV Polarstern covered a large geographical region within the Arctic Ocean during MOSAiC Leg5. This included western Fram Strait, the western Arctic Ocean north of Greenland, the North Pole, the western parts of Amundsen Basin and Nansen Basin, and eventually Eastern Fram Strait, while different environmental conditions, such as sea ice coverage, characterized these different geographical regions. Beyond the large geographical area, MOSAiC Leg5 covered the two months long transition period from Polar Day to Polar Night, and from sea ice melt to freeze up. This transition period was characterized by rapid changes in physico-chemical properties and sea ice coverage over the water column. Marine microbes are from utmost importance for marine ecosystem functionality and services. Arctic marine microbial communities are well prepared to respond to rapid changes in environmental conditions, reflecting the pronounced seasonality in the Arctic Ocean. In consequence, we can expect that rapid changes in microbial communities go alongside with rapid changes of ambient environmental conditions, leading to changes in ecosystem functionality. Our work at sea during MOSAiC Leg5 was dedicated to elucidate the impact of rapidly changing environmental conditions on pelagic microbial community composition over a large geographical area and during the transition period from Polar Day to Polar Night. This included sampling for 18S metabarcoding with high spatial and temporal resolution using the **auto**mated **fi**ltration system for **m**arine microbes (AUTOFIM) (Figure 1). The device reduces the effort related to adequate sampling of marine phytoplankton, as it provides the technical background for automated high resolution collection of marine samples for molecular analyses. It is coupled to the ships pump system and allows filtration of a sampling volume up to 5 litres. Filtration can be triggered after defined regular time intervals or remote controlled. Twelve consecutive samples can be processed in total. Samples are treated with a preservative prior to the transfer of samples into a filter archive to prevent degradation of sample material. During MOSAiC Leg5 AUTOFIM was used to collect samples from the upper water column at a depth of ~ 10 m, which is the depth of the inlet of the ships water pump system. Samples were collected approximately every two hours during the transit from Fram Strait to the MOSAiC Leg5 floe and every four hours during the transit from the floe back to Fram Strait. This sampling strategy allowed to collect samples along the ship's track with an approximate spatial resolution of ~ 15 nautical miles. Sampling frequency was every 24 h while RV Polarstern was drifting with the floe. Overall, we collected 139 samples (30 samples during drift and 109 samples during transit) for molecular analyses of pelagic microbial community composition during MOSAiC Leg5. All samples were preserved and frozen at -80°C for storage until analyses in the home laboratories (AWI, Bremerhaven).

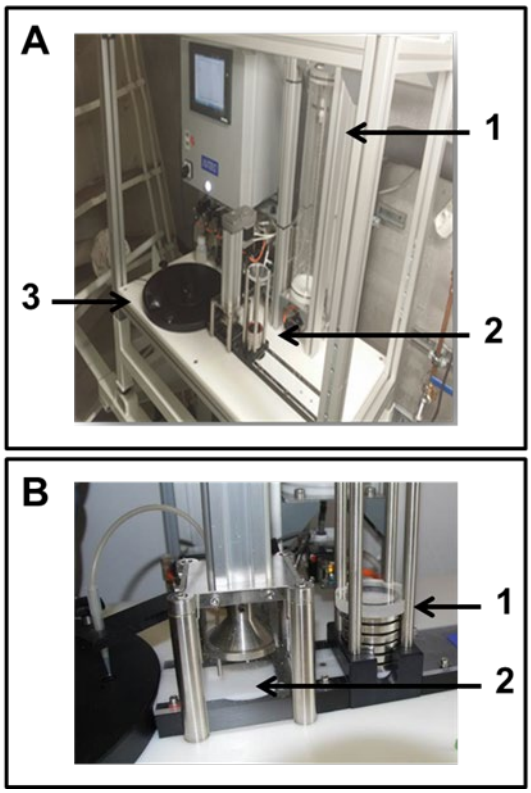

Fig. 1 A: AUTOFIM installed on board RV Polarstern (1: Sample reservoir; 2: Filtration; 3: Archive for preserved filters. B: Filtration-module (1:Filter stacker; 2:Filtration cap).

Preliminary (expected) results

The samples will be subjected to nucleic acid isolation and sequencing in the home laboratory at AWI Bremerhaven.

Data management

Raw sequences generated in this project will be published via GfBio in collaboration with the European Archive for Nucleotides (ENA).