the Nansen LEGACY

Seasonal cruise Q1 2021

Cruise Report

The Nansen Legacy Report Series 29/2022

Seasonal cruise Q1 2021

Cruise 20210703

R/V Kronprins Haakon
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Summary

The Nansen Legacy cruise Q1 (Q1: 1st quarter of the year) was part of the seasonal investigation of the northern Barents Sea and adjacent Arctic Basin. The cruise was conducted in March 2021, and focused on comparing the physical, chemical and biological conditions along the Nansen Legacy main transect in open waters and within the sea ice. The cruise addressed objectives of the Nansen Legacy work packages 'Physical drivers' (Research Focus 1), 'Human impact' (Research Focus 2) and 'The living Barents Sea' (Research Focus 3). In total, seven process stations (P1, P2, P3, P4, P5, P6 and P7) were conducted, with some more additional (NLEG) stations in-between. The station P1 was the only open water station, all other stations were in ice covered waters at the shelf, on the slope and in the deep basin. The area was dominated by about half meter thick first year ice with the thinnest ice in the south and around the Atlantic inflow in the area of P6 and P7. The ice and snow thickness were measured and observed at different scales using an electrodynamic GEM-2 device and a Magna-probe within a few hundred meters of the ship. For mapping of the regional scale of ice thickness a small drone as well as a helicopter-carried EM-bird were used. One drifter buoy and one ice mass balance buoy were deployed. Each process station lasted more than a 24-hour period (except for P3) to allow full daily cycle process measurements (i.e. rates), in addition to extensive biodiversity- and abundance sampling of microbial, plankton and benthic communities. Samples for trophic interaction, ecotoxicology and ocean acidification studies were also collected. Between process stations, CTD depth profiles were taken for higher resolution of the physical environment and water chemistry. Acoustic survey, ADCP, pCO_2, GNSS recordings and radiosonde launches (weather balloons) were conducted throughout the cruise.

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1. Background

The RV Kronprins Haakon cruise “Nansen Legacy Q1” was part of the seasonal investigation (Q1= 1st quarter of the year) of the northern Barents Sea and adjacent Arctic Basin. The cruise addressed objectives of the research foci in RF1 on Physical drivers, RF2 on Human drivers and RF3 on the living Barents Sea, and collected necessary data along the Nansen Legacy transect, with special focus on sea ice work. Experiments were conducted to measure and quantify processes and rates.
The ”Nansen Legacy Q1” cruise should be seen as a part of the set of seasonal cruises undertaken in Nansen Legacy, together with the cruises Q2 (April/May 2021), Q3 (August 2019) and Q4 (November/December 2019). In this context, the “Nansen Legacy Q1” covers the time when it was expected to be coldest in the research area, and sea ice formation and growth is going on. For the cruise, the capacity of RV Kronprins Haakon was fully used in order to cover the different research foci, and to work also across the different disciplines.

After a short presentation of the survey area (section 2), this report focuses on the different activities of the science team members on board (section 3). At the end an appendix contains various information about the cruise in form of tables, and the blogs that were published parallel to the cruise.

Figure 1: View on working deck of RV Kronprins Haakon. Photo: Sebastian Gerland, Norwegian Polar Institute.

2. Survey area

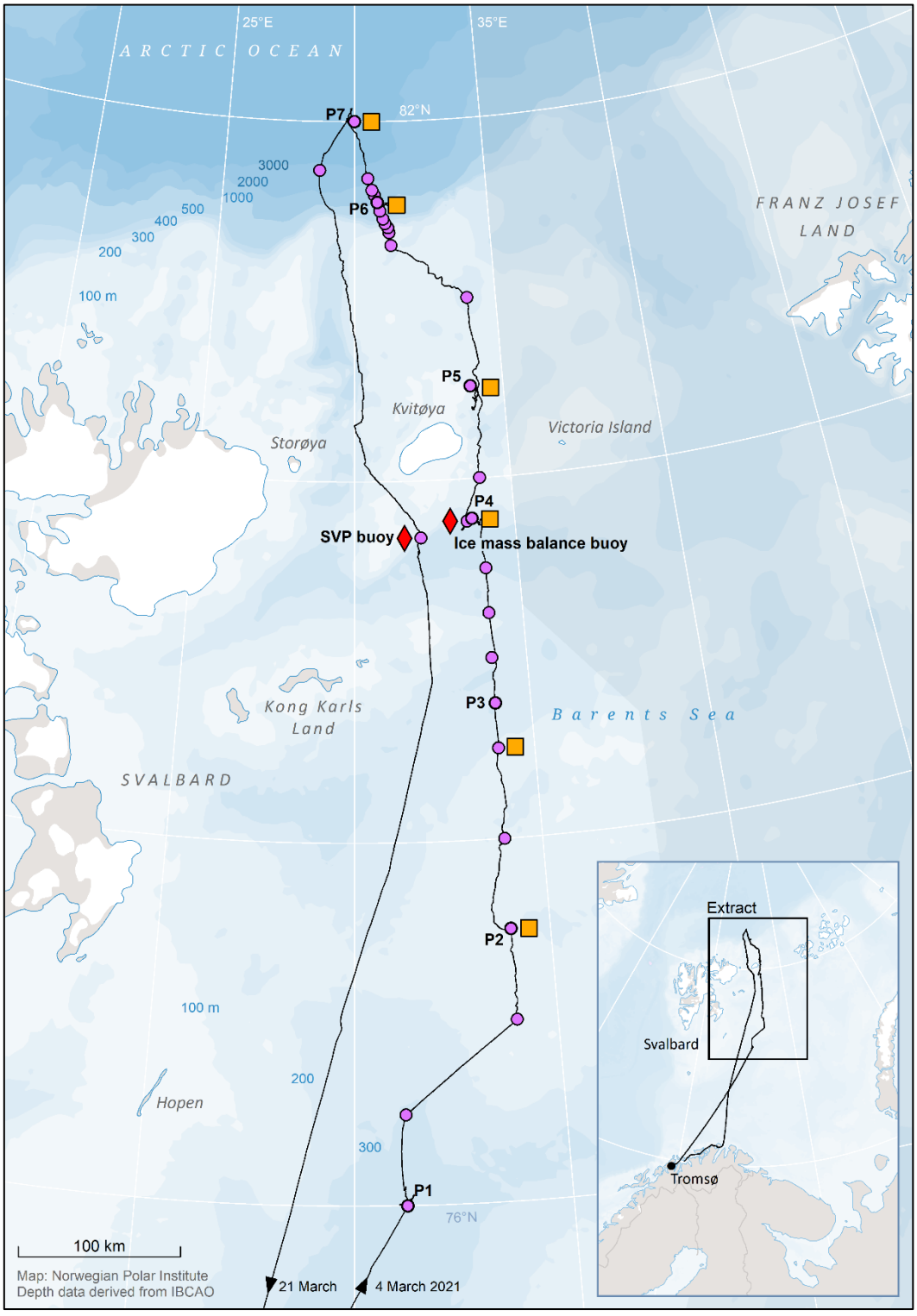


Figure 2: Cruise map with stations (purple circles: all stations, P and number: main stations, yellow squares: ice station, red rhombuses: buoy deployments with small ice stations) and cruise track (black line). Map preparation and design: Anders Skoglund, Norwegian Polar Institute.

3. Activity reports

3.1 Underway surveys

3.1.1 Acoustic EK80, ADCP & LADCP

Asgeir Steinsland (IMR) and Randi Ingvaldsen (IMR)

Acoustic surveying was conducted using the six Simrad EK80 echo sounders, mounted on the drop keel, 18kHz, 38kHz, 70kHz, 120kHz, 200kHz, 333 kHz split beam systems. When the ice conditions were such that the keel was retracted, and protected, the data collection was continued with similar systems mounted in the Arctic tanks. For depths shallower than 500m, automatic ping rate and a range of 500 m was used and for depths deeper than 500 m, a ping rate of 0.1 Hz and a range of 800 m was used.

3.1.2 Radiosondes

Sebastian Gerland (NPI) and Asgeir Steinsland (IMR)

Radiosondes were conducted every 12 hours. The data from these sondes give information on atmospheric properties such as temperature and moisture vs. height, and they are fed directly into the Global Telecommunications System (GTS), where weather data are collected. Every 12 hours per day is twice as often as the standard how radiosondes are otherwise launched from RV Kronprins Haakon. The use of more frequent radiosonde launches on this and other process cruises in Nansen Legacy was discussed within the project, with the IMR crew, and with the contact IMR has for this in Germany at Deutscher Wetterdienst (Rudolf Krockauer). All sides were interested in more radiosondes, since there are few observations for the area and thus forecasts can be improved, and to give later more possibilities for inspecting atmospheric conditions during the cruise, when assessing processes and changes in sea ice and ocean in the same region.

Figure 3: Radiosonde launch from Kronprins Haakon on 15 March 2021. Photo: S. Gerland, NPI.

3.1.3 GNSS satellite signal reflection measurements

Sebastian Gerland, Dmitry Divine, Marius Bratrein (all NPI), and Asgeir Steinsland (IMR)

A receiver for GNSS satellite signals is mounted on the port side of the vessel, close to the observation deck. With this, continuous measurements of GNSS signals were performed. GNSS signals are part of the satellite navigation GPS system. Here, they are used to learn more about surfaces they are reflected on, for the case of the cruise sea ice with different properties or the ocean surface under different wind/wave conditions. Similar measurements have been performed earlier from RV Lance in Fram Strait, and during the MOSAiC expedition with RV Polarstern. This work is done in close collaboration with the Geoforschungszentrum Potsdam (GFZ) and DLR Neustrelitz in Germany, the contact person is Maximilian Semmling.

3.1.4 Ice observations from bridge (ASSIST)

Dmitry Divine (NPI), Adam Steer (NPI) and Tristan Petit (NPI/UiB)

Regular visual sea ice observations using ASSIST protocol (see https://cryo.met.no/en/icewatch) were made by while RV KPH was in ice-covered waters. Sea ice conditions were observed everyone to three hours, except for the night time between midnight and 6:30, from the observation deck of the vessel. Various sea ice parameters including sea ice types, floe sizes, snow cover, ridges, rafting etc. were recorded along with ship data (position, speed, and heading) and meteorological data (air and water temperature, air pressure, wind speed and direction, and humidity). Photos were taken with each observation (3 photos, looking out towards port, bow, and starboard. In total 93 observations were made during the cruise while RV KPH was in the ice zone.

3.2 Physics

3.2.1 Sea ice physics (RF1)

Dmitry V. Divine (NPI), Adam Steer (NPI), Tristan Petit (NPI/UiB), Marius Bratrein (NPI), Jan Are Jacobsen, Elisabeth Jones (IMR), Sebastian Gerland (NPI) and Jørn Dybdahl (NPI).

General

The sea ice work during the AEN SQ1 cruise was conducted during the period of 06-21 March 2021 while vessel was in the sea ice covered area. Most of this period the ice conditions in the northern Barents Sea remained relatively stable with a homogeneous sea ice cover. A dominance of level drift first year ice some 40-60 cm thick was observed between the areas of stations P3 and P7. The floe sizes varied from larger floes of some few hundred meters size and bigger at NL stations P3, P4 and P5 with ice concentration close to 10, to smaller floes at P6 and P7 close to the area of Atlantic Water influence north of Svalbard. This area (P6 and P7) north of Svalbard also featured a combination of thicker and more deformed ice forms such as rubble ice formed by ice dynamics earlier, level FYI ice of 40-60 cm thick and younger ice forms some 10-20 cm thick. This is indicative of ice divergence and cold stable weather conditions for about a week prior to our arrival to the area. Significant changes in the structure of ice pack were also observed along the route of KPH from 20.03. on the way south when a swell from the passing storm broke up the ice into floes of cake ice size of about 20 m and less.

The RF1 package work, with specific Nansen Legacy project tasks, conducted by sea ice physics group on the cruise comprised the following components:

Local scale (*in situ*) sea ice observations such as:
T1.1-1.2, T1-2.2 Ice coring;
T1.1-1.2, T1-2.2 Snow pits to study the *in situ* properties of the snow pack;
T1.1-1.2, T1-2.2 Ice and snow thickness surveys along transects using electromagnetic instrument GEM-2 and snow thickness surveys using Magnaprobe;

T1.1-1.2, T1-2.2 Local scale sea ice surface topography aerial surveys using drone Anafi Parrot supported by GPS surveys using the two stationary Leica base stations on the ice and Leica rover;
T1-2.4 Study of the optical properties of sea ice (light transmissivity) using TriOS RAMSES setup
T1.1-1.2, T1-2.2 BlueEye ROV survey of bottom sea ice surface.
T1.1-1.2, T1-2.2, RA-C *Regional scale* ice and snow thickness surveys using the helicopter-borne electromagnetic instrument (HEM, EM-bird) and a higher resolution camera system to map ice surface topography (ICE camera).
T1.1-1.2, T1-2.2 *Buoy deployments* to follow sea ice drift and time evolution ice thickness at a buoy location.
T1-2.4 *Light climate* program (See dedicated report).
T1.1-1.2, T1-2.2, RA-C *Ordering high resolution SAR imagery* from Radarsat-2 satellite for some ice station areas to upscale the local on-ice work to a regional scale and provide necessary validation data for sea ice remote sensing.
T1.1-1.2, T1-2.2 *ASSIST regular ice observations* of sea ice conditions. These observations are conducted also to support GNSS reflectometry using the onboard GNSS-R setup from DLR, Germany.
T1-2.3 *Weather balloons (radiosonde) launch* from KPH every 12 hours.

Both local and regional scale work was also carried out in coordination with the NPI data section and the Centre for Remote Sensing at UiT (CIRFA) and RA-C who assisted in ordering the acquisitions of Radarsat-2 high-resolution SAR scenes during the cruise.

On ice work

In total 8 ice stations for ice physics were made on pack ice, of which 4 where 2-days long stations. On longer stations an extended ice physics program was implemented while on shorter stations the program was reduced to basic coring, snow thickness measurements and shallow on ice CTD casts and buoy deployment. Short description of stations and an overview of the activities is follows below.

Ice coring

The following ice cores are included in the general ice coring program for physics:

- Salinity/Stable water isotopes core, processed onboard, subsampled for stable water isotopes
- Temperature core, processed on the ice and used as a Chemistry core 2
- Stratigraphy core, stored frozen, to be analysed later
- Archive core, stored frozen, to be analyzed later
- Chemistry core 1, processed onboard
- Chemistry core 2, processed onboard.
  Density core, stored frozen, to be analysed later.
  Optics core, processed onboard.

Figure 4: Adam Steer (NPI) doing a descriptive analysis of the recovered ice core at P5. Photo: Sebastian Gerland (NPI).

Sea ice and snow thickness surveys

On longer ice stations with extended program (P4, P5, P6, P7), spatial distribution of sea ice thickness was additionally surveyed directly by thickness drillings and indirectly using a combination of a snow probe (Magnaprobe, Snowhydro Ltd) and multi-frequency ground EM instrument (GEM-2, Geophex Ltd). The GEM-2 is placed on a sledge and pulled over the ice; the data including GPS position is logged at a frequency of 0.5 Hz to an Archer II field computer. The snow thickness is measured in parallel with Magnaprobe enables to obtain both ice and snow thickness profiles along the transect lines. Thickness drillings were done on selected spots, also for calibration of GEM-2, and ice thickness and freeboard were measured with a Kovacs thickness gauge. The data acquired during the transect work was partly analysed already onboard.

Figure 5: Dmitry Divine, Adam Steer and Jørn Dybdal (NPI) doing snow and ice thickness survey with the GEM-2 and Magnaprobe instruments at P5. Photo: Sebastian Gerland (NPI).

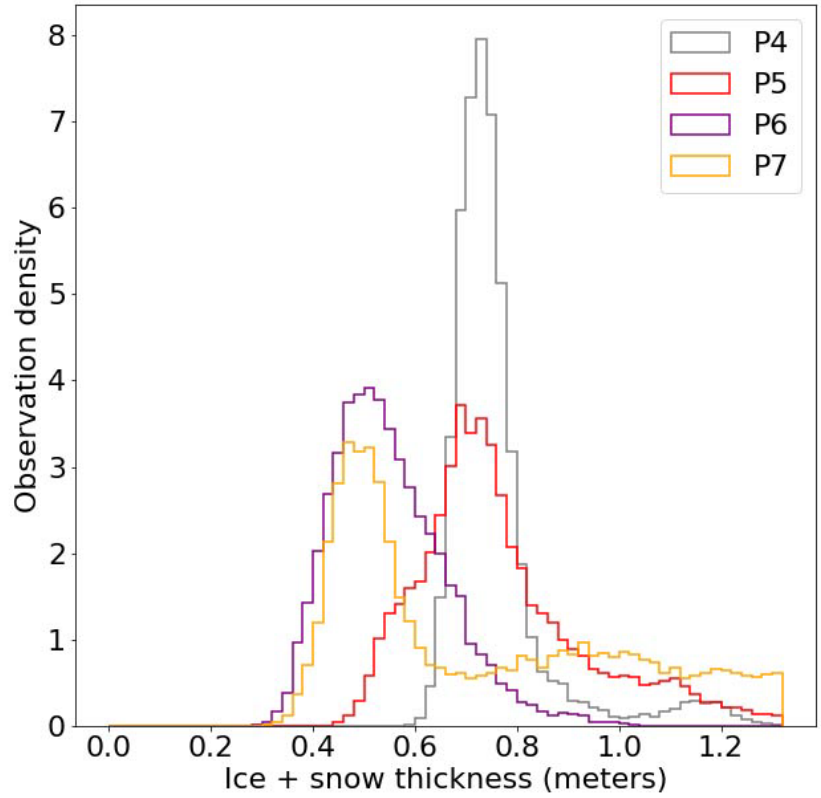


Figure 6: Combined snow depth and ice thickness (distance from snow surface to seawater) histograms for the immediate surrounds of sampling sites at P4, P5, P6, and P7. Note - data shown here are not final, processing and QA is underway at the time of writing.

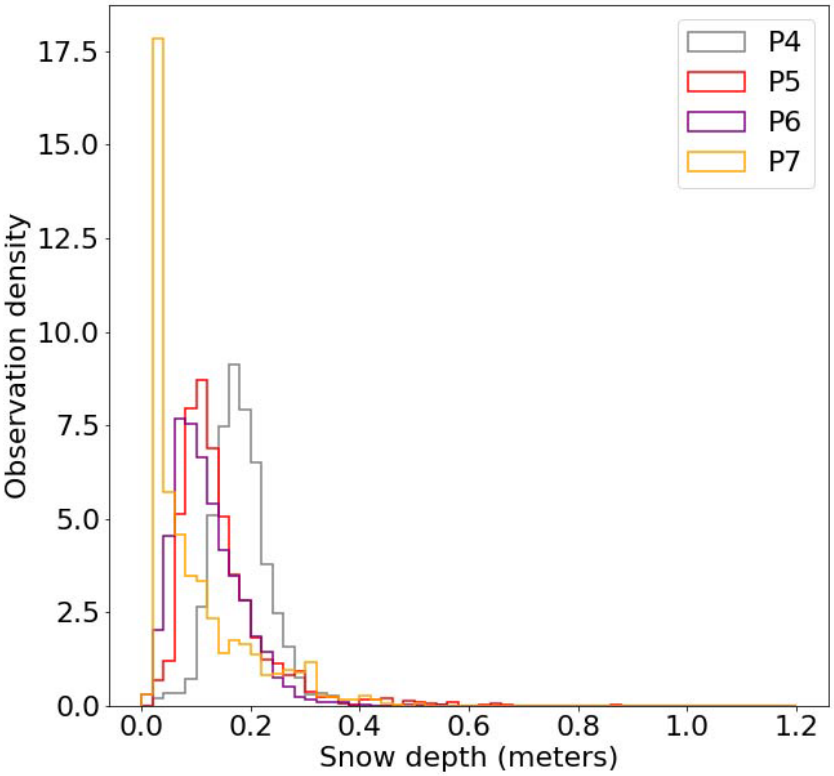


Figure 7: Histograms of snow depth collected by transect walks with a Magnaprobe for the immediate surrounds of sea ice sampling sites at stations P4, P5, P6 and P7. Note - data shown here are not final, processing and QA is underway at the time of writing.

Sea ice/snow surface topography aerial surveys using a small drone

A small drone (Parrot ANAFI USA) was used to capture sea ice topography on a local scale at stations P4, P6 and P7. In total five flight were undertaken:

Date	Mission
9 March 2021	Short test flight (15 min) from KPH helideck to assess behavior in ship environment
10 March 2021	Ice station 3/ P4 mapping
15 March 2021	Station P6 mapping, hampered by fogging goggles
16 March 2021	NLEG 23 flight from KPH helideck
17 March 2021	Station P7 mapping

Because of the magnetic environment and ice drift, all mapping missions were flown manually in 'GPS lapse' imaging mode, capturing an image every time the aircraft moved 5 meters (in three dimensions) from the last image.

The ANAFI USA performed well in adverse conditions, operating at -26 on station 6 / P6. The aircraft experienced some icing on the initial test flight and the final P7 flight. At very high latitudes the aircraft compass must be recalibrated at every battery change, and the pilot must ensure that a clear line of sight is kept between the controller and aircraft. Flying at P6 and 7 was very dynamic and demanding.

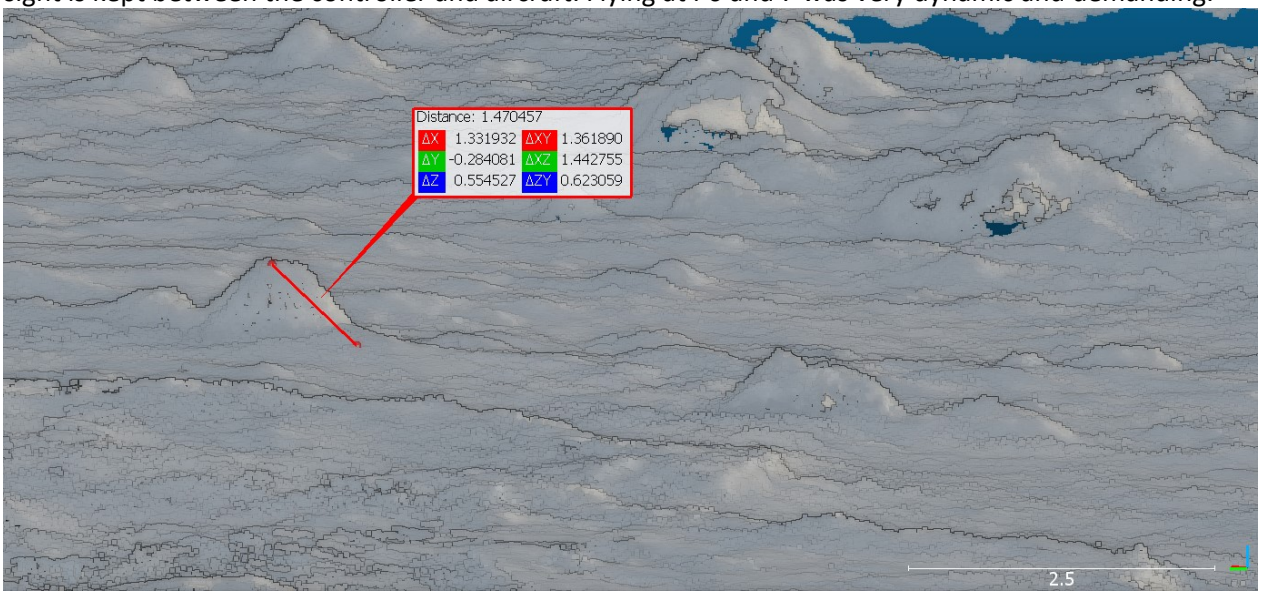


Figure 8: Photogrammetric reconstruction of sea ice surface from the blocky region of rubble ice area at station P6


Figure 9: Icing after drone operations at P7, in -17 C air temperatures

In order to support the work on transects as well as aerial ice topography surveys, on stations P4 and P7 two Leica base stations were setup on the ice. The stations allowed following sea ice floe drift and rotation with a high accuracy. This was also complemented with a GPS survey for several selected locations in order to acquire additional Z-control points for subsequent photogrammetric reconstruction of snow surface.

Figure 10: Adam Steer (NPI) is setting up Leica GPS base station at P7. Photo: Dmitry Divine (NPI).

List of sea ice stations with stations notes/overview.
Note that more details on the work conducted on ice stations, already processed station data, as well as relevant photos are provided in the respective Ice station folders.

07.03.2021 Ice station 1; Nansen Legacy P2 site
Coordinates at start: 77° 30.23'; E 33° 55.994' at 09:25 UTC; station duration about 2 hours. Atmospheric conditions: air about -10, water -1.8. Partly cloudy, moderate wind about 8 m/sec.
Ice station on drift ice in central Barents Sea. Station conducted in the area covered with partly refrozen/cemented pancake ice conglomerated in some 10-15 m size small ice floes. Grey/young ice some 15 cm in between. Very uneven surface covered with relatively fresh loose snow 12-15 cm thick. Ice thickness very uneven (see core thicknesses that vary a lot), most likely due to rafting with gaps between the ice not refrozen. Main ice thickness is (gap depth) is about 70 cm. GoPro footage have shown large, 5-10 cm gap at 70 cm depth with fish schools populating them.
The site was found representative for the area. Photos of the area and ice radar are taken from the bridge are found in the respective ASSIST folder and radar image in "Station photos".
Science program: short coring program physics/chemistry, RBR CTD cast, snow pit. Outreach: GoPro filming (fish school found in between the floes).

08.03.2021 Ice station 2; Nansen Legacy NLEG6 site
Coordinates at start: 78° 30.461'; E 34° 00.843' at 08:52 UTC; station duration about 2 hours. Atmospheric conditions: air about -16, water -1.8. Sunny, weak wind about 4-5 m/sec.
Ice station on drift ice in central Barents Sea. Station conducted in the area covered with level first year ice some 40-50 cm thick. Some areas at distance might have a larger thickness up to 70 cm. Coring site featured a level ice with little variability in ice thickness. Smooth snow surface with wind compacted snow of 6-10 cm thick. Photos of the area and ice radar are taken from the bridge are found in the respective ASSIST folder and radar image in "Station photos".
The site was found representative for the area.
Scientific program: short coring program physics/chemistry, one bio core, RBR CTD cast, snow pit and short snow transect. Outreach: GoPro filming.

10.-11.03.2021 Ice station 3; Nansen Legacy P4 site

Coordinates at start: 79.770873, 33.662819 at 06:15 UTC; 2 days ice station.
Atmospheric conditions: air about -17, water -1.8. Sunny, weak wind about 4-5 m/sec.
Ice station on drift ice in central Barents Sea. Station conducted in the area covered with slightly ridged (some 10% ice ridge concentration) first year ice some 50-60 cm thick (level ice part). Coring site featured a level ice with little variability in ice thickness. Some minor ridges/bumps on the surface probably in the areas where thin ice rafting might took place. The site was found representative for the area.
Surface covered with fresh snow which is not yet wind compacted on the top. More compact part lies below. Snow thickness some 15-20 cm.
Photos of the area and ice radar are taken from the bridge and found in the respective ASSIST folder and radar image in "Station photos".
Scientific program:

Day 1: 10.03

1) Test TOPO field marking; setting 2 GPS Leica stations (see sketch of the area) in a separate file (success).
2) GEM2/MP transects across the test TOPO field (success).
3) Short transect with crossing the ridge. GEM2 calibration (success)
4) Drone ANAFI overflight of the area (success)
5) ICEcamera flight over the area in a meander pattern at 3 altitudes (35-40m, 100 m and 800 m).
6) Optical cast from the ice, GPS survey and water sampling had to be moved to Day 2 due to bear interference with the scientific program. One of the Leica GPS was slightly damaged but can be used further.

Day 2: 11:03

1) Coring physics/chemistry (success)
2) Optics cast with hole opening in the ice. (instrument did not tolerate the cold and malfunctioned).
3) Water sampling for optics (success)
4) RAMSES on the optics site (partly success)
5) Drill holes on the TOPO site (success)

Outreach: GoPro filming.

11.03.2021 Ice station P4

Coordinates at start: 79°45.67', 33° 26.186 at 18:21 UTC; 1.5-hour station.
Short station on FYI drift ice to deploy SIMBA buoy. See deployment card for details in the respective station folder. The station is about 3-5 nm from the P4 station floe. Ice conditions are similar to Ice station 3 at P4. Snow thickness transect on the way back to the ship.

12-13.03.2021 Ice station P5; Nansen Legacy P5 site

Coordinates at start: N 80°29.832' E 034°06.758 at 13:15 UTC
Atmospheric conditions: Day 1: air temperature about -18, water -1.8. Cloudy, "flat light", weak wind about 4-5 m/sec. Day 2: air temperature -26; sunny, weak wind about 3-4 m/sec.
Ice station on drift ice in northern Barents Sea north east of Kvitøya. Station conducted in the area covered with preferentially level FYI some 45-55 cm thick. Ridges ranges across the transect triangle, coring site featured a level ice with little variability in ice thickness.Surface covered with cold wind-packed snow with thickness some 10-20 cm.
The site was found representative for the area.
Scientific program:

Day 1: 12.03 afternoon

1) GEM2/MP transects some 1 km long away of the ship, triangular shape (success).

Day 2: 13.03 morning and afternoon

2) Coring physics and chemistry (success),
3) CTD cast (2 casts, success)
4) RAMSES ice transmissivity (partly success).
5) Snow pit (success).
6) ICE Camera/EM bird flight in the station area with some passages over the ice station site and a transect.

14-15.03.2021 Ice station 6; Nansen Legacy P6 site

Coordinates at start: N 81°32.347' E 031°06.073 at 15:48 UTC
Atmospheric conditions. Day 1: air temperature about -28, water -1.3. Cloudy, fog, "flat light", weak wind about 4-5 m/sec.
Ice station on drift ice north of Svalbard on the Arctic slope. The ice floe is some 250 by 150 m size. One of the biggest with the thickness suitable for a safe on-ice work. Water warm due to Atlantic water inflow, a lot of steam from the open water areas, openings in the ice including large melt holes. Area of very intense ice melt.
Station conducted in the area covered with a mix of ice types, including melting FYI and younger ice types. A lot of ridged ice and ice rubble, including newly formed ridges.
Surface covered with cold wind-packed snow with thickness some 5-20 cm.
The site was found representative for the thicker ice in the area.
Science program:
Day 1: 14.03 afternoon

1) GEM2/MP transects some 200 m long away of the ship, triangular shape (success). And a short transect in the other direction away of the ship, interrupted. GEM2 calibration.

Day 2: 15.03 morning

2) Coring physics/chemistry (success).

Day 2: 15.03 afternoon

3) Snow pit with snow sampling (success)
4) RAMSES - logger and PC got frozen, partly success.
5) RBR CTD cast 2 times at "Ramses" site, (success).
6) Drone overflight (success).
7) Repeat GEM2/MP transect, partial success. Reached a fresh crack close to the first turning point, transect interrupted, "Archer" got frozen and could not be reactivated.

17-18.03.2021 Ice station 7; Nansen Legacy P7 site

Coordinates at start: N 81.996928; E 29.986175 at 05:45 UTC
Atmospheric conditions:
Day 1: air temperature about -24 C (morning, then rising to -17 during the day), water -1.8. Sunny in the morning, cloudy in the afternoon, weak northerly to easterly wind about 0-4 m/sec. Changed to south-westerly over evening.
Ice station 7 on drift FYI at Nansen Legacy P7 site north of Svalbard in the deep Arctic basin. Station is in the area some 35-40 km away of open water. Ice divergence with lot of recently formed ice in its early stages of ice formation (young grey ice to young grey to white ice). Station ice floe is an aggregate of ice floes of different age, thickness and roughness. The thinner level ice area is some 250 by 150 m size, with adjacent areas of rubble ice and patches of thicker level ice for hundreds of meters in two directions (see panoramic images in the respective folder).
Three major ice types: level ice some 40-50 cm thick, level ice some 50-70 cm thick, ice rubble area (heavily ridged).

Surface covered with cold wind-packed snow with thickness some 4-20 cm. Thinner ice of some 40 cm thick featured a homogeneous snow cover some 3-8 cm thick with hard wind packed snow. Thicker level ice with 15 cm some snow and thick snow accumulated around the rubble areas.
The site was found representative for the ice in the area.
Scientific program:

Day 1: 17.03 morning

1) Setting up 2 base GPS stations (success), marking the Z-control points;
2) GEM2/MP transects some few hundred meters long away of the ship, with irregular shape (success). GEM2 calibration.
3) Camera and EM-bird fight to north-east and over the RS2 acquisition area in the afternoon. Camera did not work already over the RS2 box.

Day 1: 17.03 afternoon

4) Drone overflight of the area (success);
5) Ice coring physics/chemistry, 2 coring sites with different level ice thicknesses (success);
6) Snow pit, 2 pits on two different types of level ice (success);
7) GPS survey (success).

Day 2: 18.03 morning and afternoon

8) RAMSES in the area of coring site 1 on 40 cm thick ice + coring for optics (success)
9) ROV test run (success)
10) Two flight with EM-bird and ICE camera, morning and afternoon, over the area of RS-2 acquisition at 13:17 UTC. Extensions of these flights to north, east and south east. See flight log. (success)

20.03.2021 Ice station 8; 2 nm from M2 mooring location

Coordinates at start: N 79°41.244'; E 032°05.631 at 07:00 UTC; station duration 2 hours. Atmospheric conditions: air about -3 C, water -1.8 C. Fog with visibility around 300-400 m, wind 9-10 m/sec.
Ice station on drift ice in central Barents Sea. Ice floe some 400 m size, with level ice some 50-60 cm thick. The site was found representative for the area.
Scientific program: short coring program physics/chemistry, RBR CTD cast, snow pit, SVP buoy deployment.

Regional scale helicopter-borne ice and snow thickness surveys

While KPH was in ice covered waters, we conducted in total 10 aerial regional scale sea ice helicopter-borne surveys of ice conditions along the Nansen Legacy transect. Two instruments were used during the surveys: a helicopter-borne electromagnetic instrument (HEM) EM-bird, providing the thickness of ice and snow along the flight track, and ICE camera acquiring images of sea ice/snow surface with a resolution and time lapse sufficient to enable a photogrammetric reconstruction of surface topography with a cm- scale accuracy.
Due to technical troubles with the EM-bird, the first two flights (F1 and F2) were conducted with ICE camera only. For all remaining flights both instruments were in use. Flight tracks for the airborne campaign are shown in Figure 11; short overview of the conducted flights presented in Table 1.

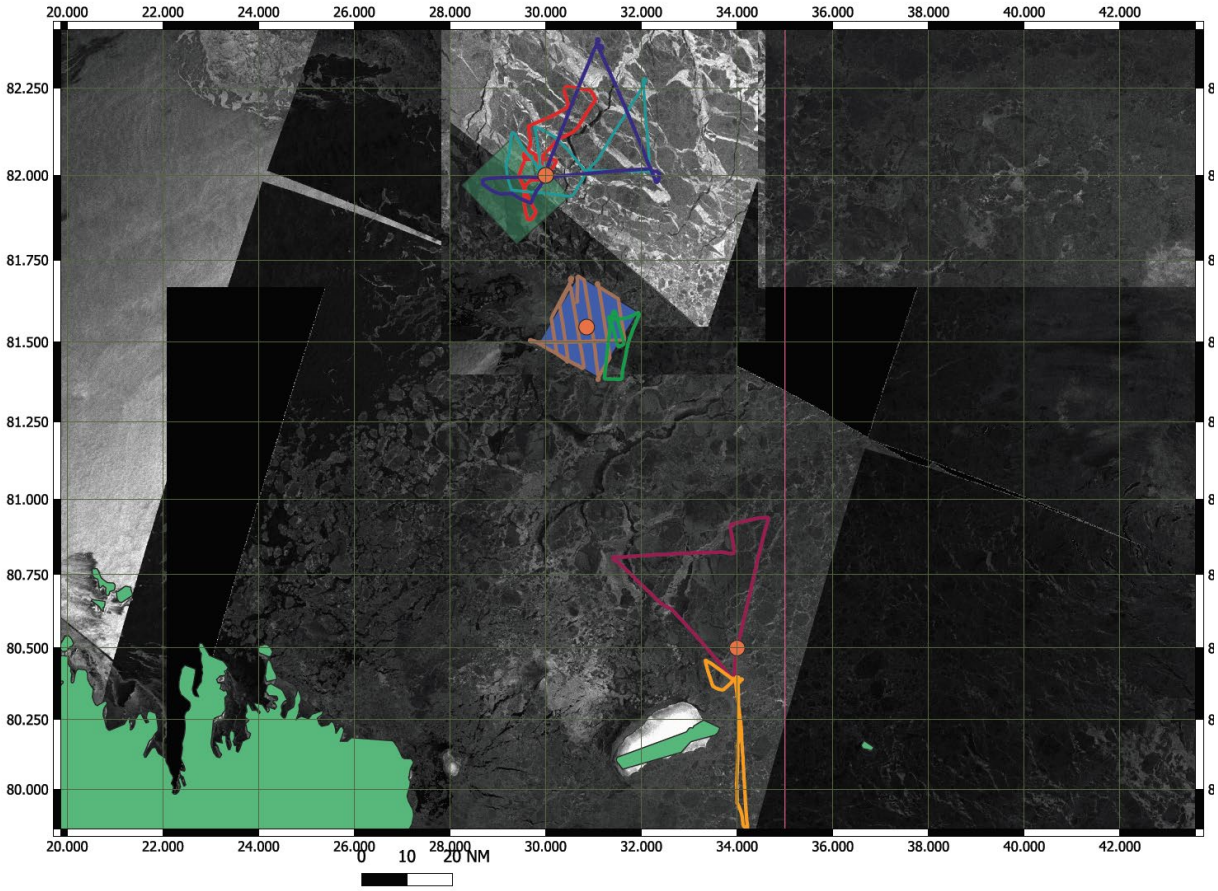


Figure 11: Flight tracks for combined EM-bird/ICE camera ice survey flights F4-F11, conducted 13-18.03.2021; see table NN below for more details on the flights. Colored boxes show footprints (bounding boxes) of ordered Radarsat-2 high resolution SAR scenes. Sea ice image of the area is the mosaic of SAR images acquired by Sentinel-1 in different days and it do not exactly correspond the real ice situation during the flights.

Table 1: List of sea ice survey helicopter flights with a short overview of the flight patterns. All times in UTC.

Flight ID	Date	Time takeoff	Time landing	Description
F1	07.03	14:35	14:51	Test flight 1, helicopter crew training, ICE camera
F2	08.03	12:48	13:26	Test flight 2, helicopter crew training; ICE camera
F3	10.03	08:16	09:46	Flight with ICE camera over the test TOPO site of the Station 3 (P4) and in the area
F4	13.03	06:11	07:51	EM-bird/Ice camera flight from Ice station 5 (P5) to the south towards P4 location
F5	13.03	11:11	13:07	EM-bird/Ice camera flight from Ice station 5 (P5) to the north and north east
F6	14.03			Flight aborted after 4 minutes due to low visibility and icing fog banks from nearby open water; no data acquired
F7	15.03	13:17	14:20	EM-bird/ICE camera flight to the south from Ice station 6 (P6)
F8	16.03	11:57	13:22	EM-bird/ICE camera flight towards the morning (09:00 UTC) RS2 acquisition bounding box
F9	17.03	06:10	08:02	EM-bird/ICE camera flight towards east to north east and then towards the RS2 acquisition area (afternoon RS2 scene) No flight in the afternoon to the acquisition bounding box of RS2 at 13:47 UTC due to bad weather
F10	18.03	06:57	08:52	EM-bird/ICE camera flight from Ice station 7 (P7) towards the RS2 bounding box for today (13:17 UTC) acquisition; box could not be well covered due to open water areas and low clouds, flight continued to north and north east
F11	18.03	11:42	12:57	EM-bird/ICE camera flight from Ice station 7 (P7) to the south-east and east- and north east, then continued again to the RS2 bounding box from 18.03

The total length of flight tracks during the cruise was about 1300 km over 15.5 flight hours. Interpretation of the derived data including a conversion to the actual total sea ice and snow thickness will follow.

Buoy deployments

Two buoys were deployed during the cruise, both on drift ice of the northern Barents Sea.

1) SAMS SRSL Ice mass balance buoy of SIMBA type deployed on Ice station 4 on 11.03.2021 on level ice some 45 cm thick at N 79.7612 E 33.4364, UTC 18:21. The buoy is equipped with a thermistor chain that measures a temperature profile in snow pack, ice slab and underneath the ice, as well as an air temperature sensor on the top.
2) SVP buoy deployed on Ice station 8 on 20.03.21 on 55 cm thick level ice at N 79.684109; E 32.063809, UTC 08:14. At the time of deployment the location was some 2 nm away of the Nansen Legacy mooring M2. The buoy provides on the hourly basis data on air temperature, sea level pressure and buoy coordinates.

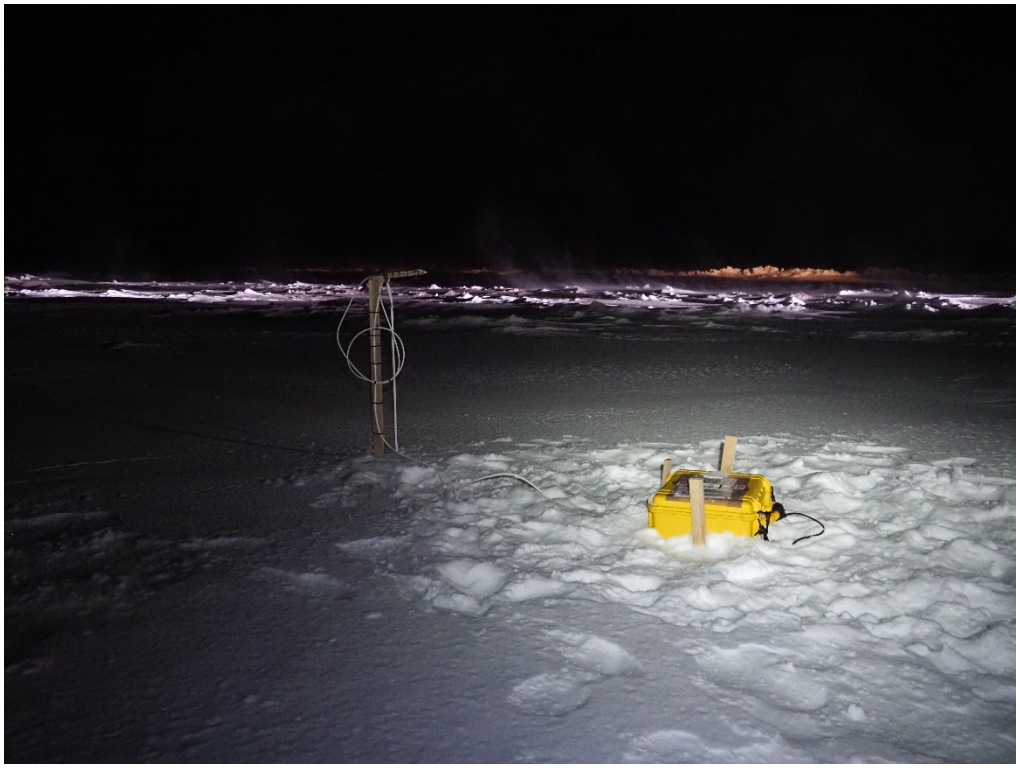


Figure 12: SAMS SRSL SIMBA buoy deployed on ice floe of Ice station 4. Photo: Adam Steer (NPI).

More details on the buoys and the deployment locations are found in the respective deployment cards in Ice station folders.

3.3 Microbiology

3.3.1 Microbes: biodiversity, abundance, biomass, distribution & activity (T3-1 & T3-4)

Oliver Müller (UiB), Anna Grytaas (UiB), Miriam Marquardt (UiT), Martí Amargant (UiT), Simon Kline (UiO), Snorre Flo (UNIS), Cheshtaa Chitkara (UNIS), Natalie Summers (NTNU), Yasemin Bodur (UiT)

The activity contributes to tasks T3-1 and T3-2 and links to T3-3 and T3-4. Samples for microbial (viruses, prokaryotes and protists) community composition, abundance and activity were collected from one open water stations (P1) and six ice covered stations (P2, P3, P4, P5, P6 and P7). A reduced sampling effort was conducted at the open water station P3. Pelagic samples were collected at all stations, while stations P4, P6 and P7 also included ice samples (ice-cores and under ice water). In addition, flow cytometry samples, XRF samples, and Durapore filters for DNA extraction were taken for the standard depths at several NLEG stations (FCM and Durapore: NLEG2, NLEG3, NLEG5, NLEG6, NLEG8, NLEG9, NLEG10, NLEG12, NLEG14, NLEG15, NLEG19, NLEG23; XRF: NLEG2, NLEG3, NLEG5, NLEG6, NLEG9, NLEG14, NLEG19). Sampling also included phytoplankton nets. Chl *a* and live protist samples were analysed on board, while all other samples were preserved or frozen for later analyses. On board experiments included a grazer exclusion experiment. These were done at stations P1, P4 and P6, prepared by gentle reverse filtration of surface water from 20m to retain organisms of different size fractions (<0.8µm; <3µm; <90µm) and were incubated each for six days with additional nutrient and copepod treatments at *in situ* temperature and light. Subsamples for abundance and diversity analyses were collected at different frequencies throughout the incubation period.

Several functional aspects of pelagic and sympagic primary producers were studied during the Nansen Legacy Q1 cruise. At stations P1, P4, P5, P6 and P7, water was sampled from the standard depths 10, 20, 30, 40, 60, 90 and spiked with radioactively labeled carbon in order to determine the carbon

fixation rate (i.e. the primary production rate) of phototrophic organisms. Additionally, water from 10m and 20m was spiked with stable isotopes of Carbon (13C) and Nitrogen (15N) to estimate the F-ratio (which fraction of the primary production is new production). One incubation bottle was also treated to assess the nitrification activity of microbes. This water was incubated in situ for 24 hours, attached to the sediment traps or from an ice hole (P4). The mooring was not recovered at P1. In parallel, water from 10m was used to study the photosynthetic response of the community to light intensity (P vs I curves). At the ice-covered stations (P4, P6 and P7), the bottom 3cm of 4 ice cores were sampled and pooled for similar incubations: under-ice primary production and nitrogen uptake in situ, P vs I curves. In addition, one ice core was collected at P6 and P7. The brine from the bottom 10 cm was analyzed with a spectroradiometer, to assess the absorption spectra of ice algal pigments.

The aim of sampling during the Nansen Legacy Q1 cruise was to assess the pre-bloom condition of microalgae (phytoplankton and under ice algae). Water samples were taken at the open water stations P1, P2, P3, P5 and P6, at 10m and 20m using the CTD. Photosynthetic parameters were measures using Pulse Amplitude Modulated fluorometer (PhytoPAM), that measures fluorescence output at increasing light intensities. As the biomass was low, 300mL of water was concentrated down to 3mL. Water was also filtered through GFF filters then frozen to bring back to Trondheim where pigment analysis will be conducted using HPLC. Additional water samples were fixed in Glutaraldehyde to be analysed in Southampton using automated flow cytometry (CytoSense) to look at trait variability of phytoplankton cells. The same protocols were used at the ice stations P4ice, P6ice and P7ice with under ice water from the water hole (0.5m deep). At stations P4ice and P7ice, the bottom 3cm of ice cores were melted in 300mL of seawater and similarly processed.

Additionally, three ice cores (0-30cm) were sampled at P4ice, P6ice and P7ice for investigation of sea ice meiofauna (sympagic meiofauna) abundance and biodiversity. All ice sections were examined with a stereomicroscope on board after melting and no organisms were found.

Sampling for protist and prokaryote community compositions (DNA metabarcoding) and activities (metatranscriptomics) was conducted as on previous cruises. At ice-stations (P4, P6 and P7) additional samples for metabarcoding were taken from under-ice water (UIW, 0.5 m), and from ice-core sections (Biobulk cores).

List of parameters sampled:

Biodiversity

- Genetic identification of community composition of protists and prokaryotes (Metabarcoding)
- Genetic identification of (free) virus diversity (Virus diversity)
- Qualitative analyses of protists >10 µm from net hauls (Net)
- Qualitative and quantitative analysis of plankton including coccolithophores by scanning electron microscopy (SEM)
- Algal diversity by culturing (Cultures)
- Biodiversity of ice meiofauna (Barcoding)
- Chemotaxonomy (HPLC pigment analysis)
- Microalgae trait variability (flow cytometry)

Abundance and biomass

- Algal biomass (total and >10 µm chlorophyll a concentration Chl *a*)
- Abundance of bacteria, virus, pico and nano-plankton by flow cytometry (FCM)
- Quantitative analyses of protists from water samples by light microscopy (Microscopy)
- Particulate organic carbon and nitrogen (POC/PON)
- Elemental composition of seston (XRF, particulate C:N:Si:Ca:P:Mg:S:K:Fe)(XRF)
- Abundance of ice meiofauna

Activity

- Genetic identification of protist activities (Metatranscriptome)
- Bacterial production
- Primary production
- Nitrogen uptake by primary producers (Nitrogen uptake)
- Primary producer's response to light intensity (P vs I curve)
- Microalgae photosynthesis (Rapid light curves)

Table 2: water column and ice sampling for microbes (see text above for abbreviations).

Stn	Depth (m)	Metabarcoding	Virus diversity	Phytoplankton net	Vivaflow	SEM	Cultures	Chl. *a*	FCM	Microscopy	POC/PON	XRF	Metatranscriptome	Bacterial production	Primary production	Nitrogen uptake	P vs. I curve	Ice meiofauna	Rapid Light curves, Flow cytom. & HPLC
P1																			
	10	X				X		X	X	X	X	X	X	X	X				X
	20	X				X		X	X	X	X	X		X	X				X
	30							X	X	X	X	X		X	X				
	40							X	X		X	X		X	X				
	50							X	X		X	X		X					
	60						X	X	X	X	X	X		X	X				
	90						X	X	X	X	X	X		X	X				
	120					X		X	X		X	X		X					
	200	X				X	X	X	X		X	X		X					
	bottom	X	X				X	X	X		X	X		X					
	0-50			X			X			X									
P2																			
	10	X				X	X	X	X	X	X	X	X	X					X
	20	X				X		X	X	X	X	X		X					X
	30							X	X	X	X	X		X			X		
	40							X	X		X	X		X					
	50		X		X	X	X	X	X	X	X	X		X					
	60						X	X	X	X	X	X		X					
	90						X	X	X	X	X	X		X					
	120					X		X	X		X	X		X					
	bottom	X	X				X	X	X		X	X		X					
	0-100			X			X			X									
P3																			
	10	X				X	X	X	X	X	X	X	X	X					X
	20	X						X	X	X	X	X		X					X
	30							X	X	X	X	X		X					
	40							X	X		X	X		X					
	50							X	X		X	X		X					
	60						X	X	X	X	X	X		X					
	90						X	X	X	X	X	X		X					
	120					X		X	X		X	X		X					
	200	X				X	X	X	X		X	X		X					
	bottom	X				X	X	X	X		X	X		X					
	0-100			X			X			X									
P4																			
	10	X				X	X	X	X	X	X	X	X	X	X	X			
	20	X				X		X	X		X	X		X	X				
	30		X		X	X	X	X	X	X	X	X		X	X	X	X		
	40							X	X		X	X		X	X				

	50							X	X		X	X		X					
	60						X	X	X	X	X	X		X	X				
	90						X	X	X	X	X	X		X	X				
	120					X		X	X		X	X		X					
	150					X													
	200	X				X	X	X	X		X	X		X					
	bottom	X	X			X	X	X	X		X	X		X					
	0-100			X			X			X									
P5																			
	10	X				X	X	X	X	X	X	X	X	X	X	X			X
	20	X	X		X	X	X	X	X	X	X	X		X	X				X
	30							X	X	X	X	X		X	X	X	X		
	40							X	X		X	X		X	X				
	50							X	X		X	X		X					
	60						X	X	X	X	X	X		X	X				
	90					X	X	X	X	X	X	X		X	X				
	120					X		X	X		X	X		X					
	bottom	X	X			X	X	X	X		X	X		X					
	0-100			X			X			X									
P6																			
	10	X				X		X	X	X	X	X	X	X	X	X	X		X
	20	X				X		X	X	X	X	X		X	X				X
	30							X	X	X	X	X		X	X				
	40							X	X		X	X		X	X				
	50							X	X		X	X		X					
	60						X	X	X	X	X	X		X	X				
	90						X	X	X	X	X	X		X	X				
	120					X		X	X		X	X		X					
	200	X				X	X	X	X		X	X		X					
	500					X		X	X		X	X		X					
	750							X	X		X	X		X					
	bottom	X	X			X	X	X	X		X	X		X					
	0-100			X			X			X									
P7																			
	10	X				X		X	X	X	X	X	X	X	X	X	X		
	20	X				X		X	X	X	X	X		X	X				
	30							X	X	X	X	X		X	X				
	40							X	X		X	X		X	X				
	50							X			X	X							
	60						X	X	X	X	X	X		X	X				
	90						X	X	X	X	X	X		X	X				
	120							X	X		X	X		X					
	200	X				X	X	X	X		X	X		X					
	500							X	X		X	X		X					
	750																		
	1000					X		X	X		X	X		X					
	1500								X		X	X		X					
	1750																		
	2000								X		X	X		X					
	2500							X	X		X	X		X					
	bottom	X	X				X	X	X		X	X		X					

	0-100			X			X			X									
P4ice																			
	0-3	X					X	X	X	X	X			X	X	X	X	X	
	3-10	X					X	X	X	X	X			X				X	
	10-20	X						X	X	X	X			X				X	
	20-30	X						X	X	X	X			X				X	
	30-50	X						X	X	X	X			X					
	50-70	X						X		X	X								
	0-10		X			X	X			X		X							
	UIW 0.5	X			X	X	X	X	X	X	X	X		X					X
	UIW 0-5			X			X			X									
P6ice																			
	0-3	X					X	X	X	X	X			X	X	X	X	X	X
	3-10	X					X	X	X	X	X			X				X	
	10-20	X						X	X	X	X			X				X	
	20-30	X						X	X	X	X			X				X	
	30-50	X						X	X	X	X			X					
	0-10		X				X		X	X	X	X		X					
	UIW 0.5	X			X	X	X	X	X	X		X		X					X
	UIW 0-5			X			X			X									
P7ice																			
	0-3	X						X	X	X	X			X	X	X	X	X	X
	3-10	X						X	X	X	X			X				X	
	10-20	X						X	X	X	X			X				X	
	20-30	X						X	X	X	X			X				X	
	30-50	X						X	X	X	X			X					
	0-10		X			X	X			X		X							
	UIW 0.5	X				X	X	X	X	X	X			X					X
	UIW 0-5			X			X			X									

3.3.2 Microalgae and protist biodiversity and distribution (RF3 T3-1.1)

Simon Kline (UiO)

The main aim of my sampling during the AeN 2021703 cruise was to collect material which will be used to study diversity, distribution and ecology of microalgae and other protists along the Barents Sea to Arctic Ocean transect in the water column, ice cores and under-ice.

Molecular analysis

Samples for molecular analysis of diversity (metabarcoding) and function (metatranscriptomics) of phytoplankton and protist communities was taken in collaboration with Snorre Flo and Cheshtaa Chitkara (UNIS).

Phytoplankton abundance and taxonomy

Samples for phytoplankton abundance were collected from CTD Niskin bottles at 10, 20, 30, 60 & 90 m: The sample depth 5 m as stated in the protocol was changed to 10 m, since samples were taken through the moonpool. Samples were fixed in formaldehyde and glutaraldehyde solutions for further light microscopy analysis in the lab (at IOPAS, Poland). They will provide quantitative and qualitative information about phytoplankton abundance and diversity.

Morphological analysis of phytoplankton diversity

Samples were also taken for the scanning electron microscopy (SEM) analysis of small phytoplankton (passing the mesh of plankton nets) and groups which are not well preserved in quantitative samples

fixed in Lugol's solution. This includes primarily calcifying microalgae (coccolithophores) which is an important part of the Barents Sea phytoplankton. The samples for quantitative and qualitative SEM analysis were collected by CTD Niskin bottles at each station at four depths which corresponded to depths sampled for molecular metabarcoding (10 m, DCM (deep chlorophyll maximum varying between x-ym) 15 m above bottom and 200 m (at deep stations). A known volume was filtered onto a polycarbonate filter (pore size 0.8 µm) and dried.

Net samples (taxonomy & microalgae cultures)
A plankton net of mesh size 10 µm was deployed at each station to obtain a concentrated phytoplankton vertical sample between 100 or 50 m to surface. The collected material was divided in four parts. One part was fixed in 2% formalehyde for light microscopy as a complement for the quantitative samples for analyse at IOPAS. The second part was fixed in 1% glutaraldehyde, the third was fixed in 1% Lugol, and these two samples will be used for studying diversity of protists using scanning and transmission electron microscopy at UiO. The last part of the net sample was added algal growth medium (IMR1/2 without silicate) and kept alive in the cool room with light ("raw cultures"). Live samples and raw cultures were taken to UiO. Additionally, a sample was added sterile filtered seawater and kept in the dark and brought to UiO. At UiO all live samples were added algal medium containing silicate and placed in an illuminated 4oC climate room. From these samples microalgal strains will be isolated by capillary isolations and serial dilutions.

Ice algae samples
At sea ice stations, samples were taken from 0.5 m below ice and 5 m below ice and concentrated it using 10 µm phytoplankton net. Part of material was fixed for SEM, TEM and LM and another part kept as raw, live and dark cultures for later analysis. Also, the bottom 10 cm from ice- cores was sampled, part fixed for microscopy and the rest taken to UiO as a raw culture, live and dark cultures.

3.3.3 Pelagic-benthic coupling: vertical flux (T3-2.2)

Yasemin Bodur (UiT) & Martí Arumí-Amargant (UiT

Sub-tasks
Tasks T3-2.2 Measure how current environmental settings drive the phenology of primary and secondary production, and test how changing conditions may affect these seasonal patterns and T3-4.4 Sympagic-pelagic-benthic coupling

Sediment trap deployment and sampling
To assess the vertical flux at the P-stations along the cruise transect, short-term sediment traps (KC-Denmark) were deployed between 24 and 48 h (Table 1) at P1, P4, P5, P6 and P7. Originally, it was planned to deploy the traps at 6 depths (30m, 40m, 60m, 90m, 120m and 200m). However, during the first deployment at P1 the mooring was lost, and only 8 traps were left for use. Therefore, 4 traps were deployed at each 30 and 200m at all subsequent stations. Due to the shallow depth of P4 no cylinders deployed at 120m instead of 200m. At all stations, bottles for the assessment of primary production were attached to the mooring at 5, 20, 40, 60, 90m and Chl *a* max (see report from M. Amargant-Arumi). Prior to the deployment, the cylinders were filled with filtered deep water (below 200m) from the corresponding station or from a prior station to make sure that the water within the cylinders had a higher density than at the sampling depths. An anchor of 35kg was fixed to the bottom of the mooring to keep it upright in the water column. To keep the traps neutrally buoyant in the water, 14 white 2kg buoys were attached at 10 and 2 red 8.5kg at 5m (Figure 13). A flagged pole equipped with an AIS beacon was used to mark the location of the mooring and to relocate its position for recovery. A small buoy with a long rope was attached to the pole for the recovery of the mooring. At all stations except P1 a chain was added between 5 and 1m

to protect the rig from sea ice. At P4 and P5 the mooring was attached to an ice floe with an additional chain, secured with two metal poles that were hammered into the ice (Figure 14).

Table 3: overview of sediment trap stations during AeN SSQ3 with deployment and recovery time, and the total time of deployment

Station	Deployment time (UTC)	Recovery time (UTC)	Total time of deployment	Deployment conditions	Deployment depths (m)
P1	2021-03-05 02:36	-	-	Open water	2 cylinders: 40, 90, 120 4 cylinders: 30, 60, 200
P4	2021-03-09 16:03	2021-03-11 04:46	38h 43min	On an ice floe	4 cylinders: 30, 120
P5	2021-03-12 11:57	2021-03-13 13:45	25h 48min	On an ice floe	4 cylinders: 30, 200
P6	2021-03-14 14:30	2021-03-15 17:38	27h 8min	Under ice conditions, in a lead	4 cylinders: 30, 200
P7	2021-03-16 20:37	2021-03-18 06:09	33h 32min	Under ice conditions, in a lead	4 cylinders: 30, 200

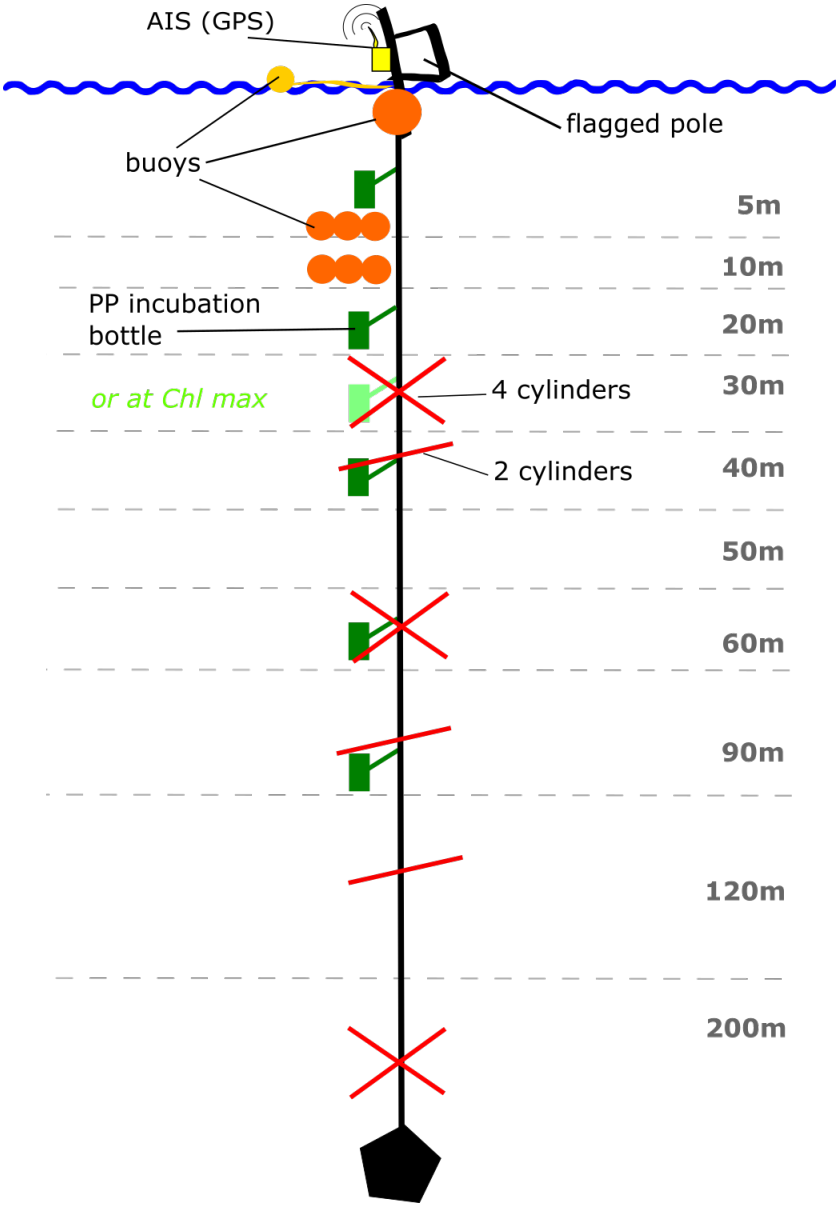


Figure 13: Scheme illustrating the structure of the mooring and the sampling depths of the sediment traps at open water conditions. At 30m, incubation bottles for primary production were deployed when the Chl *a* max was already covered at another depth. Note that during this cruise, only samples from 30 and 200m were taken since there were not enough traps available to cover all depths.

Figure 14: Deployed sediment trap under ice conditions (left) and on an ice floe (right) during SSQ3 in August 2019

Sampling largely followed the Nansen Legacy sampling protocol version 7, chapter 8. Upon recovery of the sediment traps, the cylinder content of each depth was pooled and partitioned. From each depth, water was filtered for triplicate POC/PON analyses on pre-combusted GF/F filters and for size fractionated algal pigments (total Chl *a* (in triplicates on GF/F filters) and Chl *a* >10µm; on Polycarbonate filters) and water samples were taken for microscopic counts of fecal pellets and phytoplankton communities. Filters for algal pigments were immediately stored in Methanol at 4C and measured with a fluorometer on board ideally after 12-24 h. Fecal pellets were preserved in a hexamine-buffered 4% Formaldehyde solution and phytoplankton communities in GA-Lugol. Water samples for FCM and bacterial production were taken (according to chapters 7.20 and 7.21 in Nansen legacy sampling protocol Version 7). Additional triplicate samples were filtered for stable isotopes (pre-combusted GF/F) and stored at -80C. If volume was left, additional samples were taken for particulate biogenic silica (BSi; on 0,8µm polycarbonate filters), HPLC (GF/F) IP25 (GF/F), nutrients (45ml sterile-filtered over 0.22µm GFF filters into Falcon tubes) and/or DNA analyses (Approx. 500ml was filtered through sterivex filters). DNA, IP25, HPLC and stable isotopes samples were stored at -80C. POC/PON, nutrients and BSi were stored at -20C. Field blanks for POC/PON analyses at P5, P6 and P7 were taken by filtering MilliQ on combusted GF/F, stored at -20C. For additional control of the pre-filtered water that was used for the deployments, samples for POC/PON, nutrients, FCM and bacterial production were taken as described above.

3.4 Chemistry

3.4.1 Current variability and drivers of ocean acidification (T2-1-1)

Elizabeth Jones (IMR)

The focus of the work onboard was to investigate carbonate and nutrient chemistry for the study of ocean acidification and the carbon cycle in the surface water, full water column and sea ice environment (snow, ice, brine, frost flowers, under-ice water) in different regimes and across natural gradients. The water column and sea ice were sampled for carbonate chemistry (total alkalinity (AT), total inorganic carbon (DIC)), inorganic nutrients and stable oxygen isotopes ($\delta^{18}O$) and analyses for the determination of dissolved oxygen were performed onboard.

Seawater was sampled from Niskin bottles mounted onto a 24 bottle CTD-Rosette from a total of 20 stations for post-cruise analyses of carbonate chemistry, nutrients and $\delta^{18}O$. Sampling and future analysis followed the protocol described in *Nansen Legacy Sampling Protocol version 7 and Dickson et al., 2007.* The samples for carbonate chemistry were sampled first or directly after dissolved oxygen samples and stored in the cool and dark for post-cruise analyses at IMR in Tromsø. Samples for inorganic nutrients (nitrate+nitrite, nitrite, phosphate, silicic acid) were preserved with chloroform and stored at 4°C and dark for post-cruise analyses at IMR in Bergen.

Dissolved oxygen was sampled from 6 CTD stations. On 2 CTD stations duplicate sampling was preformed to ensure that the analytical performance was acceptable. The data from the Winkler titration showed that the first oxygen sensor mounted on the CTD had drifted by about $\pm$ 0.3 ml/l. Around station NLEG15 the oxygen sensor showed considerable offset, which was attributed to the sensor freezing in the very cold temperatures, and the data is therefore questionable for those affected stations. A new sensor was installed prior to P6, and the performance was good, and values returned to be within $\pm$0.3 ml/L of the Winkler titration for dissolved oxygen performed onboard. The last calibration for both sensors was within 2-4 months.

Seven sea ice stations were sampled (P2, NLEG6, P4, P5, P6, P7 and M3) for ice cores, snow, brine, frost flowers and under-ice water. A total of 8 sea ice cores with a length from 40 cm to 70 cm of first year ice were sampled. At all stations snow depth, ice thickness and freeboard were measured

alongside temperatures for each ice core. Under-ice water was sampled from a GO-FLO bottle lowered to 0.5 m below the ice surface through a water hole. Water was sampled through the opening of the GO-FLO bottle due to freezing. Ice cores were sampled and processed as described in *Nansen Legacy Sampling Protocol version 7*. Ice cores were sliced into 10-cm sections from the top (snow-air interface) to the base (ice-seawater interface). Sea ice samples were melted in airtight bags (or cups for alkalinity and salinity measurements) at laboratory temperature and subsampled for carbonate chemistry, nutrients and $\delta^{18}O$. Samples were preserved and stored for post-cruise analysis as described above. Total samples for carbonate chemistry, inorganic nutrients and stable oxygen isotopes in seawater and sea ice were 794. Table 1 summarizes the seawater sampling from the CTD-Rosette.

Underway surface water CO_2 data

The underway instrumentation for autonomous high-frequency surface water measurements of partial pressure of CO_2, pCO_2 (General Oceanics) was running in ice-free water from ship's seawater intake at 4 m depth. Raw data are calibrated against a series of reference gases and will be quality controlled in post-cruise processing.

Table 4: Seawater samples from the CTD-Niskin Rosette.

Station Name	CTD #	# AT/DIC/pH	# Nutrients	# $\delta^{18}O$	# $DO_{Winkler}$
Pre-P1	114				3
P1	116	11	11	11	11
NLEG2	120	10	10	10	
NLEG3	121	8	8	8	
P2	122	9	9	9	
NLEG5	125	10	10	10	10
NLEG6	126	9	9	9	
P3	127	11	11	11	
NLEG8	129	9	9	9	
NLEG9	130	9	9	9	
NLEG10	131	10	10	10	
P4	133	11	11	11	
NLEG12	136	8	8	8	8
P5	140	9	9	9	
NLEG14	141	9	9	9	
NLEG15	142	9	9	9	3
NLEG19	146	12	12	12	
P6	151	13	13	13	13
NLEG23	154	16	16	16	
P7	157	17	17	17	

Figures 15 and 16 show preliminary results of physical and chemical properties from the water column.

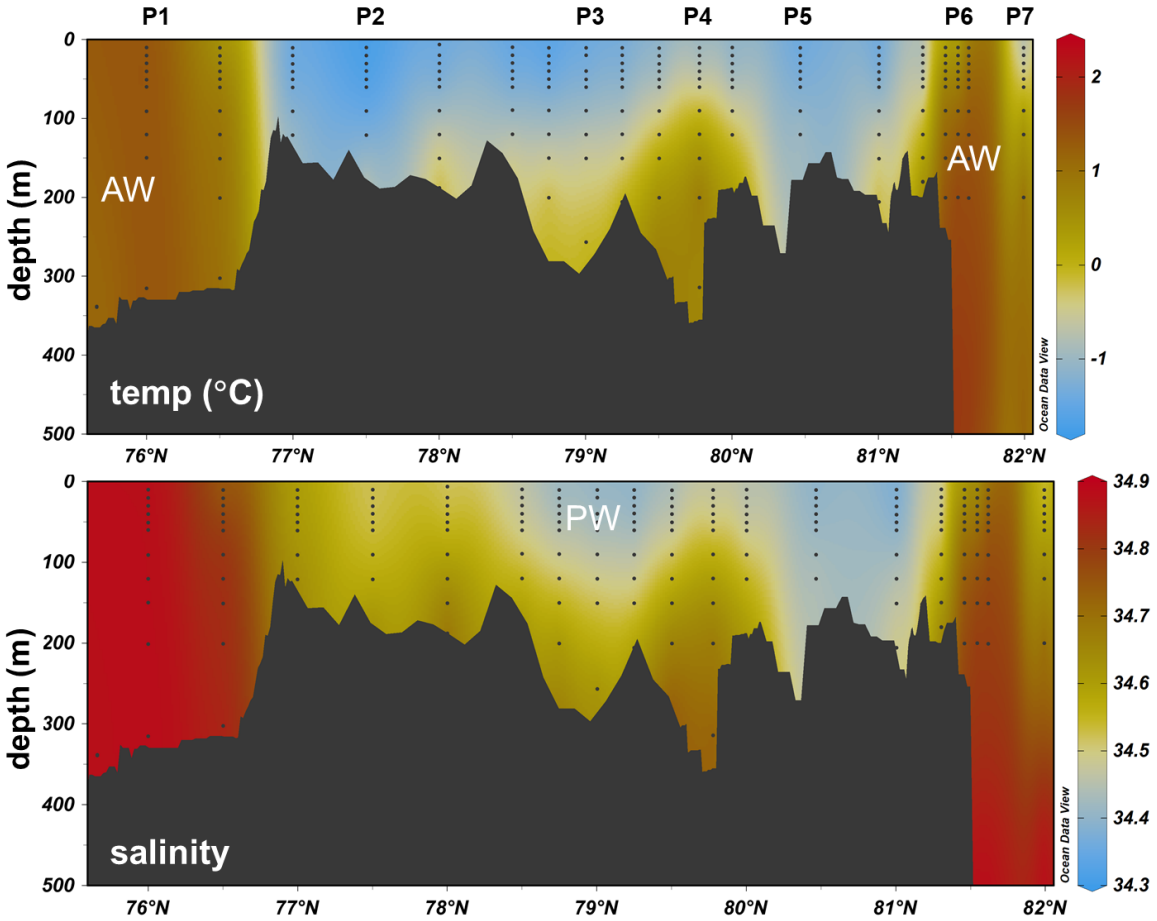


Figure 15: Temperature (upper panel) and salinity (lower panel) in the upper 500 m of the water column from south (P1) to north (P7), including numerous NLEG CTD stations along the transect. Atlantic Water (AW) and Polar Water (PW) are indicated for reference.

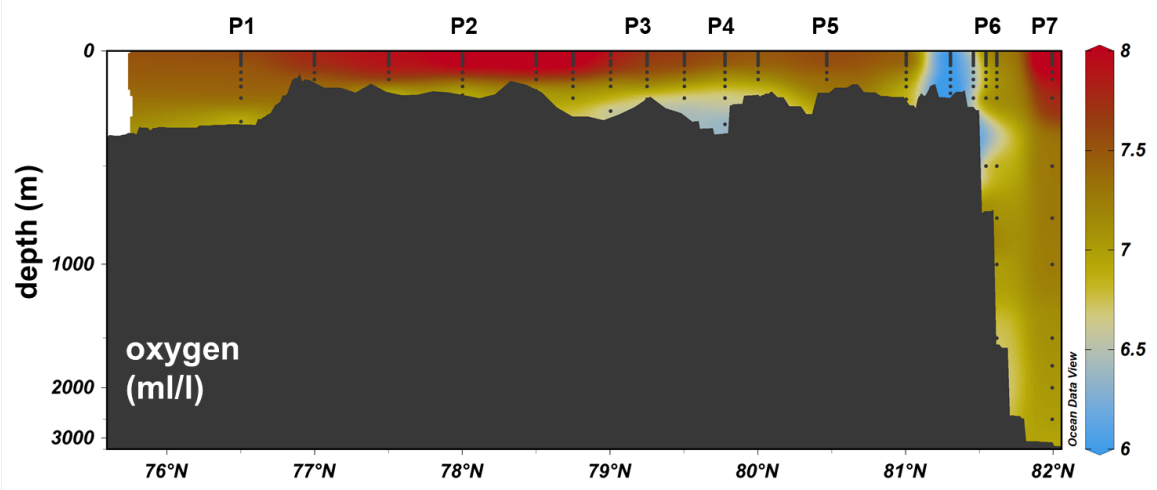


Figure 16: Dissolved oxygen (CTD sensor) in the full water column from south (P1) to north (P7), including numerous NLEG CTD stations along the transect. The issue with the first sensor is clearly shown by dramatic decrease in values at NLEG15 (between P5 and P6), after which a new sensor was installed.

3.4.2 Ocean acidification effects on the mobility of particulate and dissolved organic carbon (POC, DOC), essential trace elements (micro nutrients) and heavy metals (RF2 T2-1.2)

Stephen Kohler and Laura Kull (NTNU)

Objective

The purpose of this task is to understand the impact of ocean acidification on the biogeochemistry (cycling and mobility) of dissolved organic carbon (DOC) and trace elements in the water column of the Northern Barents Sea. To best explore this topic, a complete survey of trace elements and heavy metals needs to be sampled along the entire transect and at various depths under clean sampling and handling conditions. In addition, the characterization of dissolved organic matter (DOM, DOC), at select stations at select depths will aid in understanding the different forms and distributions of DOM and how they may interact with trace elements. As the solubility of trace metals, both essential and toxic, are dependent on its interaction with DOM, the distribution and type of both trace metals and DOM was surveyed.

Trace elements (micronutrients)

Both total (n= 56) and dissolved (n= 56) trace elements, were successfully sampled at all process stations (P1-P7) at eight depths up to 15 m above the seabed or up to 500m with GO FLO bottles with clean sampling and handling techniques. Replicate samples were collected at certain stations. Two ice cores were sampled and sectioned at P4 and P7 for total trace elements.

Heavy metals (Hg)

Separately, samples for both total mercury (n=56) and methylmercury (n=56) were also collected at all process stations (P1-P7) at eight sampling depths up to 500m with GO FLO bottles using clean sampling and handling techniques. At stations P6 and P7, samples for total mercury and methylmercury were also collected from the deeper depths (>500m) from the CTD rosette with bottles to complete the profile. Replicate samples were collected at P4 and P7. To compare the clean sampling technique to the CTD, samples were collected from the CTD at P6 and P7 at the same depth as one of the GO FLO depths. We hope to share mercury data with RF2, T2-2, and RF3, T3-4.1.

At P5, the 20m depth was selected for a stable isotope mercury methylation experiment. Briefly, stable isotopes of inorganic 199Hg and Me201Hg were spiked to unfiltered seawater incubations in triplicate and preserved at time 0 and time 24hrs. Samples were collected for Hg isotopes, THg, DOC and characterization of dissolved organic matter. This experiment is planned to be repeated for Q2 in May. This data will aid in understanding both methylation and demethylation rates throughout the water column in the Arctic basin in the presence of seasonal DOM regimes.

Three ice cores were sampled at stations P4, P6, and P7 and sectioned for both total Hg and MeHg determination. In addition, under ice water was collected from all sea ice stations. Frost flowers and snow were also collected for total Hg determination.

Dissolved organic matter (DOM) characterization, and Dissolved organic carbon (DOC)

Samples were collected for 6 depths (10m, 20m, 30m, 60m, 90m and bottom depth). Process stations (P1, P4, P6, P7) were sampled and collected from CTD bottles. All samples were subsequently collected, filtered, and extracted for DOM to be analyzed post-cruise. In addition, samples including replicates were collected for DOC analysis at 6 depths at each of the stations to complement DOM characterization analysis. DOC analysis will be performed using high temperature combustion TOC instrument.

Three ice cores were sampled at stations P4, P6, and P7 and sectioned from 0-20cm (bottom) and melted in the dark. Water was filtered for collection for DOC and extracted for DOM. Under ice water was also collected at stations P4 and P7 and filtered for DOC and extracted for DOM.

Sediment sampling

At select stations, samples of surface sediments were collected by the benthos group (UiT – Nord) for trace element analysis by sequential sediment extraction.

3.4.3 Ocean acidification effects on planktonic calcifiers and biological pump efficiency (RF2 T2-1-4)

Griselda Anglada-Ortiz (UiT), Supervisor: Tine L. Rasmussen (UiT)

The abundance of the main planktic marine calcifiers (foraminifera, pteropods and coccolithophores) and their contribution to the carbon pump will be studied from 64 µm multinet samples (foraminifera and pteropods) and Niskin bottles (coccolithophores) regarding the water chemistry from the sampling zone.

A total number of 78 samples have been retrieved on the Process stations along the transect to study these marine calcifiers following the protocol from the Nansen Legacy v7. On one hand, **33** samples have been collected using the 64 µm multinet on all P stations at the standard depths: 0–20 m, 20–50 m, 50–100 m, 100–200 m and 200–300 m (the shelf stations shallower than 300 m the same standard ranges were used). All samples have been washed through a cascade of sieves obtaining four size fractions (>500 µm, 250–500 µm, 100–250 µm, 63–100 µm) from each sample. Once on deck, **24** pteropod specimens have been individually picked from the upper 100 m and (individually) frozen at -80° C for protein extraction analysis. The rest of the samples have been analysed for pteropods and foraminifera (abundance and species distribution), stored on plastic bags, and preserved at - 20° C.
On the other hand, **45** samples coming from the P stations (1, 2, 4, 5, 6 and 7) and different depths (90 m, 60 m, 50 m, 20 m and 10 m) have been collected from the Niskin bottles. A total volume of 8 L were sampled and filtered through a 0.45 µm Acetate cellulose membrane (volume=3 L; depths 10, 20, 50, 60 and 90 m) and 0.4 µm Polycarbonate membrane (volume=5 L; depths 10, 20 and 50 m). Once the samples have been filtered, the filters have been rinsed with distilled water buffered with ammonia (5 ‰) and oven dried at 60° C.

Table 5: Overview of the samples of marine calcifiers collected during Q1 2021.

Station	Coccolithophores (Niskin)	Foraminifera and pteropods (Multinet)
P1	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-200, 200-300
P2	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-170
P3		0-20, 20-50, 50-100, 100-200, 200-300
P4	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-200, 200-300
P5	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-125
P6	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-200, 200-300
P7	10, 20, 50, 60 and 90 m	0-20, 20-50, 50-100, 100-200, 200-300

3.5 Zooplankton

3.5.1 Trophic interactions of small invertebrates (RF3 T4-4.1)

Snorre Flo (UNIS)

Sampling went as planned. Samples were taken both for the currently running “copepod diet project” starring the small copepods *Oithona similis*, *Microsetella norvegica* and *Microcalanus* spp., and for a future project on the trophic interactions of meiofauna.

Purpose of sampling

Sampling for my PhD-project on the trophic interactions of small invertebrates (<1 mm adult length) in the water column (small copepods) and in benthic sediment (meiofauna; e.g. nematodes). All samples are fixed on ethanol, kept cool (-20°C) and brought back to the lab at UNIS for dietary metabarcoding analysis. At UNIS, a number of each study species are picked, DNA is extracted from whole-body individuals, and further preparations are made for deep sequencing of the 18S small subunit (SSU) rRNA gene. Deep sequencing raw data is further processed in a bioinformatics pipeline to remove unwanted sequences (e.g. the sequence of the study-species itself, and symbionts), and with the help of an experimental control group (starved copepods).

Corrections to the Nansen Legacy sampling protocol (v7)
From P2 (NLEG04) and onwards: small particles were removed by filtration before starvation to limit feeding on small organic particles. Hence removal of both large (>1000 µm) and small (<180 µm) particles/organisms.
At P6: starvation was continued past the fixed 48h for 144h (6 days). Continued sampling each 48h, at which the batch culture was divided, sieved and diluted once more, gave a total of 3 starvation controls with varying duration (48, 96, 144 hours).

Table 6: List of samples. All samples were fixed with ice-cold ethanol (96%, -20°C) and put immediately in the freezer (-20°C). Sediment was sampled three times from different box-cores at P1, P2, P4 and P7.

Samples	P1	P2	P3	P4	P5	P6	P7
Mesozooplankton fixed immediately	1	1	1	1	1	1	1
Mesozooplankton starved then fixed	1	1	1	1	1	3	1
Sediment	3	3	N/A	3	N/A	3	N/A

3.5.2 Mesozooplankton taxonomy, abundance, biomass and genomics (RF3 T3-1.1 & 2.1)

Anette Wold (NPI) & Amalia Keck Al-Habahbeh (NPI)

Purpose
The main objective was to describe the mesozooplankton taxonomic composition, abundance and biomass along the transect going from open Atlantic water (P1) to ice covered Arctic water (P7). We expect to see a gradient in the presence of Atlantic and Arctic species.
The data obtained during this cruise (Q1) are part of the seasonal investigation of zooplankton communities with data collected in Aug 2019 (Q3), December 2019 (Q4) as well as the data that will be collected in April/May (Q2).

Description of the work
We have sampled with Multinet Midi (HydroBios, opening: 0.25m^2, net length: 250 cm) and Bongonets (HydroBios, opening: 2 x 0.2827m², net lengths: 250 cm): For both nets we have been using both 180 µm and 64 µm mesh nets in order to cover all size groups. We refer to the samples from the two mesh sizes as “mesozooplankton” and “small mesozooplankton” respectively.
Taxonomy and abundance were sampled at 5 standard depth intervals using the Multinet. The depth intervals were from the bottom-200, 200-100, 100-50, 50-20 and 20-0 m. At the deep stations, the sampling depths were from 1000-600, 600-200, 200-50, 50-20 and 20-0 m. All samples were preserved in 4 % formaldehyde free from acid.
Total biomass (dry weight) and metabarcoding were sampled using Bongonets from the bottom-surface and from 1000 m to the surface at the deep stations. Each Bongonet were split in two, net 1 was used for metabarcoding and taxonomy with ½ of the sample for each. Net 2 was used for biomass and fatty acid. However, at P1 & P2 it was very little zooplankton biomass, so we used the entire sample for biomass. The biomass samples were dried and measured onboard. Genetic samples for metabarcoding was preserved in ice cold 96 % ethanol. Taxonomy samples were stained with Neutral

red and preserved in 4 % buffered formaldehyde in order to distinguish between dead and alive specimens. The taxonomy samples will be used to support the metabarcoding samples.
Gelatinous zooplankton were picked out from MIK net at all stations except for P1. One picture was taken of each taxa including all individuals. Individuals in good conditions were weighted, photographed and stored individually with ice cold 96 % ethanol.

Table 7: Overview of mesozooplankton sampling

Purpose	**Gear**	**Station**	**Number samples**
Mesozooplankton taxonomy	Multinet 180µm	P1, P2, P3, P4, P5, P6, P7	35
Small mesozooplankton taxonomy	Multinet 64µm	P1, P2, P3, P4, P5, P6, P7	35
Mesozooplankton biomass	Bongonet 180 µm	P1, P2, P3, P4, P5, P6, P7	7
Mesozooplankton taxonomy (alive/dead)		P1, P2, P3, P4, P5, P6, P7	7
Mesozooplankton metabarcoding		P1, P2, P3, P4, P5, P6, P7	7
Mesozooplankton fatty acid (community)		P3, P4, P5, P6, P7	5
Small mesozooplankton biomass	Bongonet 64 µm	P1, P2, P3, P4, P5, P6, P7	7
Small mesozooplankton metabarcoding		P1, P2, P3, P4, P5, P6, P7	7
Small mesozooplankton tax. (alive/dead)		P1, P2, P3, P4, P5, P6, P7	7
Small mesozooplankton fatty		P3, P4, P5, P6, P7	5
Gelatinous zooplankton	MIK net 1500 µm	P2, P3, P4, P5, P6, P7	98 ind.

Table 8: Overview of sampling depths, and hauling speed for different zooplankton nets

Gear	**Sampling depth**		**Hauling speed (m/s)**	
	Shallow	Deep	lowering	heaving
Multinet 180 µm	Bot-200-100-50-20-0m	Bot-600-50-20-0m	0.5	0.5
Multinet 64 µm	Bot-200-100-50-20-0m	Bot-600-50-20-0m	0.5	0.3
Bongonet 180 µm	Bottom-0m	1000-0m	0.5	0.5
Bongonet 64 µm	Bottom-0m	1000-0m	0.5	0.3
MIK 1500 µm	Bottom-0m	Bottom-0m	0.3*	1.5

*If lowering to fast the net-bucket might flip into the net since the ring is much heavier than the bucket even when added weight to the bucket. The net bucket should be improved in order to attach heavier weights.

Table 9: Overview of gelatinous zooplankton samples sampled from the MIK net

Station	**Depth**	**Taxon**
P2	170-0 m	*Aglanta digitale* & *Mertensia ovum*
P3	280-0 m	*Aglanta digitale* & *Beroe cucumis, Mertensia ovum, Phytchogena lactea*
P4	310-0 m	*Beroe cucumis, Beroe* spp., *Mertensia ovum* & *Phytchogena lactea*
P5	125-0 m	*Aglanta digitale, Beroe cucumis* & *Beroe* spp., *Mertensia ovum* & Unknown
P6	970-0 m	*Aglanta digitale, Beroe* spp., *Mertensia ovum* & Unknown
P7	1000-0 m	*Aglanta digitale, Beroe* spp. & Unknown

3.5.3 Macrozooplankton abundance, biomass & species composition (RF3 T3-3.1)

Anette Wold (NPI) & Amalia Keck Al-Habahbeh (NPI)

Objective

The aim of the sampling is to provide information on seasonal and regional variation in abundance, biomass, and genetic composition of the microzooplankton community along a North-South gradient in the Barents Sea.

Description of sampling

Biomass was taken with vertical hauls of the MIK net (1500 µm) from the bottom to the surface at all process stations, with exception of the deepest station, P7, where the net was hauled from 1000m to the surface, due to time restrictions. Rare taxa and gelatinous zooplankton were isolated from the sample and two subsamples were weighted and taken for (1) for metabarcoding stored in ethanol at -20 degrees C, and (2) for later taxonomic identification of species, stored at room temperature in 4% buffered formaldehyde. Genetic identification of the picked out gelatinous zooplankton will be analyzed separately (see gelatinous zooplankton sample log). Macrozooplankton trawl and acoustics were not undertaken on this cruise.

Table 10: Overview of macrozooplankton samples from MIK net during Q1

Station	Depth	Main taxa in the sample
P1	300-0m	Very little biomass.
P2	170-0m	*Clione limacine*, *Calanus* spp., *Aglantha digitale* & *Mertensia ovum*
P3	280-0m	*Aglantha digitale*, *Phytchogena lactea*, *Beroe cucumis* & *Mertensia ovum*
P4	310-0m	*Clione limacine*, *Calanus* spp., *Mertensia ovum*, *Thyssanoessa* spp., *Themisto* spp.
P5	125-0m	
P6	850-0m	*Calanus* spp., *Aglantha digitale*, *Sagitta* spp., *Thyssanoessa* spp. & *Themisto* spp.
P7	1000-0m	*Calanus* spp., *Pareuchaeta* spp. & *Themisto* spp.

3.5.4 Stable isotopes, fatty acids & HBIs of POM, zooplankton & fish (RF 3 T3-1.3)

Anette Wold (NPI) & Amalia Keck Al-Habahbeh (NPI)

Purpose

Stable isotopes, fatty acids, and HBIs of POM and main zooplankton taxa will be used to study coupling/de-coupling of sympagic and pelagic primary and secondary producers. In addition, fatty acids (together with C/N ratios) will be used as a measure of food quality for the planktonic grazer communities and will be linked to on board grazing experiment.

Description of work

POM

Stable isotopes, fatty acid, and HBI samples was sampled for POM from 20 meters depth (since no Chl A max was detected) with Niskin bottles attached to the CTD at all process stations (P1-7) and from the bottom 10 cm of the ice cores at three ice stations (P4 ICE, P6 ICE, and P7 ICE). We filtered between 2-3L on pre-combusted 0.2 µm filters in three replicates for all parameters in order to get enough material. Due to little biological material in the ice cores, two cores had to be pooled in order to get enough material in the filters, so samples from P4 ICE and P6 ICE were restricted to one replicate, and two replicates at P7 ICE.

Zooplankton

Samples for all three parameters were also sampled from the main macro- and mesozooplankton taxa using MIK net 1500 µm and WP3 net 1000 µm at stations P1, P2, P4, P6, P7. This work was done in

collaboration with the Ecotoxicology group (Julia Giebichenstein and Robynne Nowicki). Stable isotopes will be analysed by Julia Giebichenstein, UiO, while fatty acids and HBI will be analysed by Doreen Kohlbach, NPI. Samples were taken from the bottom to the surface at each station except at the deep station (P7) were samples were taken from midwater and up due to time restrictions.

Fish

Since fish sampling and trawling was limited on this cruise, only *Boreogadus saida* was sampled from P2.

Table 11: Overview of fatty acid & HBI samples (overview of the stable isotope samples is in the Ecotox section).

Gear Type	Station	Depth	Taxon
MIK-net 1500 µm	P7	500-0m	*C. finmarchicus, C. glacialis, C.hyperboreus, Calanus* spp. (male), *Paraeuchaeta norvegica, P. glacialis, Paraeuchaeta* spp., *Themisto libellula, T. abyssorum, Amphipoda* indet.
MIK-net 1500 µm	P6	750-0m	*C. finmarchicus, C. glacialis, C. hyperboreus, Aglantha digitale, Paraeuchaeta* spp., *Sagitta maxima, Sagitta* spp., *Thyssanoessa* spp., *Themisto abyssorum*
MIK-net 1500 µm	P4	320-0m	*Calanus glacialis, C. hyperboreus, Clione limacine, Meganyctiphanes norvegia, Mertensia ovum, Thyssanoessa* spp., *Themisto libellula, T. abyssorum, Pareuchaeta sp.*
WP3 1000 µm	P2	145-0m	*Calanus glacialis, Clione limacine, Boreogadus saida*
MIK-net 1500 µm	P1	300-0m	*Calanus finmarchicus*, *C. glacialis*, *Thyssanoessa* spp., *Meganyctiphanes norvegia, Sagitta* spp.

3.5.5 Critical seasonal windows of responses to multiple stressors on key organisms in a pelagic food chain (RF2 T2-2.5)

Robynne Nowicki (UNIS/UiO), Supervisors: Øystein Varpe (UiB), Geir Wing Gabrielsen (NPI), Katrine Borgå (UiO), Janne Søreide (UNIS)

Purpose

The samples taken on this cruise will be used in T2-2.5 "Critical seasonal windows of responses to multiple stressors on key organisms in a pelagic food chain". Macrozooplankton and fish samples will be taken on all four seasonal cruises (Q1-4) for bioenergetics, protein, lipid and pollutant remobilization analysis. The samples taken will be used to assess seasonal fluctuations in energy content of key organisms in the pelagic food web of the Barents Sea. This data will be used to expose annual critical windows in which organisms may be of weakened body condition and predators may have a low-quality food supply. Thus these organisms may be more susceptible to stressors such as persistent organic pollutants and climate change parameters, during this critical period. As well as this, polar cod brains were collected (to be used in conjunction with brains collected from kittiwakes from Svalbard in future) for organ specific analysis of seasonal pollutant remobilization. Samples were taken at each process station (excluding P3), allowing for additional comparison of southern (Atlantic) and northern (Arctic) species, as well as regional differences in individuals of the same species.

Sampling approach

Macrozooplankton: Macrozooplankton were sampled using MIK-net 1500um V- hauls (P1, P2) and vertical hauls (P4, P5, P6, P7). Multiple MIK nets were taken at each station to provide substantial biomass. The bulk samples were sorted into major zooplankton groups, with this work focusing on krill and amphipods, with 2 species selected for each (see overview table). Individuals were selected and measured, with an aim to collect a range of size classes, in order to assess the relationship between life history stage and energy content. However, due to the low abundance of larger macrozooplankton

in the water this time of year, *Calanus* copepods were also targeted, using Bongo 180um nets in addition to MIK nets. For each sample, organisms were wrapped in aluminium foil, or placed in cryovials (copepods) and placed in a labelled Ziploc bag and frozen at -20°C. Organisms of the same species and size class were pooled together in order to achieve a sample that weighed 2-3g. Samples were taken opportunistically, with not all species being collected from each station.

Fish: Fish were collected using campelen trawl at station P1 and between stations P2 and P3 (P2/P3). Capelin (*Mallotus villosus)* and polar cod (*Boreogadus saida)* were the target species collected at P1 and only polar cod were found at P2/P3 (see overview table). The fish were taken whole from the trawl, weighed and measured for total length. Individuals were then wrapped in aluminium foil and frozen at -20°C. Polar cod that were dissected for other simultaneous sampling onboard had their brains removed for remobilization studies, with weight and total length of the individual recorded.

Table 12: Overview of zooplankton samples per species per station

Station	P1	P2	P4	P5	P6	P7
Thysanoessa inermis	14	4	2	- 1	-	-
Meganyctiphanes norvegica	8	-	2	-	-	-
Themisto libellula	1	5	1	-	-	2
Themisto abyssorum	-	-	-	4	-	4
Calanus finmarchicus	3	1	-	-	-	-
Calanus glacialis	-	-	13	2	1	1
Calanus hyperboreus	-	-	2	-	3	4

Table 13: Overview of fish samples per species per station

Station	**Capelin**	**Polar cod**
P1	26	30
P2/P3	-	16

3.5.6 Effects of changes in species composition and distribution on contaminant in food web accumulation (RF2 T2-2.1)

Julia Giebichenstein (UiO), PI: Katrine Borgå (UiO)

Purpose

As changes in temperature and sea ice distribution and thickness are expected in the Barents Sea, the energy transfer processes in the food web are expected to change. The present study aims at identifying and comparing bioaccumulation and biomagnification processes of legacy and emerging contaminants (e.g. persistent organic pollutants and mercury) related to energy use and availability between an Atlantic-influenced and an Arctic marine pelagic food web in the Barents Sea throughout the year. Zooplankton and fish samples will be collected during the process study cruises. From these, chemicals representing lipid soluble and protein associated contaminants will be analyzed, in addition to dietary descriptors to trace energy source (stable isotopes and lipid analyses). Model predictions of climate change effect on food web accumulation of contaminants include reduced accumulation due to predicted reduction in lipid storage. Bioaccumulation changes due to altered dietary composition is predicted to have less influence than the predicted lower lipid content. These predictions will be tested in the present task.

Sampling approach

During this cruise we have collected water, zooplankton and fish samples for legacy and emerging contaminants, mercury, stable isotope and fatty acid analyses. Doreen Kohlbach (NPI) will analyze the fatty acid samples and the stable isotope and mercury samples will be analyzed at UiO, contaminant samples will be analyzed at NILU in Tromsø. We hope to share mercury data with T2-1.2.

Water samples for legacy persistent organic pollutant (POP) analyses were collected with an in-situ filtration pump (see Figure 17) at the process stations P7, P5, and P4. To compare the influence of warmer, more saline Atlantic water on contaminant levels with the cold, fresher Arctic water we tried to target both water masses, if applicable.

Meso- and macrozooplankton samples of key food web species were collected at each process station. Mesozooplankton (primarily Copepod stages CIV and CV) were sampled with either WP3 or Bongo Nets. Copepods clearly dominated the sampling during this cruise, as abundance of Macrozooplankton was extremely low. Macrozooplankton (mainly euphasiids, amphipods and juvenile fishes) samples were collected from the (see Figure 18 for an example from the MIK net). All zooplankton samples were sorted and grouped by family and by species, if possible. Samples for contaminants were handled as little as possible and frozen as quickly as possible to avoid cross-contamination. We sampled for POPs, mercury, stable isotope and fatty acid analyses.

Fish tissue and whole fish were sampled via bottom trawl for POPs, mercury, stable isotope analyses at P1 and between P3/P2 on our way back to Tromsø. Fish stomachs were frozen for diet and potential microplastic analyses and otoliths for age determination were dissected. The target species relevant to the pelagic Barents Sea food web included Polar cod (*Boreogadus saida*), Atlantic cod (*Gadus morhua*) and Capelin (*Mallotus villosus*) and were below 25 cm in total length (see Table 13).

Table 14: Overview of the number of dissected fishes at the process stations.

Process station	**P1**	**P3/P2**
Atlantic cod (*Gadus morhua*)	0	0
Polar cod (*Boreogadus saida*)	10	5
Capelin (*Mallotus villosus*)	10	0

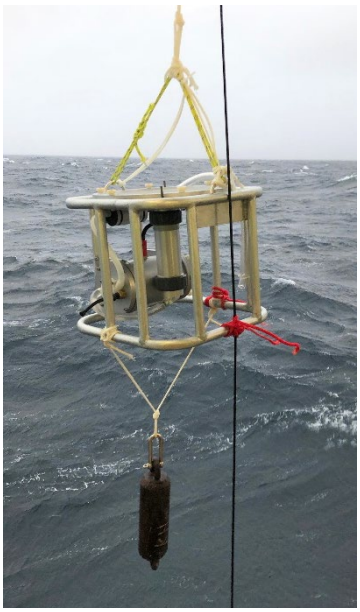


Figure 17: *In-situ* filtration pump


Figure 18: *Themisto libelulla*, Photo credit: Christine Gawinski

3.5.7 Effect of multiple stressors on sub-lethal physiological and ecological responses in Arctic zooplankton/fish (RF2 T2-2.2 & 2.3)

Khuong Dinh (UiO) & Andreas Jortveit (UiO), PI: Ketil Hylland (UiO) & Katrine Borgå (UiO)

Purpose

The main objective was to empirically assess the single and combined effects of dominant stressors, particularly warming, ocean acidification and pollution on zooplankton describe the mesozooplankton from open Atlantic water (P1) to ice covered Arctic water (P7).
We also collected 30 polar cods (*Bereogadus saida*) at P1 station for blood and bile samples.
The data obtained during this cruise (Q1) are part of series experiments investigating the sublethal physiological and ecological responses zooplankton/fish communities during the winter (Q1) and post-cruise experiments in the spring-summer.

Description of work

We have sampled with Bongonets (HydroBios, opening: 2 x 0.2827m², net lengths: 250 cm) and WP3: For both nets we have been using both 180 and 1000 µm mesh nets to collect *Calanus finmarchicus*, *C. glacialis* and *C. hyperboreus*, these are key zooplankton in the Barents Sea and Arctic Ocean.
At P1 station, we collected 150 *C. finmarchicus* stages CIV-CV for the experiment investigating pyrene, an oil substance, and temperature. Another 30 C. finmarchicus CIV-CV were used for investigating the LC-50 Cu, the concentration of Cu that killed 50% of the exposed individuals.
At P4 station, we collected 150 *C. glacialis* females for preliminary test the effects of pyrene at in situ water and temperature. Other 40 *C. glacialis* females were used for the LC-50 Cu test. We further collected 300 *C. glacialis* females to transport to Department of Biosciences, University of Oslo where we will test the effects of temperature, ocean acidification and pyrene on parental and offspring generations.

In all four experiments at P1 and P4, we also measured the size and lipid sac of study species.
At P7 station, we collected 100 *C. hyperboreus* for investigating single, two and three stressor effects on the reproduction and recovery of females under different stressors on this key zooplankton species. *C. hyperboreus* will also be transported to University of Oslo where we will conduct the experiment after the cruise.

Table 15: Overview of fish and mesozooplankton sampling

Purpose	Gear	Station	N samples	Task
PAH metabolites in fish	Trawl	P1	30 polar cods	T2-2.3
Pyrene x temperature and Cu experiments	Multinet 180 µm	P1	1 (180 ind. *C. finmarchicus* CIV-CV)	T2-2.2
Pyrene and Cu onboard experiments Post-cruise experiments of pyrene x temperature x ocean acidification at Oslo	Bongonet / WP 1000 µm	P4	1 (490 females *C. glacialis*)	T2-2.2
Post-cruise experiment of pyrene x temperature x ocean acidification at UiO	WP 1000 µm	P7	2 (100 females *C. hyperboreus*)	T2-2.2

3.6 Benthos

3.6.1 Benthos (RF3, T3-1-1, T3-1-2, T3-4-3 & T3-4-4)

Arunima Sen (Nord University), Eric Jorda Molina (Nord University), Thaise Ricardo de Freitas (UiO) & Amanda Ziegler (UiT)

Aims

T3-1-1: Characterize and quantify biota in the seasonal ice zone of the northern Barents Sea and adjacent Arctic Basin by sampling sediment communities for biodiversity and abundance/biomass assessments; specifically, microbes (PI Lise Øverås, UiB), benthic foraminifera (PIs Elisabeth Alve, and Silvia Hess UiO, PhD student: Thaise Freitas), multicellular meiofauna (PI Bodil Bluhm) and macro-infauna (PIs Paul Renaud, APN and Henning Reiss, PhD student Eric Jorda Molina, Nord University).

T3-1-1: Characterize biota in the seasonal ice zone by collecting voucher material of benthic macro- and megafauna to be archived at the UiT Museum for a legacy of physical material of the project (PIs: Bodil Bluhm and Andreas Altenburger UiT)

T3-1-2: Relate environmental conditions to biological communities by sampling for sediment properties (grain size), indicators of food availability (total organic carbon and nitrogen, sediment pigment amount) and food sources ($\delta^{13}C/\delta^{15}N$, pigment composition) (PIs Elisabeth Alve and Silvia Hess, UiO and Paul Renaud, Akvaplan-niva)

T3-4-4: Sympagic-pelagic-benthic coupling by sampling representative benthic invertebrate taxa and demersal fishes for stable carbon and nitrogen stable isotope analysis (PIs Bodil Bluhm, UiT and Lis Jørgensen, IMR, for shared PD to be hired)

T3-4-4: Sympagic-pelagic-benthic coupling by conducting sediment community respiration incubation experiments onboard (PI Paul Renaud, APN, with PD Arunima Sen and PhD student Eric Jorda, Nord Univ.)

T3-4-4: Sympagic-pelagic-benthic coupling by sampling sediment for IP_{25} analysis and biogenic silica as indicators of ice algal food available to the sediment communities (PI Marit Reigstad with PhD student Yasemin Bodur, UiT).

T3-4-4: Trophic ecology of benthos by sampling benthic meiofauna for molecular characterization of diets of small benthic invertebrates (PI Anna Vader, with PhD student Snorre Flo, UNIS/ UiT).

RF1 T1-3: To help to interpret changes in sea-ice distribution, paleoproductivity, and related environmental conditions during the past 2 kyrs by using results gained by living benthic foraminiferal assemblage and associated parameter analyses of surface and sub-surface sediments (PI Elisabeth Alve, with PhD student Thaise Freitas and Silvia Hess, UiO)

RF2 - T2-1.2 Ocean acidification effects on the mobility of particulate and dissolved organic carbon (POC, DOC), essential trace elements (micronutrients) and heavy metals by sampling sediment sub-samples for trace element analysis by sequential
sediment extraction (PI Murat Ardelan with PhD Stephen Kohler).

Sampling sites and strategy

Sampling largely followed the Nansen Legacy sampling protocol version 7. We sampled demersal fish and epibenthos from two locations: a site south of P2 and north of P1, as well as a site just north of P2, with ~15-30 min Campelen 1800 trawl hauls. Bottom trawl sampling at P7, P6, P5, P4, P3 was not possible due to sea ice appearance. Details on the trawling procedure are described in the fish section of protocol version 5. Benthic organisms were picked from the trawl haul both on deck and in the fish lab, identified to the highest practical taxonomic resolution, and either frozen (for later stable isotope analysis and wet weight-to-carbon analysis), or fixed in formalin or 70% ethanol (for the museum collection, depending on taxon), or 96% ethanol (to allow later molecular analysis of museum archived specimens).

Sampling for sediment parameters, organismal abundance and diversity was done at stations P1, P2, P4, P6 and P7 using a 50 x 50 x 50 cm giant box core (owned by UiT - Department of Geosciences). At all these sites three box core replicates (2 at P7) were taken for further sub-sampling. Sediment cores for respiration experiments were collected at P1, P4 and P6.

Gear: Demersal Campelen trawl and a box corer (50 x 50 cm)

Station P1 (6th March 2021)

Three box core replicates were successfully recovered after three deployments. Sediment surfaces of all replicate cores were well preserved, had clear surface water on top and some visible macrofauna (Figure 19). Sediments were light brownish down to 3 cm core depth. Sediments below were gray and stiff. Many long polychaete tubes from Spiochaetopterus were present in all replicate cores.

Figure 19: Sediment surface of box cores (replicate 1, 2, and 3) at site P1.

Microbes were sampled in replicates of three (one per box core) with a 4.7 cm diameter core and sectioned in 0.5 cm layers up to 3 cm. The center of each section was taken out with a 60 ml syringe and the sediment placed into a sterile whirl pack bag and frozen at -80°C. The rest sediment of each section and the lower part of the sub-core (>6 cm core depth) were stored in separate sterile whirl pack bags and kept in a fridge for on-board single cell extraction by Lise Øverås (UiB).

Benthic foraminifera and multicellular meiofauna were sampled in replicates of three with a 5.5 cm diameter core and sectioned in 0.5 cm layers up to 3 cm, placed into Joni containers and preserved with rose Bengal stained 70% ethanol (2g rB per liter) and stored at room temperature.

Sediment grain size, TOC, TN and $d^{13}C$/ $d^{15}N$ samples were sampled in bulk using a 5.5 cm diameter core and sectioned in 0.5 cm layers up to 3 cm in each of the three replicate cores. Samples were immediately stored at -20°C.

Sediment pigment (chlorophyll a, phaeopigments) samples were taken from a 4.7 cm sub-core sliced down to 3 cm in 0.5 cm-slices and from there on in 1 cm-slices down to 5 cm core depth. Samples were wrapped in aluminum foil and stored in a -20°C freezer.

To assess pigment composition using HPLC analysis, a single sample from each box core was taken from the 0-2 cm layer using a 60 ml syringe and stored wrapped with aluminum foil at -80°C as part of a collaboration with the CHAOS project in the UK's Changing Arctic Ocean program.
A surface sediment sample (0-1 cm) was taken for IP25 analysis with a 60 ml syringe and stored at -80°C.
One surface scrape each was taken for molecular analysis of diets of selected meiofauna taxa (stored in 96% ethanol at -20°C), and for trace metal analysis from the two firsts replicates. For the third replicate the sample was collected using a 60 ml syringe.
Two spoonsful of the sediment surface were scraped off and placed into 15ml falcon tubes and stored at -20°C for measuring trace metals from each replicate box core.
A single sample from each box core replicate was taken from the 0-3 cm layer using a 60 ml syringe. One-centimeter sections were made and placed into Ziploc bags and stored at -20°C for analysis of biogenic silica.
Twenty sediment cores (11.7 cm inner diameter) were taken from the three box corers (7 from the first two and 6 from the third) for incubation and measurement of bulk sediment respiration rates. Four treatments (5 replicates each) were carried out: treatment 1 was at ambient bottom water temperature (1°C), treatment 2 was also at ambient conditions, but isotopically labeled algae was added, treatment 3 was carried out at 4°C above ambient temperature, and treatment 5 was also carried out at the warmer temperature with the algal addition. Control cores with just bottom water were also measured (2 at each temperature). Cores were first acclimated and bubbled to oxygen saturation for 12 hours. 50ml of the water was then collected for measuring nutrients (silica, nitrate, etc.). Afterwards, cores were sealed, and oxygen measurements were taken every 6 hours to measure oxygen consumption rates. Core tops with magnetic stir bars were fixed on, removing air bubbles, and connected to electric transformers to keep the bars stirring in order to avoid stratification of the water in the cores. Oxygen measurements were taken every 6 hours via the *PreSens Fibox* 4 optical sensor system. Experiments were terminated when 30% oxygen was consumed, upon which 50ml nutrient samples were taken again to measure the rate at which they were released. After incubation, microbe samples were taken from each core (5g surface sediment frozen directly at -80°C and 0.1 g surface sediment mixed with 40µl glutaraldehyde and 90 µl phosphate buffered saline solution and frozen at -80°C). From the two treatments where algae were added (treatments 2 and 4), the first 2 cm were sampled via two 60ml cutoff syringes for measuring uptake rates of foraminifera, these samples were frozen at -20°C. After taking the microbe and meiofauna samples, the sediment incubation/respiration cores were washed through a 0.5 mm sieve and remaining macrofauna were preserved in 4% formaldehyde seawater and Rose Bengal solution. Sediment cores for respiration incubations were given a UUID through the system, but no labels were generated since these cores did not have a physical form after incubations were terminated. However, macrofauna samples, nutrient samples and meiofauna samples (post-incubations) were taken from these cores and all these samples had UUIDs and appropriate labels, with the parent UUID being the generated, but label-less UUIDs for the incubation cores.
A single multicore liner was inserted into the third box corer to collect sediment samples for porewater chemistry analysis. Holes were predrilled into the sub core and upon retrieval, porewater was collected via rhizons every 6 cm. In each layer, 1 ml of porewater was added to 1 ml of zinc acetate solution and then frozen at -20°C for sulfide concentrations measurement. The rest of the porewater from each layer was frozen at -20°C for measuring nutrients and DIC.
The remaining surface area was sieved through 1 mm mesh and the organisms retrieved (mostly polychaetes) were identified to family level when possible and frozen at -20°C for later stable isotope analysis. For future cruises, a 0.5 mm should be used together with a 1 mm in a cascade. For these samples, only sieves that have not been in contact with enriched material (from incubation experiments) were used.

Station P2 (7th March 2021)
Three box core replicates were successfully recovered after four deployments. Sediment surfaces of all replicate cores were well preserved, had clear surface water on top and some visible macrofauna

(Figure 20). Before we started with the cores, part of the surface started to open and collapse due to a crust layer and rocks that trapped air and leaked when extruding the cores in the lab. Sediments were light brownish down to 3 cm core depth. Sediments below were gray and stiff, with a crust layer close to 10 cm.

Figure 20: Sediment surface of box cores at site P2. The first label states BC3 but it is BC1. The replicates are in order (replicate 1, 2, and 3).

Microbes were sampled in replicates of three (one per box core) with a 4.7 cm diameter core and sectioned in 1 cm layers up to 6 cm. The center of each section was taken out with a 60 ml syringe and the sediment placed into a sterile whirl pack bag and frozen at -80°C. The rest sediment of each section and the lower part of the sub-core (>6 cm core depth) were stored in separate sterile whirl pack bags and kept in a fridge for on-board single cell extraction by Lise Øverås (UiB).
Benthic foraminifera and multicellular meiofauna were sampled in replicates of three with a 5.5 cm diameter core and sectioned in 1 cm layers up to 6 cm, placed into Joni containers and preserved with rose Bengal stained 70% ethanol (2g rB per liter) and stored at room temperature.
Sediment grain size, TOC, TN and $d^{13}C$/ $d^{15}N$ samples were sampled in bulk using a 5.5 cm diameter core and sectioned in 1 cm layers up to 6 cm in each of the three replicate cores. Samples were immediately stored at -20°C.
Sediment pigment (chlorophyll a, phaeopigments) samples were taken from a 4.7 cm sub-core sliced down to 6 cm in 1 cm-slices and from there on in 2 cm-slices down to 10 cm core depth. Samples were wrapped in aluminum foil and stored in a -20°C freezer.
Six, six and seven sediment cores (11.7 cm inner diameter) were taken from each replicate box core, for macrofauna analyses and sieved immediately (not used for incubation experiments) through 0.5 mm sieve and preserved in 4% formaldehyde seawater solution.
Sediment surface samples (pigments for HPLC analysis, IP25, biogenic silica, trace metals, meiofauna diet samples, stable isotope analysis) were sampled in a similar way as station P1.

Station P4 (11th March 2021)
Three box core replicates were successfully recovered after three deployments. Sediment surfaces of all replicate cores were well preserved, had clear surface water on top and some visible macrofauna (Figure 21). Sediments were light brownish down to 3 cm core depth. Sediments below were gray and stiff. In the sediment cores, some air pockets were present and leaked air while we were extruding in the lab. Many long polychaete tubes from Spiochaetopterus were present in all replicate cores. The same sampling procedure was conducted, including setting up a new incubation experiment was set up. Temperatures were set at 1°C and 5°C for the experiments (based on bottom water conditions). Microbes samples post incubation were only taken from treatments 1 and 2 (2 replicates each).

Figure 21: Sediment surface of box cores (replicate 1, 2, and 3) at site P4.

Station P6 (15th – 16th March 2021)

Three box core replicates were successfully recovered after three deployments. Sediment surfaces of all replicate cores were well preserved, had clear surface water on top and some visible macrofauna (Figure 22). Sediments were light brownish down to 3 cm core depth. Sediments below were gray and stiff. In the sediment cores, some air pockets were present and leaked air while we were extruding in the lab. Sampling was identical to at P4, including setting up a new incubation experiment. Temperatures for experiments were maintained at 0°C (ambient was negative, but negative temperatures were not possible) and 2°C (since deeper water is not expected to experience as much of an increase in temperature as shallower shelf areas).

Figure 22: Sediment surface of box cores (replicate 1, 2, and 3) at site P6.

Station P7 (18th-19th March 2021)

Three box core deployments were conducted at P7, and 2 were successful. Additional attempts to collect sediment material were cancelled due to inappropriate weather conditions. Even though the box corer penetrated the sediment and close correctly, due to rough sea conditions and high waves the sediment surfaces was disturbed when it was brough to the deck. Sediment surface samples (pigments for HPLC analysis, IP25, biogenic silica, trace metals, meiofauna diet samples) were not taken. Incubations were not possible either. However, sampling for meiofauna, sediment pigments, TOC/grainsize/TN, microbes, and stable isotopes were conducted as at other stations for each of the two box cores (Figure 23). A total of 16 macrofauna cores were taken from the two box corers, sieved immediately and fixed in formaldehyde/Rose Bengal for macrofauna analyses.

Figure 23: Sediment surface of box cores (replicate 1 and 2) at site P7.

Respiration incubation experiments

Respiration experiments were carried out at 3 of the 4 target stations (P1, P4 and P6). Incubations were not conducted at P7 due to the sediment being highly disturbed in box cores that were retrieved at this location. In all experiments, treatment 4 (higher temperature and algae added) oxygen consumption rates were higher than other treatments and had to be terminated well before the other treatments. Differences in rates between other treatments and between stations will be examined once all the data is processed.

Macrofauna observations

Epifauna

Trawls were not quantitatively analyzed. However, we noticed some differences in the epifauna collected by the two trawls. *Pandalus borealis* shrimp was highly abundant at the first station between P1 and P2. Overall, this location appeared not to be very diverse. Much higher variety in terms of different types of animals and species were collected during the second trawl north of P2. At this location, *P. borealis* was not abundant, and polar cod made up most of the haul. However, we retrieved animals such as the sea cucumber *Molpadia borealis*, polychaetes from the family *Flabelligeridae* (*Brada* sp.), numerous gastropods, including with anemones attached, sea urchins, multiple species of pycnogonids, and even an ocopus. Differences were observed between the box corers from the stations. Spiochaetopterids were present in high numbers at the shelf stations. The quantity or biomass appeared to be considerably lower at the deeper stations (P6 and P7). At P6 crustaceans appeared to dominate the community instead of polychaetes. Sibolginid worms, that have an obligate symbiotic relationship with chemosynthetic bacteria were recovered from both deeper stations.

Table 16: Overview of stations sampled for each of the different activities. Numbers in parentheses indicate number of sediment layers.

				Station / number of replicates / treatments for incubation						
Sample type	Task	PI/responsible	Institution	P1	P2	P3	P4	P5	P6	P7
Sediment microbes	T3-1-1	L. Øvreås	UiB	3 (6)	3 (6)	-	3 (6)	-	3 (6)	2 (6)
Meiofauna	T3-1-1	E. Alve	UiO	3 (6)	3 (6)	-	3 (6)	-	3 (6)	2 (6)
Macrofauna	T3-1-1	P. Renaud/H. Reiss	APN / Nord	20	20	-	20	-	20	16
Museum vouchers	T3-1-1	B. Bluhm	UiT			-	-	-	-	-
Grain size, TOC/TON, d13C/d15N	T3-1-2	E. Alve	UiO	3 (6)	3 (6)	-	3 (6)	-	3 (6)	2 (6)
Sediment Chl / phaeopigments	T3-1-2	P. Renaud	APN	3 (8)	3 (8)	-	3 (8)	-	3 (8)	2 (8)
Sediment pigment compositon	T3-1-2	P. Renaud / UK CHAOS	APN	3 (1)	3 (1)	-	3(1)	-	3 (1)	2 (1)
Organisms $\delta C^{13}C/\delta N^{15}N$	T3-4-4	B. Bluhm / L. Jørgensen	UiT / IMR	20 taxa	34 taxa	-	28 taxa	-	22 taxa	10 taxa
Incubation experiments	T3-4-4	P. Renaud / A. Sen	APN / Nord	20	-	-	20	-	20	-
Nutrients pre-incubations	T3-4-4	P. Renaud / A. Sen	APN / Nord	24	-	-	24	-	24	-
Nutrients post-incubations	T3-4-4	P. Renaud / A. Sen	APN / Nord	24	-	-	24	-	24	-
Sediment IP_{25}	T3-4-4	M. Reigstad	UiT	3 (1)	3 (1)	-	3 (1)	-	3 (1)	-
Meiofauna molecular diet	T3-4-4	A. Vader	UNIS	3 (1)	3 (1)	-	3 (1)	-	3 (1)	-
Trace metals	RF2	M. Adelan / N. Sanchez	NTNU	3 (1)	3 (1)	-	3 (1)	-	3 (1)	-
Biogenic silica	T3-4-4	M. Reigstad	UiT	3 (3)	3 (3)	-	3 (3)	-	3 (3)	-

3.7 Experiments

3.7.1 Effects of ocean acidification on Arctic planktonic crustaceans (RF2 T2-1.3)

Nadjejda Espinel-Velasco (NPI) & PI: Haakon Hop (NPI)

The main goal of the experiments carried out on board was to investigate the metabolic responses of living copepods to stressors of anthropogenic origin (in this case ocean acidification) through a series of respiration experiments.

Planktonic live specimens were collected with a WP3 net (1000 µm) from P1, P4 and P7 for experimental use on board. *Calanus glacialis* copepodite stage V were selected from the haul at the P1 station. Female *C. glacialis* were selected from the haul taken at P4 and P7 stations.

The oxygen uptake of the copepods when exposed to ocean acidification was measured by means of the Loligo® multiwell system. The selected copepods were individually placed in 1700 µL wells in the plates which were subsequently placed on the readers. Three plates were used simultaneously for each experiment (two treatments and one control). Each experiment consisted on exposing the organisms to a gradual decrease of seawater pH at the in-situ temperature in each of the stations where the organisms were collected. The pH decrease of 0.3 units pH was carried out every 12h, while continuously measuring the oxygen uptake. Each experiment consisted of 5 to 6 steps. At the end of the experiment, the individual copepods were photographed (for body size and lipid sac measurements), snap-frozen and stored at -80°C for further analyses.

On the other hand, *Calanus hyperboreus* females with eggs caught at station P4 were incubated by C. Gawinski until hatching. Using the same Loligo® multiwell system (500 µL wells), oxygen uptake of the resulting nauplii larvae was measured at two different temperatures (0.0°C and 3.0°C) and two different seawater pH (ambient and reduced pH – decrease of 0.3 units pH from ambient). Three nauplii were placed in each well and the measurements were carried until reaching no less than 60% total oxygen saturation (approx. 8h). Subsequently, the larvae were retrieved, snap frozen and stored at -80°C for further analyses. Simultaneously, a 24h incubation was set up to test the same treatments (2pH and 2 temperatures). Three replicates were set up for each treatment. Approximately 150 nauplii larvae were incubated in each replicate at the target pH and temperature. After 24h, the larvae were retrieved, counted and stored at -80°C for further analyses.

Table 17: Overview of the samples collected during Q1 2021.

Station	Life Stage	No. of individuals
P1	CV	60
P4	Females	60
	Nauplii	1500
P7	Female	60

3.7.2 Respiration experiments (RF3 T3-2.2)

Vanessa Pitusi (UNIS), Konrad Karlsson (UNIS) & PI: Janne Søreide (UNIS)

Respiration experiments were carried out during SSQ1 at 4 of the 7 AeN stations

Mesozooplankton was collected with a WP3 (1000 µm) net from the water column at stations P1, P4, P6, and P7 to capture Atlantic, shelf and Arctic zooplankton communities. The samples were concentrated in a sieve and processed right away or preferably within the first 12 hours of collection. The most dominant species and life stages were picked and placed in 100 % oxygenated water in an incubator at 0°C for at least 4 hours (in order to acclimatize). 20 or 40 individuals were picked per species and stage to be placed in 500 or 1700 µL Loligo microplates to measure the respiration of each individual for 4 to 10 hours. The duration was dependent on how fast the oxygen level dropped below

60 %. The transfer of copepods from the sample to the microplates was done in the dark, as the plates are light sensitive and strong light could have an effect on the readings. The plates were hydrated 30 min prior to the start of the experiment with filter seawater from the station; the water was kept in the incubator. After the experiment, each copepod was photographed, "washed" in distilled water and frozen in individual tin cups at -20°C. Samples were shipped and dried at The University Centre in Svalbard for dry weight. Photos were used to measure prosome length and determine lipid sac area.

Table 18: Species included in respiration experiments

Station	Species	Life Stage	No. of individuals
P1	*Calanus finmarchicus*	CIV	40
		CV	40
	Metridia longa	Female	40
P4	*Calanus glacialis*	CIV	40
		Female	40
	Calanus hyperboreus	Female	20
	Metridia longa	Female	40
P6	*Calanus* spp.	Male	40
	Calanus finmarchicus	CV	40
P7	*Calanus glacialis*	Female	40
	Calanus finmarchicus	CV	40
		Female	40
	Calanus hyperboreus	Female	40
	Calanus spp.	Male	40
	Metridia longa	Female	40

3.7.3 Effect of environmental drivers on the phenology of primary and secondary production (RF3 T3-2-2)

Christine Gawinski (UiT) & PI: Camilla Svensen (UiT)

The goal of this task is to characterize how current environmental settings drive the seasonality of copepod production. To meet this goal mesozooplankton productivity will be determined experimentally for selected key-species through egg-production/egg-hatching incubations in different seasons, representing species with contrasting life-history traits and reproductive strategies in open and ice-covered waters. Assuming that female copepods allocate their ingested carbon into egg production rather than into growth, the specific egg production rate can be used as an estimate of the production of the population. The focus during the cruise in March 2021 was on *Calanus hyperboreus*, *Calanus glacialis*, *Calanus finmarchicus*, *Paraeuchaeta sp., Metridia longa* and *Oithona similis*. To assess how population dynamics vary across space, egg incubation experiments were set up at three stations, namely P1 (1.5 ˚C), representing Atlantic conditions, P4 (-1.5 ˚C), based on the shelf and P7 (-1.5 ˚C), representing Arctic conditions.

Table 19: List of samples collected during Q1

Egg incubation experiments				
Station	Temperature (˚C)	Species	Number of individuals	Comment
P1-P4	1.5	*Oithona similis*	12	
P1	1.5	*Paraeuchaeta sp.*	11	4 females with eggs, 7 loose egg sacks

P4	-1.5	*Calanus hyperboreus*	30	
P4	-1.5	*Paraeuchaeta sp.*	71	30 females, 11 females with eggs, 30 loose egg sacks
P4	0	*Calanus hyperboreus*	20	From Vanessa's respiration exp.
P4	0	*Metridia longa*	19	From Vanessa's respiration exp.
P4	0	*Calanus glacialis*	40	From Vanessa's respiration exp.
P7	-1.5	*Calanus hyperboreus*	30	
P7	0	*Calanus hyperboreus*	20	From Vanessa's respiration exp.
P7	0	*Calanus finmarchicus*	37	From Vanessa's respiration exp.
Bongo net samples for female:egg ratio				
Station	Net size (µm)	Fixative	comment	
P1	64	½ Formaldehyde, ½ Ethanol	1 net	
P1	180	Formaldehyde	1 net	
P2	64	Formaldehyde	1 net	
P2	180	Formaldehyde	1 net	
P3	64	Formaldehyde	1 net	
P4	64	Formaldehyde	1 net	
P4	180	Formaldehyde	1 net	
P5	64	Formaldehyde	1 net	
P6	64	Formaldehyde	1 net	
P6	180	Formaldehyde	1 net	
P7	64	Formaldehyde	1 net	
P7	180	Formaldehyde	1 net	
Dilution experiment				
Station	Treatment	Number of replicates	Temperature	Samples taken
P4	Normal sea water	3	1.5	Phytoplankton, MZP, Flowcytometry, Nutrients, Chla, POC/PON, POP, HPLC, Ammonium
P4	20 % dilution	3	1.5	
P7	Normal sea water	3	-1.5	
P7	20 % dilution	3	-1.5	
P7	50 Oithona	3	-1.5	
P7	4 Calanus	3	-1.5	
Grazer exclusion experiment				
Station	Treatment	Number of replicates	Temperature	
P1	20 Oithona	3	1.5	
P1	3 Calanus	3	1.5	
P4	20 Oithona	3	-1.5	
P4	3 Calanus	3	-1.5	

P7	20 Oithona	3	-1.5	
P7	3 Calanus	3	-1.5	
CHN samples				
Species	type	Number of individuals	Station	comment
Paraeuchaeta sp.	females	60	P4, P6	Frozen individually in cryo tubes
Paraeuchaeta sp.	Egg sacs	30	P4	27 frozen individually in cryo tubes, plus 3 x 5 egg sacs pooled
Calanus hyperboreus	females	30	P4	Frozen individually in cryo tubes
Calanus hyperboreus	eggs	30 x 30	P1, P4, P7	30 eggs frozen in cryo tubes
Calanus hyperboreus	Unhatched eggs	4 x 30	P1, P4	30 unhatched eggs frozen in cryo tubes
Calanus hyperboreus	Nauplii	16 x 30	P1, P4	30 nauplii frozen in cryo tubes
Calanus hyperboreus	Experimental females	80	P1, P4, P7	Frozen individually in cryo tubes
FA, SI samples				
Species	station	Number of individuals	replicates	comment
Oithona similis	P1	50	3	FA
Oithona similis	P1	50	3	SI
Oithona similis	P7	50	3	FA
Oithona similis	P7	50	3	SI
Nauplii multiple stressor experiment				
Station	Treatment	Temperature	Comment	
P7	Normal pH	0	Respiration measurement + 24 h bottle incubation for lipids and metabolomics	
P7	Decreased pH	0	Respiration measurement + 24 h bottle incubation for lipids and metabolomics	
P7	Normal pH	3	Respiration measurement + 24 h bottle incubation for lipids and metabolomics	
P7	Decreased pH	3	Respiration measurement + 24 h bottle incubation for lipids and metabolomics	

Preliminary results

Calanus finmarchicus, Calanus glacialis and *Metridia longa* did not reproduce. *Oithona similis* only reproduced at a bare minimum, almost no females with eggs were found at every experimental station.

C. hyperboreus:

EGGS

P7 respiration	581
P7	2008
P4 respiration	1187
P4	8452
P1	1103
TOTAL TOTAL	13331

NAUPLII

P4 respiration	530
P4	2447
P1	634
TOTAL TOTAL	3611

Paraeuchaeta sp.:

NAUPLII

P4 females with eggs	51
P4 loose egg sacks	85
P1	61
TOTAL TOTAL	197

Appendix 1. Tables

Cruise participants

Table 20: Cruise participants (* team leads)

#	Team	Activity	Name	E-mail	Institution	WP
1	Cruise lead	Cruise leading and sea ice physics	Sebastian Gerland	gerland@npolar.no	NPI	RF1
2	Co-lead	Cruise leading and zooplankton	Anette Wold	anette.wold@npolar.no	NPI	RF3/2
3	Microbes	POC, Chl a	Miriam Marquardt	miriam.marquardt@uit.no	UiT	RF3
4	Microbes	RNA/DNA, algae	Simon Kline	simonhk@student.ibv.uio.no	UiO	RF3
5	Microbes	RNA/DNA, algae	Cheshtaa Chitkara	cheshtaac@unis.no	UNIS	RF3
6	Microbes	Transcriptomics	Snorre Flo	Snorre.Flo@unis.no	UNIS	RF3
7	Microbes	Community/bacterial production	Oliver Müller*	Oliver.Muller@uib.no	UiB	RF3
8	Microbes	Community, food web	Anna Grytaas	anna.grytaas@student.uib.no	UiB	RF3
9	Microbes	Primary production	Marti A. Arumi	marti.a.arumi@uit.no	UiT	RF3
10	Microbes	Primary production	Natalie Summers	natalie.summers@ntnu.no	NTNU	RAC
11	Microbes	Vertical flux	Yasemin Bodur	yasmin.v.bodur@uit.no	UiT	RF3
12	Chemistry	Carbonate chemistry, nutrients	Elizabeth Jones*	elizabeth.jones@hi.no	IMR	RF2
13	Chemistry	Ocean acidification pteropods	Griselda Anglada-Ortiz	griselda.a.ortiz@uit.no	UiT	RF2
14	Chemistry	Trace metals, Hg methylation	Stephen Kohler	stephen.g.kohler@ntnu.no	NTNU	RF2
15	Chemistry	Trace metals, methylation	Laura Kull	lauramk@stud.ntnu.no	NTNU	RF2
16	Zooplankton	Community, biomass, metabarcoding	Amalia Keck*	Amalia.Keck@npolar.no	NPI	RF3
17	Zooplankton	Production small copepods	Christine Gawinski	christine.gawinski@uit.no	UiT	RF3
18	Zooplankton	Grazing large copepods	Vanessa Pitusi	vanessa.pitusi@gmail.com	UNIS	RF2/3
19	Zooplankton	Ocean acidification experiments	Nadjejda Espinel	nadjejda.espinel@npolar.no	NPI	RF2/3
20	Zooplankton	Energetics (zooplankton, fish)	Robynne Nowicki	Robynne.Nowicki@unis.no	UNIS	RF2
21	Zooplankton	Ecotox experiments	Dihn Khuong	van.k.dinh@ibv.uio.no	UiO	RF2
22	Zooplankton	Ecotox (water, zooplankton, fish)	Julia Giebichestein	julia.giebichenstein@ibv.uio.no	UiO	RF2
23	Zooplankton	Ecotox experiments	Andreas Jortveit	andrjor@uio.no	UiB	RF2/3
24	Benthos	Respiration, experiment	Arunima Sen*	arunima.sen@nord.no	Nord	RF3
25	Benthos	Respiration, experiment	Eric Jorda	eric.jorda-molina@nord.no	Nord	RF3
26	Benthos	museum collections, sediment sampling	Amanda Ziegler	amanda.f.ziegler@uit.no	UiT	RF1/3
27	Benthos	Living foraminifera	Thaise R. de Freitas	t.r.de.freitas@geo.uio.no	UiO	RF1/3
28	Sea ice physics	Polar bear guard & technical support	Jørn Dybdahl	Jorn.Dybdahl@npolar.no	NPI	RF1+
29	Sea ice physics	Sea ice physics	Dmitry Divine*	Dmitry.divine@npolar.no	NPI	RF1
30	Sea ice physics	Sea ice physics	Adam Steer	adam.steer@npolar.no	NPI	RF1
31	Optics	Optics	Tristan Petit	Tristan.Petit@npolar.no	UiB; NPI	RF1
32	Sea ice / heli	EM-bird; sea ice work	Jan Are Jacobsen	jan.are.jacobsen@npolar.no	NPI	RF1
33	Sea ice / heli	EM-bird; sea ice work	Marius Bratrein	marius.bratrein@npolar.no	NPI	RF1+

34	Helicopter crew	Pilot	Magne Palmesen	magne.palmesen@airlift.no	Airlift	RF1
35	Helicopter crew	Engineer	Johan Karlsson	johan.karlsson@airlift.no	Airlift	RF1

Figure 24: Nansen Legacy Seasonal cruise Q1 scientific cruise participants. Photo: Andreas Wolden, IMR.

Station table with date, location, gear & parameters measured

Date	Station	Latitude	Longitude	Bottom depth	Gear Type	Parameters	Sampling depth
05.03.2021	P1	76.019 N	31.274 E	333 m	Beam trawl	ecotox, FA, SI, HBI, energetics	
04.03.2021	prior P1	75.658 N	30.367 E	347 m	CTD w/bottles	deepwater - sediment traps	335-0 m
04-05.03.2021	P1	75.000 N	31.220 E	325 m	Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	310-0 m
					Bongonet 180 um	ecotox, FA, SI, HBI, energetics	300-0 m
					Bongonet 180 um	experiements	100-0 m
					Bongonet 180 um	female/egg ratio	310-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	310-0 m
					Bongonet 64 um	female/egg ratio, experiments	300-0 m
					Bongonet 64 um	experimetns	70-0 m
					Box core	benthos	
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	315-0 m
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	315-0 m
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	315-0 m
					GO-FLO	trace metals	325-0 m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	300-0 m
					MIK-net 1500 um	abundance/taxonomy	300-0 m
					Multinet 180 um	abundance/taxonomy	300-0 m
					Multinet 64 um	abundance/taxonomy	300-0 m
					Multinet 64 um	foraminifera/pteropods	300-0 m
					Optical profiler	optics	200-2 m
					Phytoplankton net 10 um	abundance/taxonomy	50-0 m
					Sediment trap (short term)	vertical flux	
					WP3 1000 um	experiments	100-0 m
06.03.2021	NLEG2	76.500 N	31.222 E	312 m	CTD w/bottles	Chlorophyll, DIC/AT	302-0 m
06.03.2021	NLEG3	77.000 N	33.996 E	154 m	CTD w/bottles	Chlorophyll, DIC/AT	143-0 m

07.03.2021	P2	77.516 N	33.6745 E	165 m	Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	145-0m
					Bongonet 180 um	female/egg ratio	145-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	145-0 m
					Bongonet 64 um	female/egg ratio, experiments	70-0 m
					Box core	benthos	170 m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	183-0 m
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	183-0 m
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	183-0 m
					GO-FLO	trace metals	178-10m
					MIK-net 1500 um	abundance/taxonomy; A-frame stopped	170-0 m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	170-0 m
					Multinet 180 um	abundance/taxonomy	170-0 m
					Multinet 64 um	abundance/taxonomy	170-0 m
					Multinet 64 um	foraminifera/pteropods	170-0 m
					Optical profiler	optics	178-2 m
					Phytoplankton net 10 um	abundance/taxonomy	50-0 m
					WP3 1000 um	ecotox, FA, SI, HBI, energetics	145-0 m
					Ice station	physics	
08.03.2021	NLEG 5	78.000 N	33.996 E	197 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	188-0 m
08.03.2021	NLEG 6	78.500 N	34.003 E	181 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	170-0 m
08.03.2021	P3-ice	78.508 N	34.013 E	179 m		Ice station physics	
08.03.2021	P3	78.749 N	34.000 E	305 m	Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	280-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	280-0 m
					Bongonet 64 um	female/egg ratio, experiments	70-0 m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	298-0 m

					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	298-0 m
					GO-FLO	trace metals	89-10 m
					MIK-net 1500 um	abundance/taxonomy	280-0 m
					Multinet 180 um	abundance/taxonomy	280-0 m
					Multinet 64 um	abundance/taxonomy	280-0 m
					Multinet 64 um	foraminifera/pteropods	280-0 m
					Optical profiler	optics	200-2 m
					Phytoplankton net 10 um	abundance/taxonomy	50-0 m
09.03.2021	NLEG 8	79.002 N	33.992 E	268 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	120-0 m
09.03.2021	NLEG 9	79.250 N	34.000 E	215 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	256-0 m
09.03.2021	NLEG 10	79.500 N	33.995 E	295 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	206-0 m
09-10.03.2021	P4	79.778 N	33.668 E	324 m	Active water sampler	ecotox	
					Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	320-0 m
					Bongonet 180 um	ecotox, FA, SI, HBI, energetics	320-0 m
					Bongonet 180 um	female/egg ratio, experiments	320-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	320-0 m
					Bongonet 64 um	experiment	320-0 m
					Bongonet 64 um	female/egg ratio, experiments	70-0 m
					Box core	benthos	327 m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	313-0 m
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	313-0 m
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	313-0 m
					GO-FLO	trace metal	321-10m
					MIK-net 1500 um	abundance/taxonomy	310-0 m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	320-0 m
					Multinet 180 um	abundance/taxonomy	320-0 m
					Multinet 64 um	abundance/taxonomy	320-0 m

					Multinet 64 um	foraminifera/pteropods	320-0 m
					Niskin	back-up for CTD during reparation	20 m
					Optical profiler	optics	200-0 m
					Phytoplankton net 10 um	abundance/taxonomy	50-0 m
					Sediment trap (short term)	vertical flux	
					WP3 1000 um	experiments	327 m
					Ice station	physics & biology	
11.03.2021	P4-buoy	79.765 N	33.453 E	316 m	SIMBA Bouy	Buoy deployment	
11.03.2021	NLEG 12	80.001 N	33.998 E	212 m	CTD w/bottles	ocean acidification	203-0 m
12.03.2021	P5	80.444 N	33.963 E	157 m	Active water sampler	ecotox	
					Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	130-0 m
					Bongonet 180 um	ecotox, FA, SI, HBI, energetics	130-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	130-0 m
					Bongonet 64 um	ecotox, FA, SI, HBI, energetics	130-0 m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	165-0 m
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	165-0 m
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	165-0 m
					GO-FLO	trace metal	123-10m
					MIK-net 1500 um	abundance/taxonomy	125-0 m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	140-0 m
					Multinet 180 um	abundance/taxonomy	125-0 m
					Multinet 64 um	abundance/taxonomy	125-0 m
					Multinet 64 um	foraminifera/pteropods	125-0 m
					Optical profiler	optics	145-2 m
					Phytoplankton net 10 um	abundance/taxonomy	100-0 m
					Sediment trap (short term)	vertical flux	
					Ice station	physics	

13.03.2021	NLEG 14	81.003 N	33.992 E	211 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	180 m
14.03.2021	NLEG 15	81.309 N	31.348 E	199 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	180 m
14.03.2021	NLEG 16	81.381 N	31.288 E	188 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	177 m
14.03.2021	NLEG 17	81.410 N	31.242 E	202 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	192 m
14.03.2021	NLEG 18	81.432 N	31.140 E	276 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	266 m
14.03.2021	NLEG 19	81.458 N	31.073 E	499 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	490 m
14.03.2021	NLEG 20	81.502 N	30.959 E	707 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	701 m
14-15.03.2021	P6	81.550 N	30.863 E	898 m	Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	750-0 m
					Bongonet 180 um	female/egg ratio	750-0 m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	750-0 m
					Bongonet 64 um	female/egg ratio, experiments	70-0 m
					Box core	benthos	868 m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	875-0 m
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	875-0 m
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorption	875-0 m
					GO-FLO	trace metal	500-10m
					MIK-net 1500 um	abundance/taxonomy	850-0 m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	750-0 m
					Multinet 180 um	abundance/taxonomy	820-0 m
					Multinet 64 um	abundance/taxonomy	820-0 m
					Multinet 64 um	foraminifera/pteropods	300-0 m
					Optical profiler	optics	200-2 m
					Phytoplankton net 10 um	abundance/taxonomy	100-0 m
					Sediment trap (short term)	sediment trap	
					WP3 1000 um	experiments	750-0m
					WP3 1000 um	ecotox, FA, SI, HBI, energetics	750-0m
					Ice station	physics & biology	
16.03.2021	NLEG 22	81.590 N	30.761 E	1596 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	1619m

16.03.2021	NLEG 23	81.618 N	30.669 E	1988 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	2014m
16.03.2021	NLEG 24	81.683 N	30.524 E	2824 m	CTD w/bottles	Chlorophyll, DIC/AT, nutrients, δ^{18}Oxygen	2869m
16-17.03.2021	P7	82.000 N	30.000 E	3298 m	Active water sampler	ecotox	
					Bongonet 180 um	biomass, metabarcoding, taxonomy, fatty acid	1000-0m
					Bongonet 180 um	experiment (Maja)	200-0m
					Bongonet 180 um	female/egg ratio	1000-0m
					Bongonet 64 um	biomass, metabarcoding, taxonomy, fatty acid	1000-0m
					Bongonet 64 um	experiment	1000-0m
					Bongonet 64 um	female/egg ratio, experiments	70-0m
					CTD w/bottles standard parameter	Chlorophyll, POC/N, phytoplankton tax., XRF, SEM, BP, FCM, metabarcoding, coccolithophore, vivaflow, DIC/AT, nutrients, δ^{18}Oxygen	
					CTD w/bottles noon	Metatranscriptomic, experiments, PI-curv, FA/SI/HB, virus, pigments	
					CTD w/bottles other parameters	DOM, Mercury, SI, CDOM, FDOM, Particle absorbsion	
					GO-FLO	trace metal	500-10m
					MIK-net 1500 um	abundance/taxonomy	1000-0m
					MIK-net 1500 um	ecotox, FA, SI, HBI, energetics	600-0m
					Multinet 180 um	abundance/taxonomy	2900-0m
					Multinet 64 um	abundance/taxonomy	2900-0m
					Multinet 64 um	foraminifera/pteropods	300-0m
					Optical profiler	optics	200-2m
					Phytoplankton net 10 um	abundance/taxonomy	100-0m
					Sediment trap (short term)	vertical flux	
					WP3 1000 um	experiments & alive animals	400-0m
					Ice station	physics & biology	
19.03.2021	P7-box	81.727 N	28.671 E	2668 m	Box core	benthos	2668m
20.03.2021		79.683 N	32.057 E	230 m	SVP Buoy	deployment SVP Buoy and short ice station	
21.03.2021		77.992 N	31.074 E	244 m	Beam trawl	ecotox, FA, SI, HBI, energetics	0

Appendix 2. List of datasets

Shipmounted datasets

Who		Sample info			Analyses				Relevance to Nansen Legacy Implementation plan		Data				
Cruise participant	PI	Sample type	Intended method	Parameter	Analysis protocol	Dataset	Where will analyses be done	When are analyses planned for	RF	Task/Subtask	Sharing within project	Publishing data	Ask for embargo of data?	If yes, why?	Comments
KHP instrumentation	Helge Sagen (IMR)					Acoustic data surveying fish and zooplankton, logged continuously					2021, NIRD	2021	No		EK80
KHP instrumentation	Øystein Godøy (MET)					Air and sea temperature (8 m depth), air pressure, wind speed and direction, relative humidity and solar radiation logged continuously					post cruise on NIRD	2021	No		Weather station
KHP instrumentation	Helge Sagen (IMR)					Temperature, salinity, density and fluorescence at 4m, logged continuously					post cruise on NIRD	2021	No		Thermosalinograph
KHP instrumentation	Helge Sagen (IMR)					Currents in the upper ~500 m logged continuously					post cruise on NIRD	2021	No		ADCP 150 kHz
KHP instrumentation	Agneta Fransson (NPI)					pCO2 measured from the underway system, 4 m intake during the open water part of the cruise					post cruise on NIRD	2022	Yes	COS project, public after substantial QC, restricted for use by PD	pCO2 underway
KHP instrumentation	Helge Sagen (IMR)					Temperature, salinity, density fluorescence, oxygen profiles from NLEG stations					post cruise on NIRD	2021	No		CTD
KHP instrumentation	Helge Sagen (IMR)					Atmospheric pressure, temperature and humidity profiles					post cruise on NIRD	2021	No		Radiosondes

Datasets

Who		Sample info		Analyses					Relevance to Nansen Legacy implementation plan		Data				
Cruise participant	PI	Sample type	Intended method	Parameter	Analysis protocol	Dataset	Where will analyses be done	Planned analysed	RF	Task/Subtask	Sharing within project	Publishing data	Ask for embargo of data?	If yes, why?	Comments
Adam Steer	Sebastian Gerland, Arild Sundfjord	geolocated imagery of sea ice captured by remotely piloted aircraft (drone)	Parrot ANAFI USA	ice and snow topoography	not established	small scale orthophotos and elevation models of sea ice	NPI	2021-2022	RF1	T1.1-1.2, T1-2.2	2021	2021	No		
Dmitry Divine, Adam Steer	Sebastian Gerland, Arild Sundfjord	Electromagnetic induction soundings of snow + ice thickness	GEM2 electromagnetic induction sounder	ice and snow thickness	not established	geolocated ice and snow combined thickness	NPI	2021-2022	RF1	T1.1-1.2, T1-2.2	2021	2021	No		
Dmitry Divine, Adam Steer	Sebastian Gerland, Arild Sundfjord	Snow probe surveys of snow depth	Magnaprobe GPS snow probe	Snow depth	not established	Geolocated snow depths	NPI	2021-2022	RF1	T1.1-1.2, T1-2.2	2021	2021	No		
Dmitry Divine, Adam Steer	Sebastian Gerland, Arild Sundfjord	Precise GNSS observations of ice station drift and rotation	Leica Viva GPS receiver x 3	ice drift and rotation	not established	Precise ice drift, rotation and surface elevation parameters for correcting drift in airborne datasets	NPI	2021-2023	RF1	T1.1-1.2, T1-2.2	2021	2021	No		
Dmitry Divine, Adam Steer	Sebastian Gerland, Arild Sundfjord	Regional scale helicopter borne electromagnetic induction soundings of snow + ice thickness	EM-bird	ice and snow thickness	not established	Ice and snow combined thickness along the flight track	NPI	2021-2023	RF1	T1.1-1.2, T1-2.2	2021	2021	No		
Dmitry Divine, Adam Steer	Sebastian Gerland, Arild Sundfjord	sea ice cores	ice sampling using Kovacs corer	Physical characteristics of sea ice	AeN V7	Physical characersistics of sea ice in the northern Barents Sea from in situ observations	NPI	2021	RF1	T1.1-1.2, T1-2.2	2022	2022-2023			
Dmitry Divine, Adam Steer, Tristan Petit	Dmitry Divine, Sebastian Gerland	Sea ice observations	Sea ice observations/pictures from the bridge follow ASSIST protocol	Sea ice coverage, Sea ice age and type, Snow cover	NL v5 4.1	Sea ice observations	NPI	2021-2022	RF1	T1.1-1.2, T1-2.2	2021	2021	No		made publicly available in icewatch.met.no within a month of return
Dmitry Divine, Sebastian Gerland	Maximilian Semmling (DLR, Germany)	only data	GNSS-R	Sea ice surface characteristics	not established	Sea-ice permittivity derived from GNSS reflection profiles; sea ice concentration around the ship	DLR/GFZ (Germany)	2021	RF1; RA-C	T1-2.2, T1-1.2	2022	2022-2023			
Sebastian Gerland, Dmitry Divine	Rudolf Krakauer (DWD, Germany)	only data	Radiosondes	Air temp., pressure, moisture, wind	not established	Altitude profile of air temp., pressure, moisture, wind during the cruise period	DWD	2021	RF1	T1-2.3, T1-2.2, T1-1.2	2021	2022-2023			
Natalie Summers	Geir Johnsen	Water samples in cuvette	PhytoPam fluorometer	Photosynthetic parameters	AeN V7	Rapid Light Curves	NTNU	2021-2022	RF1; RA-C	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2021	2021-2023	yes	PhD-project	
Natalie Summers	Geir Johnsen	GFF filters	HPLC (pigment analysis)	Spectra of pigments	AeN V7	Chemeotaxonomy	NTNU	2021-2022	RF1; RA-C	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2021	2021-2023	yes	PhD-project	
Natalie Summers	Geir Johnsen	Water samples fixed in Gluteraldehyde	Flow cytometry	CytoSense	AeN V7	Cell traits	NTNU	2021-2022	RF1; RA-C	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2021	2021-2023	yes	PhD-project	
Thaise Freitas, Arunima Sen, Eric Jorda	Elisabeth Alve & PhD- Thaise Freitas	Grain size	Laser Diffraction Particle Size Analyzer (grain size); combustion in muffle furnace (TOC, TN), IRMS (d13C/d15N)	sediment grain size fractions, sediment total organic carbon (TOC, %), sediment total nitrogen (TN, %), d13C (per mil), d15N (per mil)	(10.3.3)	sediment grain size fractions, sediment total organic carbon (TOC, %), sediment total nitrogen (TN, %), d13C (per mil), d15N (per mil)	UiO	2019-2022	RF1; RF3	RF1, RF3 T3-1.2	2020	2021-2022	Yes, possibly	PhD project	to be finalized by PI
Thaise Freitas, Arunima Sen, Eric Jorda	Elisabeth Alve & PhD student- Thaise Freitas (Foraminifera), Bodil Bluhm (metazoan meiofauna)	Meiofauna abundance	Sorting and morphological identification	number of (taxon) / cm2	(10.3.5)	Foraminifera abundance, diversity and composition; metazoan meiofauna abundance, diversisty and composition	UiO (Foraminifera), UiT / IOPAS (metazoan meiofauna)	2019-2022	RF1; RF3		2020	2021-2022	Yes, possibly	PhD project	
Tristan Petit	Mats Granskog; Børge Hamre; Pedro Duarte; Philipp Assmy	Particulate absorbtion	Spectophotometer with integrating sphere	absorption spectra for algal and non-algal particles	Instrument: QFT-ICAM	Particulate absorbtion from standard depth sampled from CTD at all process stations	Abroad in collaboration with Rudiger Röttgers (Germany) (Tristan Petit)	2021 (within 6 months)	RF1; RF3	T1-2.3/T1T3-1.3/T3.3.1/T1-2.4	2021	2021-2022	yes	PD project	
Griselda Anglada-Ortiz	Tine L. Rasmussen	Plankton sample	Absolute abundance and carbonate contribution from pteropods and foraminifera	#/m3 and mg CaCO3/m3	AeN v7	Relative and absolute abundance of marine calcifiers on the water column and their contribution to the carbonate pump	CAGE-UiT (Tromsø)	2021	RF2	T2-1.4	2021	2021-2022	yes	PhD project	
Griselda Anglada-Ortiz	Tine L. Rasmussen	Water sample	Absolute abundance and carbonate contribution from coccolithophores	#/m3 and mg CaCO3/m3	AeN v7	Relative and absolute abundance of marine calcifiers on the water column and their contribution to the carbonate pump	CAGE-UiT (Tromsø)	2021	RF2	T2-1.4	2021	2021-2022	yes	PhD project	
Julia Giebichenstein	Katrine Borgå	Meso- and Macrozooplankton	stable isotopes, mercury, persistent organic pollutants analyses	food web contaminant biomagnification	NL V5 chapter 13	food web contaminant biomagnification	UiO	2019-2021	RF2	T2-2.1	2021	2022	yes	PhD project	
Julia Giebichenstein	Katrine Borgå	In-situ filtration pump	persistent organic pollutant analyses	food web contaminant biomagnification	NL V5 chapter 13	food web contaminant biomagnification	UiO	2019-2021	RF2	T2-2.1	2021	2022	yes	PhD project	
Julia Giebichenstein	Katrine Borgå	frozen (-20C) whole and dissected fishes: muscle, otoliths, stomach	stable isotopes, mercury, persistent organic pollutants	food web contaminant biomagnification	NL V5 chapter 13	food web contaminant biomagnification	UiO / NP	2019-2021	RF2	T2-2.1	2021	2022	yes	PhD project	SI analyses will be done at UiO
Libby Jones	Melissa Chierici, Agneta Fransson	Water samples from the CTD	Carbonate chemistry and chemical parameters	dissolved oxygen, pH, dissolved inorganic carbon, alkalinity, nutrients, d18O	NL v7	dissolved oxygen, pH, dissolved inorganic carbon, alkalinity, nutrients, d18O	IMR/NPI	2021	RF2	T2-1.1	2020	2021	No		Samples taken for post-cruise analysis in 2021
Libby Jones	Melissa Chierici, Agneta Fransson	Sea ice, snow, brine, under-ice water	Carbonate chemistry and chemical parameters	pH, dissolved inorganic carbon, alkalinity, nutrients, d18O	NL v7	pH, dissolved inorganic carbon, alkalinity, nutrients, d18O	IMR/NPI	2021	RF2	T2-1.1	2020	2021	No		Samples taken for post-cruise analysis in 2021
Nadjejda Espinel-Velasco	Geir Wing Gabrielsen, Haakon Hop	Frozen adult copepods (-80)	Metabolomics + Lipid analyses	measures of metabolites and lipid content in ug/individual	AeN V7	Physiological responses of lower trophic levels of arctic ecosystems, when exposed to stressors of anthropogenic origin	NPI	2022-2023	RF2	T2-1.3	2021	2021-2022	yes	Postdoc	
Stephen Kohler, Laura Kull	Maria Digernes, Murat V. Ardelan	Dissolved organic matter characterization, DOC	HPLC-MS	Type and composition of DOM, DOC, ancillary	NL v7, 7.6	Variation, composition, and distribution of DOM and DOC, with ancillary POC measurements	NTNU	2020-2022	RF2	T2-2.2	2020	2022	yes	phd project	Maria Digernes PhD project
Stephen Kohler, Laura Kull	Nicolas Sanchez, Murat V. Ardelan	Total trace elements and dissolved trace elements	Preconcentration via SeaFAST and ICP-MS	Concentration of elements in nM	NL v7 7.7	Total and dissolved trace elements transect profile	NTNU	2019-2021	RF2	T2-2.2	2020	2022	Need to ask PI		Confirm with the PI
Stephen Kohler, Laura Kull	Stephen Kohler, Murat V. Ardelan	Total mercury and methylmercury	Cold vapor atomic fluorescence spectrometry (CVAFS) for THg and MeHg, or GC-SF-IR-ICPMS for MeHg	THg, MeHg in pM	NL v7, 7.7.1	Total mercury and methylmercury transect profile	Mediterranean Institute of Oceanography (MIO) in Marseille, France	2019-2021	RF2	T2-2.2	2020-2022	2022	yes	PhD project	Stephen Kohler PhD project
Stephen Kohler, Laura Kull	Stephen Kohler, Murat V. Ardelan	Sediment samples	Sequential extraction for trace elements and Hg determination, DMA-80	THg in ng/g, Trace element concentrations	Nansen Legacy v4 10.4	Distribution of trace elements in sediments	NTNU	2019-2022	RF2	T2-2.2	2022	2022	maybe, check with PI		
Stephen Kohler, Laura Kull	Stephen Kohler, Maria Digernes, Murat V. Ardelan	Hg transformation under different DOM regimes	GC-SF-ICP-MS and CVAFS for Hg, Q-TOF or Orbitrap for DOM characterization	Hg in pM, DOM characterization	not established	Hg transformation under different DOM regimes	NTNU	2021-2023	RF2	T2-2.2	2022	2022	yes	PhD project	
Van Khuong Dinh	Katrine Borgå, Ketil Hylland	Alive copepods	Exposure experiments	Life history traits	not established	Survival, body size, development, egg reproduction	UiO	2021-2022	RF2	T2-2.2	2021	2021-2023	yes	Postdoc	
Robynne Nowicki	Øystein Varpe, Katrine borga, Geir wing gabrielsen	Macrozooplankton and fish	Energetics analysis using bomb calorimetry and Cellular Energy Allocation	Energy, protein and lipid content; pollutant concentration of polar cod brain	NL v7 13.3-13.4	Seasonal variation in macrozooplankton and fish energy content; Seasonal remobilization of pollutants in polar cod	UIT/UNIS/UiO	2020-2021	RF2	T2-2.5	2021	2021-2022	Unsure	PhD project	
Amalia Kech, Anette Wold	Espen Bagøien, Post Doc	Macrozooplankton	Sorting and morphological identification, metabarcoding	taxonomic composition, biomass	NL v5 7.11.1	Key organims, e.g. Euphausiids and amphipods, Map spatial distribution, taxonomic compostion and biomass indices, temporal and spatial variation in abundance, biomass, diveristy	IMR	2019-2021	RF3	T3-1.1; T3-2.1	2020	2020-2022	No		to be finalized by PI
Anette Wold; Amalia Keck	Anette Wold; Janne Søreide (in collabaoration with Sanna Majaneva, NTNU)	Gelatinous zooplankton	Genetic analyses, counts, size measurmnts	species list; ind/m3; ml/m3	NL v5 9.1.1.6	Gelatinous zooplankton abundance (ind/m3), volume & species composition (species list)	Counts, weight and length measurments done onboard; species identification NTNU (Sanna Majaneva)	2021	RF3	T3-1.1 & 2.1 T3-2.1 & 2.2	2021-2022	2021-2022	Yes	master student	Gelatinous zooplankton were picked out from the standard MIK net, each taxa was counted, weighted (wet weight) and measured length. A picture was taken of each taxa. Individuals in good condition were picked out and stored on ice cold EtOH.

Anette Wold; Amalia Keck	Philipp Assmy; Doreen Kohlbach	Fatty acids	Analysis of relative proportions of lipid classes by HPLC and individual fatty acids by GC, and fatty acid-specific stable isotopes by GC-c-MS	Relative proportions of neutral and polar lipid classes and fatty acids, and carbon stable isotope compositions of fatty acids	NL v5 9.2.5 (9.1.5)	Fatty acids of POM & main zooplankton taxa	AWI (collaboration w/ Martin Graeve) University la Rouchelle (collaboration w/ Benoit Lebreton)	2021	RF3	T3-1.3	2021-2022	2021-2022	Yes	Post doc project	Dataset shared with Ecotox group (see comment for Stable istope)
Anette Wold; Amalia Keck	Philipp Assmy; Doreen Kohlbach	Highly branched isoprenoids (HBIs) NOT IN SAMPLE TYPE LIST	Analysis of relative abundances of pelagic (Triene)and ice-associated highly branched isoprenoids (IP25, Diene) by GC-MS	Relative abundances of highly branched isoprenoids'	NL v5 9.2.5 (9.1.5)	HBI of POM, main zooplankton taxa & fish	Plymoth University (in collaboration with Simon Belt)	2021	RF3	T3-1.3	2021-2022	2021-2022	Yes	Post doc project	Dataset shared with Ecotox group (see comment for Stable istope)
Anette Wold; Amalia Keck; Julia	Philipp Assmy; Doreen Kohlbach	POM, zooplankton & fish stable isotopes	Stable isotopes	d13C; d14N (species specific?)	NL v5 9.2.5 (9.1.5)	Stable isotopes of POM, main zooplankton taxa & fish	UiO	2021	RF3	T3-1.3	2021-2022	2021-2022	Yes	Post doc project	Stable isotopes & fatty acid samples have been taken of the same taxa of mesozooplankton, macrozooplankton & fish. These two datasets will be shared between Julia Giebichenstein, Robynne Nowicki & Doreen Kohlbach. Stable isotopes have been sampled by Julia Giebichenstein and will be analysed at UiO. Fatty acids will be analysed by Doreen Kohlbach (NPI) at AWI The zooplankton stable isotope dataset is also refer to in row 28 (Meso & macrozooplankton stable isotopes) & is also linked to the Oithona stable isotope dataset (row 27)
Anna Grytaas, Oliver Müller	Gunnar Bratbak	SEM filter	Scanning electron microscoppy (SEM)	Qualitative analysis of small plankton	NL v6 7.24	Plankton diversity, dynamics and distribution	UiB	2021	RF3	T3.1.1, T3.1.2, T3.2.1	2021-2022	2021-2022	No		Confirm with the PI
Anna Grytaas, Oliver Müller	Gunnar Bratbak, Jorun K. Egge, Tatiana Tsagaraki	XRF filter	X-Ray Fluorescence (XRF)	Concentration of total particulate elements in µM	NL v6 7.11	Concentration of total particulate O, P, Na, Mg, Si, S, Ca, Mn, Fe, Zn (µM)	UiB	2021	RF3	T3.1.1, T3.1.2, T3.2.1	2021-2022	2021-2022	No		Confirm with the PI
Anna Grytaas, Oliver Müller	Gunnar Bratbak, Ruth-Anne Sandaa	Virus diversity	Recover viruses from natural waters via iron chloride precipitation	Virus diversity	NL v6 7.22	Virus diversity across season based on metabarcoding	UiB	2021	RF3	T3.1.1, T3.1.2, T3.2.1	2021-2022	2021-2022	No		Confirm with the PI
Cheshtaa Chitkara, Miriam Marquardt	Anna Vader	Chlorophyll a	Fluorometric analysis	Chl a total and > 10um biomass	NL v7: 7.13.1	Chl a total and > 10um biomass	Onboard KPH	During cruise	RF3	T3-1.1	Dec-19	Feb-20	No		
Cheshtaa Chitkara, Snorre Flo, Simon Kline	Anna Vader/Tove M. Gabrielsen	Microbial diversity (DNA and RNA)	rRNA	Protist diversity	NL v7: 7.17	Microbial eukaryote diversity across season based on rRNA metabarcoding	UNIS	2019-20	RF3	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2020	2020	No		Will be analysed partly by PostDoc to be hired august 2020
Cheshtaa Chitkara, Snorre Flo, Simon Kline	Anna Vader/Tove M. Gabrielsen	Microbial activity (RNA)	mRNA	Protist activity	NL v7: 7.18	Metatranscriptomics and quantification of gene expression of select genes across season	UNIS	2020	RF3	T3-2.2	2021	2021	No		Will be analysed by PostDoc to be hired august 2020
Christine Gawinski	Camilla Svensen	stable isotopes	from Oithona	d13C; d14N (species specific?)	samples will be analysed by Julia Giebichstein? Or by Christine Gawinski	Determine trophic position of Oithona	UiO	2019 - 2021	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Camilla Svensen	Productivity of Oithona similis	Egg hatching experiment	egg production rate, weight specific egg production rate	NL v7 chapter 9.3.3.	spatial and temporal variability of copepod secondary production, specific egg production rate as an estimate for copepod production	UiT	2019 - 2022	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Camilla Svensen	Productivity of Calanus hyperboreus, Calanus glacialis, Metridia longa	Egg production experiments	egg production rate, weight specific egg production rate	NL v7 chapter 9.3.3.	spatial and temporal variability of copepod secondary production, specific egg production rate as an estimate for copepod production	UiT	2019 - 2022	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Camilla Svensen	small mesozooplankton	Secondary production	Female:egg ratio, taxonomy and abundance of nauplii	NL v7 chapter 9.3.3.	spatial and temporal variability of copepod secondary production, female:egg ratio as an estimate for copepod production, copepod reproduction during the polar night	UiT	2019 - 2022	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Camilla Svensen	small mesozooplankton	Sorting and morphological identification	taxonomic composition, zooplankton abundance (ind/m3) and biomass (mg C/m3)	NL v7 chapter 9.2.1.2	characterization of the mesozooplankton community in relation to hydrography and seasons	UiT	2019 - 2022	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Doreen Kohlbach	fatty acids	from Oithona	Relative amount of fatty acid	samples will be analysed by Doreen Kohlbach	determine the quality of food of Oithona in different seasons	NPI	2019 - 2021	RF3	T3-2.2	2021	2021-22	yes	PhD project	
Christine Gawinski	Maja K Viddal Hatlebakk	Two point dilution experiment	Flow Cytometry, nutrient analysis, phytoplankton and microzooplankton diversity, HPLC, Fluorometry, CN analysis	Flow Cytometry, nutrient analysis, phytoplankton and microzooplankton diversity, HPLC, Fluorometry, CN analysis	NL v7 9.3.1	Dynamics of lower trophic level food web structure	NTNU	2018 - 2021	RF3	T3-3.1 & T3-4.2	2021	2021	Yes, possibly	Postdoc project	
Christine Gawinski, Oliver Müller, Anna Grytaas	Camilla Svensen	Grazing experiment of Oithona and Calanus	Bacterial production, Flow Cytometry, microbial diversity, microzooplankton diversity	Bacterial production, Flow Cytometry, microbial diversity, microzooplankton diversity	Samples will be analyzed at UiB	Influence of Oithona and Calanus on the microbial food web (top down control?), comparison between the two different feeding strategies	UiB	2021	RF3	T3-4.1	2021-2022	2021-2022	yes	PhD project	
Vanessa Pitusi	Janne E. Søreide	zooplankton community respiration	Physiology; respiration; energetic needs	respiration	NL v5 9.2.2	Basal metabolic rate	UNIS	2021	RF3	T3-2.1; 4.2	2020	2021	no		this was a test experiment run once during Q4
Vanessa Pitusi	Janne E. Søreide	Zooplankton community from ship's surface water intake	stable isotopes and community	13C and 15N	NL v5 9.2.5 (9.1.5)	Stable isotopes of zooplankton community	UNIS	2021	RF3	T3-4.2	2021	2021	no		surface waterintake collected a lot of zooplankton while steaming - this collected for stable isotope samples
Vanessa Pitusi	Janne E. Søreide	Individual Calanus males	DNA (antenna) and Dry matter	DNA and Dry matter	NL v5 9.2.2	Individual dry weight of species identified Calanus males	UNIS	2021	RF3	T3-4.2	2021	2021	no		Many C. hyperboreus and C. glacialis males in December
Martí Amargant-Arumí	Rolf Gradinger	Radioactively labelled algae on GF/F filters	Primary production in situ incubations	Primary production rate (14C uptake)	NL v6 7.26	Vertical profiles of primary production across latitude and seasons	UiT	2019-2020	RF3	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2020	2021-2022	Yes	PhD-project	
Martí Amargant-Arumí	Rolf Gradinger	Radioactively labelled algae on GF/F filters	Light intensity vs. Photosynthesis curves	Primary production rate (14C uptake)	NL v6 7.27	Primary production response to various light intensitites	UiT	2019-2020	RF3	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2020	2021-2022	Yes	PhD-project	
Martí Amargant-Arumí	Rolf Gradinger	Isotopically labelled algae on GF/F filters	Nitrogen uptake in situ incubations	d13C, d15N	TBD	Ratios of Carbon and Nitrogen stable isotopes before and after incubations, F-ratios of primary production	?	2019-2020	RF3	T3-1.1/T3-1.2/T3-1.3/T3.2.1/	2020	2021-2022	Yes	PhD-project	
Miriam Marquardt	Marit Reigstad, Gunnar Bratbak	POC/PON	CN analyses	µg/L	NL v7- 7.4	POC/PON	UIT/UiB	2020-2023	RF3		2020-2023	2022-2023	yes	PhD project	Q3 and Q4 data anlaysed
Miriam Marquardt	Miriam Marquardt, Rolf Gradinger, Bodil Bluhm	Ice meiofauna abundance/taxonomy	Microscopy	Ind/m3; ml/m3	NL v7 14.8.5	Ice meiofauna abundance/taxonomy	UiT	2020-2023	RF3		2020-2023	2022	Yes, possibly		Q3 and Q4 data anlaysed
Miriam Marquardt	Miriam Marquardt, Rolf Gradinger	Nutrients from sea ice cores	Nutrient analyzer	µg/L	NL v5 14.6 + 7.10	Nutrients	IMR	2020-2023	RF3		2020-2023	2023	No		just a reference measurement
Oliver Müller	Gunnar Bratbak, Aud Larsen	Microbial abundance	Flow cytometry	Planktonic cell per ml	NL v6 7.20	Abundance tables	UiB	2021	RF3	T3.1.1, T3.1.2, T3.2.1	2021-2022	2021-2022	No		Confirm with the PI
Oliver Müller	Gunnar Bratbak, Oliver Müller, Lasse Mørk Olsen	Grazer exclusion experiment	Bacterial production, Flow Cytometry, microbial diversity, nutrient analysis, microzooplankton diversity	Bacterial production, Flow Cytometry, microbial diversity, nutrient analysis, microzooplankton diversity	NL v5 7.32.1	Dynamics of lower trophic level food web structure	UiB	2021	RF3	T3-4.1	2021-2022	2021-2022	yes	Postdoc project	Confirm with the PI
Oliver Müller	Gunnar Bratbak	Bacterial activity (Radioactively labelled bacteria)	Bacterial production of carbon biomass	Bacterial production rate ([2,3,4-3H] leucine) in µgC L-1-d-1	NL v5 7.21	Bacterial production rate	UiB	2021	RF3	T3-2.3/T3-3.1/	2021-2022	2021-2022	No		Confirm with the PI
Thaise Freitas, Arunima Sen, Eric Jorda	Lise Øvreås	Microbial diversity (sediment)	Metabarcoding	taxonomic composition, abundance and distribution	NL v5-10.3.4	Microbial eukaryote diversity in sediment across season based on metabarcoding	UiB	2019-2021	RF3	T3-1.1, T3-1.2, T3-1.3, T3-4.1	2021	?	Unsure		to be finalized by L. Øvreås
Thaise Freitas, Arunima Sen, Eric Jorda	Paul Renaud	Sediment pigment	Fluorometric analysis	mg Chl a / m2, mg phaeopigment / m2	(10.3.2)	Sediment pigments	APN	2019-2021	RF3	T3-1.2	2020	2020-2022	No		to be finalized by PI
Thaise Freitas, Arunima Sen, Eric Jorda	Bodil Bluhm, Andreas Altenburger	Megafauna taxonomy	Museum archival	Taxonomic voucher inventory of Nansen Legacy fauna collected	Nl v5 10.2.3	Taxonomic voucher inventory of Nansen Legacy fauna collected	UIT Museum	2020-2023	RF3	T3-3.1	n/a	n/a	No	no embargo	Museum archival timeline tbd by new collection employee

Thaise Freitas, Arunima Sen, Eric Jorda	Bodil Bluhm, Lis Jørgensen	d13C / d15N organisms (mostly benthic)	IRMS coupled to C/N analyser	d13C, d15N	Nl v5 10.3.1	Carbon and nitrogen stable isotope composition	UiO (Nansen Legacy agreement?)	2021-2023	RF3	T3-3.4	2022-2023	2023	possibly	Post doc project	
Thaise Freitas, Arunima Sen, Eric Jorda	Paul Renaud, Henning Reiss	Nutrient concentrations in incubations	nutrient analyzer	Macronutrient concentrations in bottom water before and after incubation	NL v5 10.3	Macronutrient concentrations in bottom water before and after incubation	APN	2019-2020	RF3	T3-3.4	2021-2023	2021-2023	no	no embargo	
Thaise Freitas, Arunima Sen, Eric Jorda	Paul Renaud	Sediment community incubations	Sediment community oxygen uptake experiments	oxygen uptake mmol / h	NL v5 10.3.8	oxygen uptake	onboard	2019-2020	RF3	T3-4.3	2019-2020	2020-2021	no	no embargo	
Thaise Freitas, Arunima Sen, Eric Jorda	Henning Reiss, Paul Renaud	Macrofauna diversity and abundance	Sorting and morphological identification	number of (taxon) / cm2, diversity indexes, community analysis	10/03/2009	Macrofauna abundance, diversity and composition; metazoan macrofauna abundance, diversisty and composition, community analysis	Nord/IOPAN	2019-2020	RF3	T3-1.1, T3-1.2, T3-1.3	2021-2023	2021-2023	Yes, possibly	PhD project	to be finalized by PI
Simon Kline	Philipp Assmy, Bente Edvardsen	Fixed water samples from Niskin bottles 6 depths and ice stations	Utermöhl cell counts under the microscope	Cell abundances of protists > 10 µm	NL v5 7.13 + 7.14	Phytoplankton/protist abundance	IOPAS	2021-2022	RF3	T3.1.1	2020 or when ready	2021	No		We would like to compare metabarcoding results with micoscopical cell counts in Karoline Saubrekkas PhD-project
Simon Kline	Bente Edvardsen, Philipp Assmy	Fixed phytoplankton sample 50-0m	Light and electron microscopy	Protist diversity > 10 µm	NL v5 9.1	Species lists and micrographs	UiO and IOPAS	2021-2022	RF3	T3.1.1	2020-2021	2021	Need to ask PIs	PhD-project	Part of Karoline Saubrekkas thesis.
Simon Kline	Bente Edvardsen	Coccolithophores on PC filters	Scanning electron microscoppy (SEM)	taxonomic composition, abundance and distribution	NL v5 7.22	Coccolithophore diversity, dynamics and distribution	UiO	2021-2022	RF3	T3.1.1, T3.1.2, T3.2.1	2021-2022	2021-2022	Need to ask PI	PhD-project	Part of Karoline Saubrekkas thesis. Confirm with the PI
Simon Kline, Snorre Flo	Bente Edvardsen; Anna Vader	Protist diversity (DNA and RNA)	metabarcoding using rDNA and rRNA	Protist diversity	NL v5 7.15	Protist diversity, proportional abundance, dynamics and distribution through the seasons	UiO and UNIS	2019-2021	RF3	T3.1.1, T3.1.2, T3.2.1	2021	2021-2022	Yes	PhD-project	Part of Karoline Saubrekkas thesis
Snorre Flo	Anna Vader/Bodil Bluhm/Camilla Svensen/Kim Præbel	Small mesozooplankton diet	64 um plankton sample for DNA analysis of diet of small mesozooplankton	Zooplankton diet/prey diversity	NL v7: 10.4.14	Diversity of small zooplankton prey, possibly also zooplankton genetic identification	UNIS/UiT	2020-2021	RF3	T4-4.1	2021	2021	Yes, possibly	PhD project	
Snorre Flo, Eric Jorda, Arunima Sen, Amanda Ziegler, Thaise Freitas	Anna Vader/Bodil Bluhm/Camilla Svensen/Kim Præbel	Sediment in ethanol	Benthos sample from box core for DNA analysis of benthic diets and prey based on DNA	Benthos diet/prey diversity	NL v7: 10.4.14	Diversity of zoobenthos prey, possibly also genetic identification of benthis species	UNIS/UiT	2022	RF3	T4-4.1	2021	2021	Yes, possibly	PhD project	
Yasemin Bodur	Kim Præebel; Paul Renaud	molecular diet analysis for Pandalus borealis	indidivuals stored in 96% EthOH at -20C	DNA extraction	NL v5 chapter 10.03.14	molecular diet analysis	UiT	2020	RF2/RF3		yes	yes	no		
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	Chlorophyll a	fractionated algal pigments, filtered through GF/F filters from sediment trap samples	Chl a total	NL v5 chapter 8	Chlorophyll a	Onboard KPH	During cruise	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	Chlorophyll a >10µm	fractionated algal pigments, filtered through Polycarbonate filters from sediment trap samples	Chl a >10µm	NL v5 chapter 8	Chlorophyll a >10µm	Onboard KPH	During cruise	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	POC/PON	CN analyses from sediment trap samples	µg/L	NL v5 chapter 8	POC/PON	UiT	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	stable isotopes	from sediment trap samples	d13C; d14N	NL v5 chapter 8	stable isotopes	UiO	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Paul Renaud, Yasemin Bodur	water column pigments	HPLC from sediment trap samples	mg pigment type / m2	NL v5 chapter 8	HPLC	UK	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Paul Renaud, Yasemin Bodur	sea ice algae proxy	IP25 from sediment trap and boxcore samples	mg pigment type / m2	NL v5 chapter 8	IP25	UK	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	phytoplankton communities	from sediment trap samples	community composition and counts	NL v5 chapter 8	phytoplankton communities	UiT	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad, Yasemin Bodur	fecal pellets	from sediment trap samples	fecal pellet types and counts	NL v5 chapter 8	fecal pellets	UiT	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad; Paul Renaud	particulate biogenic Silica	biogenic silica from sediment trap and boxcore	biogenic silica	NL v5 chapter 8	bSi	UiT	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Yasemin Bodur	Marit Reigstad; Paul Renaud	stable isotopes	stable isotopes from bottom water (CTD) filtrated on GF/F	stable isotopes	not established	stable isotopes	UiO	2019-21	RF3	T3-2.2; T3-4.4; T2-1.2	2020	2021	yes	PhD-project	
Yasemin Bodur; Maria Guadalupe Digernes	Marit Reigstad	POC/PON	POC/PON from Aggregation experiment	POC/PON	NL v5 chapter 7.27.2	POC/PON	UiT	2019-21	RF3	T3-2.2; T3-4.4; T2-1.2	2020	2021	yes	PhD-project	
Yasemin Bodur; Miriam Marquardt	Marit Reigstad, Yasemin Bodur	Metatranscriptomics	DNA/RNA from sediment trap samples	biological diversity & activity on particles	NL v5 chapter 8; chapter 7.15	Metatranscriptomics	UiT/UNIS	2019-21	RF3	T3-2.2; 4.4	2020	2021	yes	PhD-project	
Silvia Hess, Thaise Freitas, Arunima Sen, Eric Jorda	Paul Renaud	Sediment pigments	HPLC	mg pigment type / m2	(10.3.1)	sediment pigments HPLC	Plymouth Marine Laboratory	2019-2020	RF3, CAO	T3-1.2	2020	2021-2022	no	no embargo	to be finalized by PI
Anette Wold; Amalia Keck	Janne Søreide; Kim Præbel	Mesozooplankton metabarcoding	Metabarcoding		NL v5 9.2.2 (9.1.2)	Barcoding Biodiversity	UiT (Kim Præbel)	2020-2022	RF4	T3-1.1 & 2.1 T3-2.1 & 2.3	2021-2022	2021-2022	yes	master student	

Appendix 3. Blogs

Seven blogs were published parallel to the Nansen Legacy Q1 cruise at blogg.forskning.no, sciencenorway.no, and project partner websites:

- Blog 1 (in Norwegian): Tverrfaglig forskning i Arktisk kulde
- Blog 2: Tiny Arctic wildlife matters
- Blog 3: Excitement onboard the KP Haakon
- Blog 4: Everything has to have somewhere to live
- Blog 5 (in Norwegian): Jakten på det skjulte livet i vann
- Blog 6: Lost and (not always) found: the ups and downs of sediment trap deployments
- Blog 7 (in Norwegian): Den ensomme algen

On the following pages, the 7 posts and their links are listed in English (and Norwegian when not available in English).

Blog 1: Tverrfaglig forskning i Arktisk kulde - Start av tokt med FF Kronprins Haakon for å se på vinterprosesser i det nordlige Barentshavet og tilgrensende del av Polhavet

Forskere som har vært i isolasjon ankommer FF Kronprins Haakon Foto: Charlotte Stark, UiT

Sebastian Gerland og Anette Wold (FORSKERE VED NORSK POLARINSTITUTT)

Link: https://blogg.forskning.no/arven-etter-nansen/tverrfaglig-forskning-i-arktisk-kulde/1822547

Årstidene i Barentshavet er preget av store forskjell i lys-, vær og isforhold. Det pleier å være ingen eller lite havis på sommeren og høsten, mens større deler av spesielt det nordlige Barentshavet er vanligvis dekket med havis om vinteren og våren. På tidsskalaer over flere tiår ser vi at Barentshavet er i endring, og havisen i Barentshavet har minket både for sommer- og vintersesong.

Prosjektet Arven etter Nansen utforsker forholdene og prosessene i Barentshavet i de ulike årstider. Det har allerede blitt gjennomført tokt i august (3. kvartal) og desember (4. kvartal), og nå i mars 2021 skal det gjennomføres et tokt der det ses nærmere på systemet og prosesser i Barentshavet i første kvartal. Derfor kalles dette toktet for «Q1» tokt. Toktet starter 2. mars i Tromsø, fører til det nordlige Barentshavet og den tilgrensende del av Polhavet, før det skal avsluttes igjen i Tromsø 25. mars. I mars pleier det å være nokså kaldt i Barentshavet, og det er ofte en god del havis til stede. Solen har akkurat kommet tilbake etter mørketiden, den står på denne tiden av året lavt over horisonten.

Islagt hav. Forskning på sjøis i Barentshavet 1999. Foto: Sebastian Gerland.

Hva skal det forskes på?

Under toktet skal forskere se nærmere på egenskapene av havisen, prosessene mens havisen vokser om vinteren, og hvilken rolle disse vinterforhold spiller for biologi og kjemi i Barentshavet. Økosystemet skal studeres nøye, med målinger i atmosfæren med værballonger, ved overflaten på og undersiden av isen, i vannsøylen og ved havbunnen. Det skal tas prøver av vann, is- og havbunnssedimenter. Med målinger i vannsøylen ses det nærmere på varmetransport og blanding av vannmasser. Varmetransport er også viktig for hvor mye havisen kan vokse, eller hvor raskt det smelter. Det skal tas mange målinger av is- og snøtykkelse, for eksempel is-temperatur, saltholdighet og hvordan isen og snøen demper lyset i og under isen.

Biologene om bord skal studere hvilke ulike organismer forekommer i isen, vannet og ved havbunnen, hvordan de er fordelt geografisk og o i hvilke vannmasser, og hvordan de tilpasser seg de ulike klimatiske forhold langs transektet. Biogeokjemikere ser blant annet på havforsuring og effekter av det for organismer i havet og isen, samt på sporelementer (små partikler av næringsstoffer) og tungmetaller. Ikke minst skal det ses på forekomst av ulike miljøgifter og deres effekt for dyrelivet spesielt i denne delen av året.

I tillegg til målinger i vannet og på isen gjennomføres det eksperimenter om bord «Kronprins Haakon». På dette toktet skal det også være med et helikopter, for å fly lengre målelinjer over havisen. Hva kan man måle fra et helikopter? Med et elektromagnetisk instrument som henger under helikopteret måles det istykkelse, og med et stereokameraoppsett fotograferes isoverflaten med høy oppløsning. Med slike data kan målinger gjort på isstasjoner utvides til en større region.

Forskningsområder i Barentshavet og Polhavet

Hvor skal forskningsarbeid foregår konkret? Forskerne jobber langs en linje (transekt) i det vestlige Barentshavet, fra midt i Barentshavet ved 76 grader nordover sokkelkanten ut i polhavet til ca. 82 grader nord. Det tas prøver ved bestemt stasjoner som har litt tatt på de

tidligere sesongtoktene. Slik kan observasjonene bedre sammenlignes og resultatene settes i perspektiv senere. Der det er havis skal forskerne ut på isen, ta is- og vannprøver og observere isen på nært hold, også med hjelp av en drone. Helikopterarbeidet gjennomføres når det er egnete flyforhold for det. Mens det meste av stasjonene befinner seg i det relativt grunne Barentshavet med vanndybder av noen få hundre meter, ligger den nordlige enden av transektet (82 grader nord) allerede i selveste Polhavet med en dybde av omtrent 3000 m.

Natalie Summers, NTNU, vinker farvel Foto: Charlotte Stark, UiT

Forskningsgruppen med internasjonal bakgrunn

Forskningsgruppen på Q1 toktet består av ulike faggrupper: Fysiske prosesser, zooplankton, kjemi, mikrober, og benthos (livet ved havbunnen). Totalt består forskningsgruppen av 35 kvinner og menn: forskere og teknikere, samt en helikopterpilot. Så er det skipets mannskap som sørger for at skipet kommer til stasjonspunktene, at prøvene kan tas, og at alle har det trygd og bra om bord FF Kronprins Haakon.

Hvordan kan et slikt tokt gjennomføres i pandemitiden? Opplegget for toktet ble nøye gjennomtenkt og planlagt iht. pandemien, og risikoanalyser ble gjennomført. Forskningsgruppen har vært i isolasjon i 10 dager før toktet, på et hotell i enkeltrom, der alle fikk maten servert til døra. Gruppen ble koronatestet, og møter mellom toktdeltakere ble gjennomført hver dag i isolasjonsperioden online via teams. Gruppen blir så kjørt til skipet dagen toktet starter og skal direkte om bord FF Kronprins Haakon.

Deltakere i forskningsgruppen er alle knyttet til institutter, universiteter eller organisasjoner i Norge, men de kommer opprinnelig fra alt i alt 14 ulike land, fra Europa, Asia, Nord-Amerika og Australia. Det vil være deltakere i dette toktet som har deltatt i ulike tokt før, men det er også noen som skal delta på sitt første tokt. Spennende blir det nok uansett.

Blog 2: Tiny Arctic wildlife matters

by Cheshtaa Chitkara, PhD student, UNIS

Link: https://sciencenorway.no/blog-nansen-legacy-project-blog-researchers-zone/tiny-arctic-wildlife-matters/1834170

Hello from another fine day from the largest research ship in Norway -Kronprins Haakon. After having a delicious pizza lunch on board today, I came up to the 7th deck (yes that's right, this boat has 10 decks), to write this blog in the conference room – a nice, cozy room with a great view. How is a girl from the south of India where winter is 20 degrees, surviving up here in the Arctic, you ask? Its hard to believe for many (including my mother) that I am all about the winter, and its way before "The Starks" from The Game of Thrones. Today is the 11th day at sea, and we are at the Process station 5 (P5) out of 7 stations of the Nansen Legacy transect in the northern Barents Sea. It is our second day here and we are waiting to retrieve the sediment trap for Yasemin – another PhD student from UiT. Which brings me to introducing myself – I am a PhD student from The University Centre in Svalbard, my name is Cheshtaa and I'm working on small organisms, so small that you would need microscopes to determinate what they are. I am here to answer an important question – what am I doing on this massive beautiful vessel for 3 weeks falling (sea) sick on the wavy days? I am an affiliated member of the Nansen Legacy project, one of the biggest marine-based Norwegian collaborative research. It brings together universities and institutions all over the country, with early career researchers and established scientists all aiming to understand the Arctic Ocean a little bit more. But why this much obsession with the ocean you ask? Keeping my opinion aside, if not for the ocean, how else do you think life would have thrived on this planet? We have a wide range of interesting topics covered on board, such as studying the smallest organisms responsible for life in the ocean and understanding effects of toxic pollutants on them. Moreover, we also study changes in sea ice thickness and conditions over the past few years as well as mapping future scenarios with current conditions. This is my very first cruise for this project, and I am not sure how accurately I can describe all parts of the project that my friends are up to everyday, but I hope I can do justice to at least one of them that I am responsible for.

One of the most important things I figured out on board was that you always have to be on stand-by for work. That is because when you are on board for such a huge national project, you need to prepare, to work, work and work – with administered rest breaks of course. It doesn't matter what day of the week it is or what time of the day. Fridays are not Fridays anymore, they're just days, to finish your work. I learned that pretty quick in my first week, when I had to wake up at 1:45 am for my work. Yes, finally, coming back to what I do on board, I filter close to 100 litres of water at every station. You might not think of it as glamorous as the fish biologists or those who we call the zooplankton people, but we are pretty important too you know. In a conversation with the First Officer on board, when I described to him what I am doing on Deck 3 (it's where we have all our labs and rooms to rest), he immediately said- "oh of course, what you do is very relevant, because if we don't have your organisms what will the big fish eat?" At this point I'm sure I radiated a thousand lumen light from my eyes (brighter than my brightest headlamps) quietly watching him in admiration, to which he said- "are you okay?". With a smile on my face I said – I am now. It is hard to explain sometimes that something we cannot see can be so important and why. Small things matter. I mean we haven't really seen outer space or aliens, but those topics somehow always steal the show.

My job on board is to collect water samples for a type of analysis called metatranscriptomics, which we use to get a snapshot of the smaller fraction of pelagic communities. In scientific terms, gene expression of eukaryotic communities gives an idea of what is going on in the community at that point of time. I am also filtering water for a type of analysis called metabarcoding (see previous blogpost), which is to check the diversity of microbial communities and how it changes based on the different environmental conditions. This gives an idea of the types and different size ranges of organisms we can see in that cross section of the ocean. After filtering we snap-freeze the filters in minus 80 degrees Celsius, in order to take it to our universities/institutes for further laboratory analysis. What we do with these filters is a process called DNA extraction. DNA as we know is the building block of life; it's what is passed on as genetic material from a parent to an offspring. This tedious 5-6 hour procedure gives us a teenie tiny amount of transparent liquid, which contains the DNA of microbial organisms. This DNA has all the information we would need to know about the whos who of the microbial kingdom of our P stations. We then send this off to a company to further process our transparent liquid into computerized results, which we try to interpret.

Mind you, we don't just sample water, we also sample the ice by taking ice cores. Our first large ice station was on P4, which was something I had not seen before. For the ice station at P4 we had to plan at least 24 hours ahead of what exactly we were going to do. This was to ensure most efficiency in a short amount of time. At this station, I was asked to be the polar bear guard for the first half of the day, not very surprising as I come from Svalbard, and have had the "polar bear guarding experience" for almost 2 years now. It wasn't "that cold" outside when I first stepped outside on deck in my regatta suit and 2 layers of wool underneath. I was sweating profusely even before starting work. The polar bear guards got a safety brief with the head of polar bear safety – Jørn from NPI (Norwegian Polar Institute) in Svalbard, half loaded the rifles and swore to protect our comrades. Like a straight line of ants walking onto the ice we diverged into 4 smaller groups. The first one was the sea ice physics group, which was going the furthest away doing transects on sea ice to measure its thickness and other properties. The second group lead by my very good friend Robynne (UNIS) was in charge of the water hole, where we were going to sample water – untouched by the ship. The third and the fourth group were both ice coring groups, which I was responsible for guarding. These groups were responsible for taking almost 44 cores. Now that's a task! 44 ice cores, while measuring their length, sawing them up into different sections, measuring the level of water that they came out from and ensuring all of those core buckets get on board ASAP to start with the melting. This could not have been possible without the planning of the three most efficient people that I have met in my life- our cruise leader Sebastian from NPI, co-cruise leader Anette from NPI as well and Miriam – the Nansen legacy engineer from UiT. Miriam planned the ice work, and divided everyone in teams to collect and process the core samples, and the cruise leaders made sure everything went as planned from the bridge. The cruise leaders were in were in fact our first polar bear watch, having a view until the horizon to look for any incoming danger.

Soon after lunch, I was shifted to the ice core team to learn how to retrieve ice cores, and saw them without contamination. Ice coring, I quickly learned, was a skill that one should have in the Arctic especially when taking samples every month for their PhD- *le* me. My other very good friend and Svalbard acquaintance Vanessa taught me how to ice core. I would like to call her the ice core queen, each cores more perfect than the last one. And if you get to learn from the best, you will start off good at least. And I DID! My second ice core ever was not broken and straighter than Natalie's hair (another PhD student with very straight hair). It was what

the kids are calling it these days- PERFECTION. Maybe that's a bit too much for an ice core, but Vanessa in her own words said – "Wow Cheshtaa! This is so good!" I even remember the length of this ice core being 54 cm. We measured the ice core temperature at every 10 cm and noted it down. While we were being successful making our little cores we got an order from the bridge at around 4 pm to get back on board, as there was a polar bear coming in our direction. Thankfully, our ice work was all done. All we had to do was pack up and head back. We all headed back and watched the polar bear from the day lounge on board. Those huge windows on the side of the boat with 35 pairs of eyes glued on to see what the bear would do next is what I live for. Curiosity. This is what makes Science what it is. This is why I got into Science. The polar bear made it to the amphipod traps set up by my friends and started to chew on it – probably because of the horrid smell of dead polar cods that were used as bait. Did you know that polar bears could smell up to 30 km! That is something I knew but witnessed that day for the first time. When it got bored of chewing on the amphipod trap, it went on to the set-up of the sea ice physicists and just sat there and chewed up on their instrument bags. With a high definition camera we could see what it was chewing on while it was sitting there like a cute little puppy. Yes I find them cute, and not see them as the carnivores they are.
Our day ended finding out, after the bear had left, that none of our instruments on ice recording our measurements were damaged, and only some of the protection/packaging of the instruments was slightly ripped.

Cheshtaa (to the right) working on the sea ice, retrieving a water sampling bottle from an ice hole (Photo: Andreas Wolden, IMR).

Sketch of sea ice groups and instruments used on sea ice stations (Graphic: Cheshtaa Chitkara).

Polar bear gently investigating a GPS antenna (Photo: Andreas Wolden, IMR).

Blog 3: Excitement onboard the KP Haakon

by Nadjejda Espinel, Norwegian Polar Institute

Link: https://sciencenorway.no/blog-nansen-legacy-project-blog-researchers-zone/excitement-onboard-the-rv-kronprins-haakon/1848777

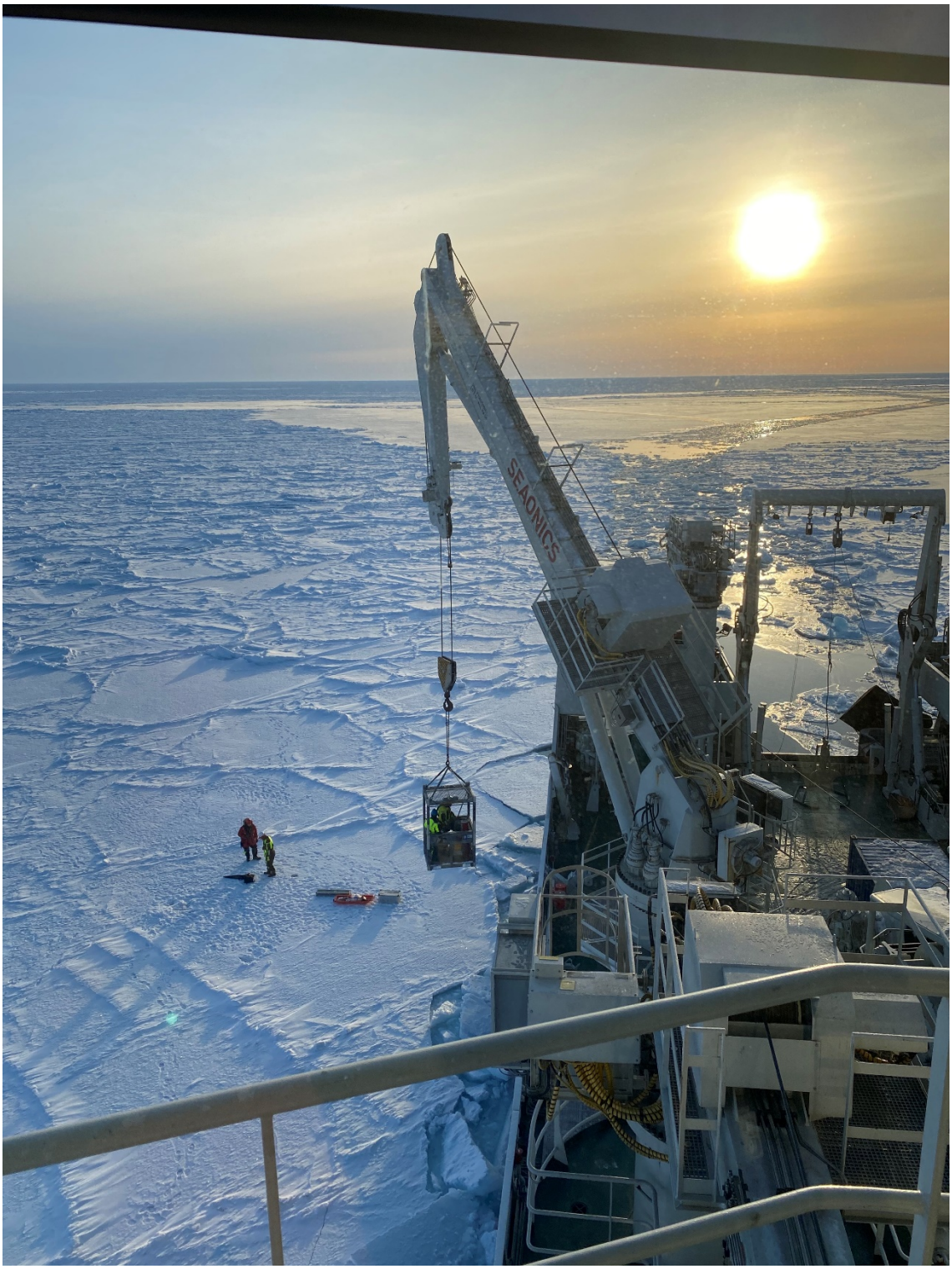
It's been a week since we left Tromsø. The Kronprins Haakon has very quickly become our home, and we are enjoying life onboard. After a couple of days through rough seas, things are calmer now. Fast steaming through open water has now changed into slow steaming through ice that needs to be broken for us to pass. Rough seas caused some of us to get seasick, but that is now long gone. Silent rocky seas have now changed into stable noisy ice. Breaking through 40-70 cm thick ice is not noiseless and earplugs are now a must in the lower parts of the ship if you want to take a rest at any moment – day or night – whenever you are not working.

Although one would think that ice is ice, I have discovered that sea ice can take many forms, all equally amazing and with their own characteristics, which I am sure any sea ice physicist would be more than delighted to explain. The beautiful unstable pancake ice formations we first encountered have now become a vast surface of ice either covered in snow or displaying amazing frost flowers. It truly looks like a frozen desert. As it moves, the ship leaves a trail of open water behind, which will close or freeze again depending on the weather and ice conditions.

There is a lot of activity happening on board both during both day and night, not always following natural biorhythms, which very much depends on arrival time at the new station. Sampling of natural processes on board is accompanied by experimental work - such as mine - taking place in some of the many cold rooms on board the ship.
For my work, I investigate how organisms respond to stressors on anthropogenic origin such as acidification or warming. Arctic regions are expected to experience the strongest and most rapid acidification and warming of all global seas. It is not well understood how arctic ecosystems will respond to these changes, and how his might affect other ecosystems on earth. In order to study this, I use as model organism arctic copepods of the genus *Calanus* (hoppekreps). These are very important in arctic ecosystems since they constitute more than 90% of zooplankton biomass and are food for many arctic species including whales, birds and fish. For my investigations on board I test the capacity of these organisms to cope with different levels of acidification and I do that by measuring the respiration of individual copepods in a special system I set up in a cold room in the dark.
At each station, sampling takes place for the different disciplines and environments: biological samples (living organisms) are begin taken out of the water with nets of different sizes, water samples are taken for chemistry, biology and a whole range of physical parameters and cores of the seafloor are also being taken for observation and experimental work.
As our first long ice station approaches, that is, the first station where we will extensively go on the ice to do sampling (biology, physics, chemistry), the excitement increases. The preparations for “ice work” are now in full swing. There are many aspects that need to be considered before leaving the ship; safety regulations make sure everything we do on the ice is safe and testing and calibrating equipment will ensure that we get all the data we need. This also requires a high level of organization and coordination to get everybody working as a team.
If things were not exciting enough, on Monday afternoon we spotted the first (of many, hopefully) polar bear of the campaign. The captain announced it through the speakers, and we all rushed to the windows on the starboard side to have a look. Two bears were coming in our direction. We all sighed with relief when we noticed the bears seemed well-fed and playful. Then we also spotted the seals between us and the bears, playfully sticking their heads in and out of the water as if they were playing hide and seek with them. The bears walked around the area where the seals were and approached the ship. Most of us put on warm clothes and went out on the deck of the ship. The bears came close, observed and smelled us, and happily continued their journey. A third bear – much bigger than the two first ones – was spotted in the same area and started to move slowly towards us. However, since we are in a tight schedule, we had to continue our journey forward to our next station. We left the spot wondering where those bears were headed and what the future holds for them.

Pancake ice (photo by Sebastian Gerland, NPI)

Nadjejda Espinel in the cold room checking her experiment (photo by Nadjejda Espinel, NPI)



Sea ice team inspecting the ice for the first time (photo by Nadjejda Espinel, NPI)

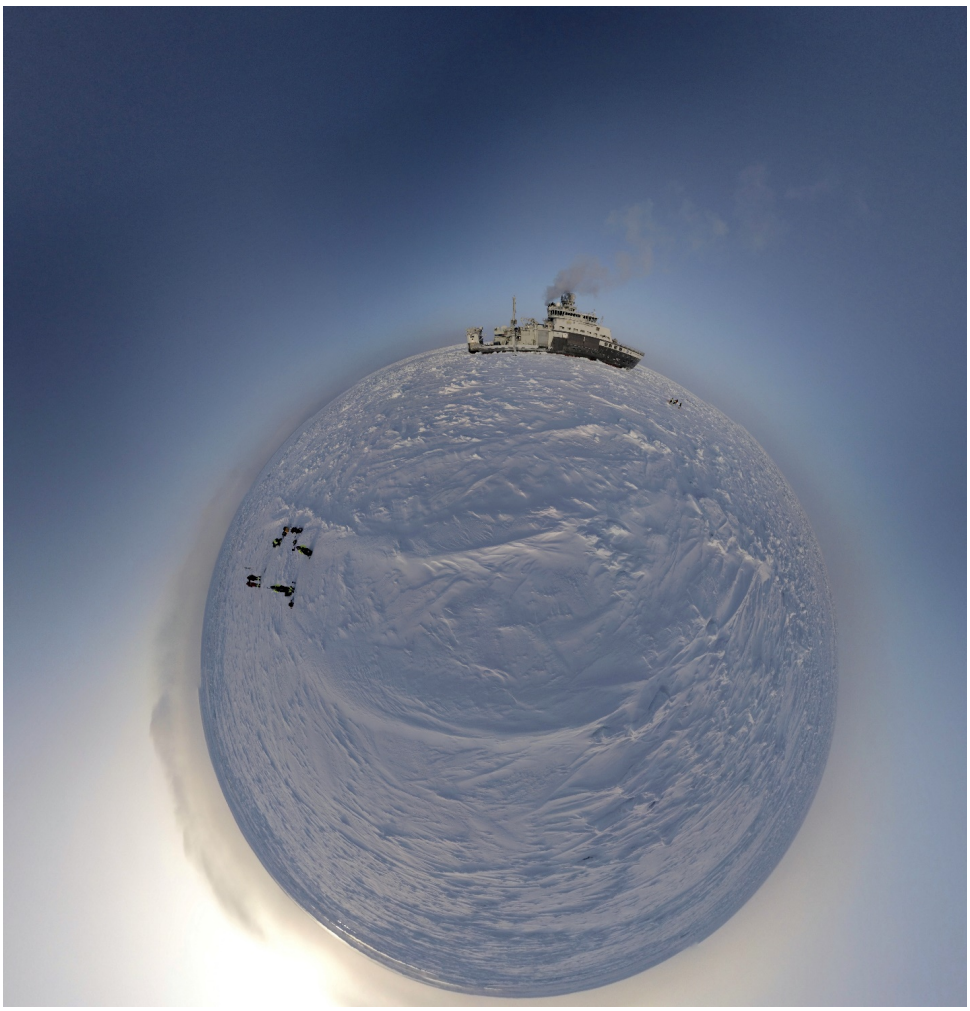
Picture 4: Polar bears visiting the vicinity of the Kronprins Haakon (photo by Nadjejda Espinel, NPI)

Blog 4: Everything has to have somewhere to live

Link: https://sciencenorway.no/blog-nansen-legacy-project-blog-researchers-zone/everything-has-to-have-somewhere-to-live/1835116

Adam Steer, postdoctoral ice physics research scientist, Norwegian Polar Institute
Tristan Petit, postdoctoral ocean and sea ice optics research scientist, Norwegian Polar Institute and University in Bergen
Libby Jones, postdoctoral research scientist in ocean and sea ice chemistry, Institute of Marine Research
Dmitry Divine, senior research scientist in sea ice physics, Norwegian Polar Institute
Sebastian Gerland, section leader, Oceans and sea ice, Norwegian Polar Institute

Here on RV "Kronprins Haakon" in the northern Barents Sea we are our own tiny world, living and working together in a bubble almost completely remote from our regular world. In our microcosm we are reminded that we all have to have some place to live, and to also understand how it works, so that the system we live in functions well.



Our little planet of ice – working on Nansen Legacy process station P6 at 81.5 degrees north (Photo: Adam Steer, Norwegian Polar Institute).

Looking outward to the icy seas around us, we see a dramatic 'blue desert' – a vast treeless plain which both provides a platform for life, and is also shaped by the life around it. Understanding this system-of-systems is the core work of researchers focused on sea ice physical, optical and chemical characteristics; ocean chemistry, optical properties of water, down to the sea floor and its composition.
Starting at the surface, the sea ice physical properties team looks at what the sea ice is made of, how it is structured, and how it changes – more or less the visible parts of a tiny skin of ice between the ocean and the atmosphere. We spend many hours walking around with an electromagnetic induction sounder and a snow depth probe made for geophysical and hydrological applications. With these we seek to understand the distribution of sea ice thickness and snow depth across a single ice floe.

Sea ice and snow thickness transect (Photo: Sebastian Gerland, Norwegian Polar Institute).

Then, we collect ice cores to understand the detailed structure of sea ice, its density and salinity. These simple datasets are critical to inferences of sea ice thickness and structure from satellite instruments. They help us understand what can be seen from space, and how to interpret the data we get from space-based observations.
We use airborne instruments of our own – a helicopter towing an electromagnetic induction sounder and carrying a pair of cameras. This setup helps us look at larger regions, reconstructing sea ice depth and surface topography over tens to hundreds of kilometers. A small drone fills in gaps at ice floe scales, generating 'floe scale' reconstructions of surface topography using many overlapping images.

Helicopter take-off with the 'EM bird' ice thickness sensor hanging below, and the stereo camera system (Photo: Sebastian Gerland, Norwegian Polar Institute).

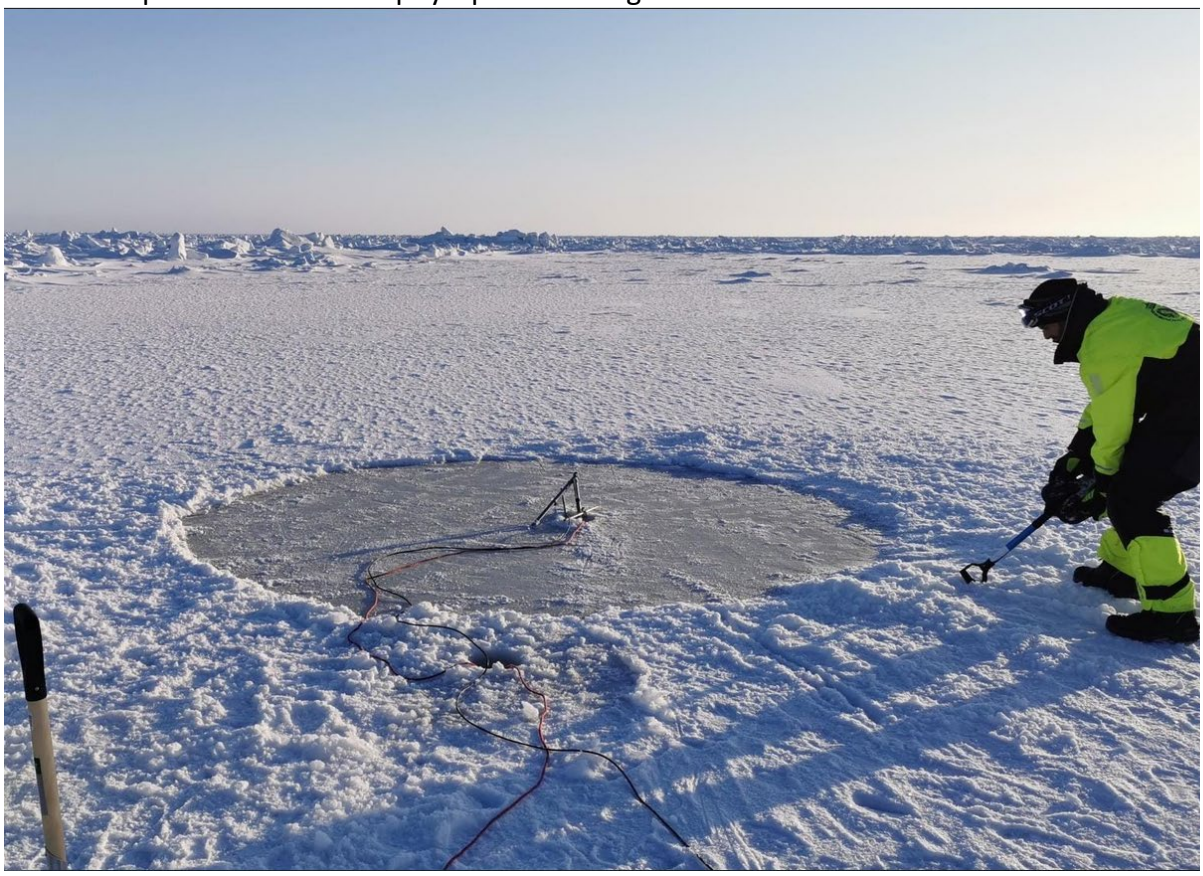
Putting all this together, we aim to understand how the ice is put together, how snow and sea ice ridges are distributed, how much ice is being made, melting, or drifting from one place to another. In turn, we hope to provide a picture about where things live on the ice – how much ridged area, for example, gives an idea of how much space there is for small animals and fish to hide from larger predators. The snow distribution gives an idea of how much light might be available under the ice; the floe size distribution an idea of how much ice perimeter is available for sea water inwashing to the space between snow and ice where things can live.
In the process, we sometimes catch things in the act of living! Just a small waterproof camera on a stick can tell us about how the physical stuff we study provides room to shelter and live, like this serendipitous capture of juvenile polar cod living in situ. Without taking small chances to engage our curiosity and wonder in seemingly trivial activities, we would otherwise only be able to guess at what is really happening in there.

A school of polar cod hiding in gaps between rafted sea ice at Nansen Legacy process station P2, at about 77.5° degrees north and 34°degrees east (Photo: Adam Steer, Norwegian Polar Institute).

This polar cod specimen, as well as all the living organisms who live in and around the sea ice and upper ocean, depend in one way or another on light. Tristan Petit works on understanding the evolution of the light climate in the northern Barents Sea with climate change. In order to adjust his mathematical models, he first needs to measure different quantities that affect the propagation and extinction of light from the bottom of atmosphere to a hundred meters depth in the ocean. This begins by measuring the snow/ice albedo, which corresponds to the portion of light reflected by its surface, as well as its transmittance, which quantifies the remaining portion of light at the bottom of the ice.

Then, we measure the vertical structure of the light absorption and scattering within water which gives indication on the ability of water to transmit light and depends on the quantity of three types of water constituents. There are first micro algae, called phytoplankton, whose most common species absorb mainly the blue, and to a lesser extent red, part of the light spectrum. Phytoplankton is the main driver of the ocean colour in most of the open sea waters around the world. Then the Colored Dissolved Organic Matter (CDOM) absorbs blue light and is thus sometimes called “yellow substance” as it transmits well the green and red light. And

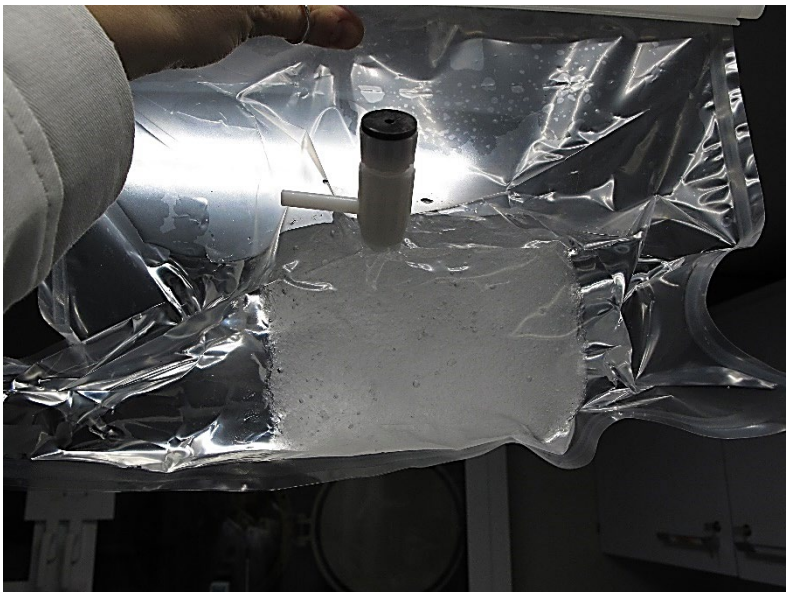
finally, the Non-Algal Particles (NAP) are the strongest scatterers and are thus sending back part of the light to the atmosphere. CDOM and NAP are mostly present in coastal areas but can also be produced from the phytoplankton degradation.



Tristan is collecting on his computer the data acquired by a light sensor (TriOS Ramses spectral irradiance sensor) placed at the bottom of the ice thanks to a steal frame with an L shape. By combining this measurement with concomitant light measurement above the ice, we can then compute the ice transmittance (Photo: Tristan Petit, Norwegian Polar Institute).

The ocean itself is both the physical home for an in incredible array of life on Earth, and a vital 'blanket' for everything which doesn't actually live in it.

The sea ice forms a unique environment for the cycling of different chemical compounds and the exchanges of these between the ocean and the atmosphere. Ice cores are collected and sectioned to understand the variability of carbonate chemistry, inorganic nutrients and tracers for different water sources from the top of the ice to the base of the ice pack. In addition, measurements are made in the unique structures that characterise the ice zone, such as in snow, under-ice seawater, brines and frost flowers. These datasets provide a better insight into the role of sea ice in polar ocean chemistry and how that might shift during this period of environmental change.



A section of an ice core in a vacuum packed bag ready for melting to analyse for carbonate chemistry and inorganic nutrients (Photo: Libby Jones, Institute of Marine Research).

High in the Arctic, working in temperatures down to 30 degrees below the freezing point of our bodies, we are acutely aware that we are visitors here - permitted to exist in our cocoon of steel as long as we guide it wisely. In a way it is better to think of our place here that way, contained in a tiny bubble and exploring outward to find our limits, or seek new knowledge.

Inverting our viewpoint – the bubble we exist in and explore outward from on Nansen Legacy process station P6 (Photo: Adam Steer, Norwegian Polar Institute).

This space both calls to our sense of wonder and serves as a reminder that we are just a part of an intricate and complex system of systems. There is no doubt that it is a privilege to be here, and a key part of all our roles as researchers is to communicate that sense of surreal amazement.

For us as researchers we have to sometimes narrow our focus to understand a very specific component of one aspect of this dynamic system-of-systems. This is where we get into the dry nuts and bolts of science – statistics, graphs, long and complicated words. Approaching our work with curiosity and wonder is essential to seeing how this narrow focus fits into the larger puzzle.

As geographers, physical scientists, chemists, we are concerned with the scaffolding which sets the stage for life to happen – which in turn is shaped by life itself! Everything has to have somewhere to live, and we are lucky to be able to discover how this works in the inhospitable – at least to us humans - high Arctic.

Blog 5: Jakten på det skjulte livet i vann

Link: https://blogg.forskning.no/arven-etter-nansen/jakten-pa-det-skjulte-livet-i-vann/1829063

Simon Kline, Masterstudent Universitetet i Oslo (UiO)
Snorre Flo, PhD student Universitetssenteret på Svalbard (UNIS)

Livet om bord i et forskningsfartøy har sin egen og unike rytme. Tid operer litt annerledes her, både fordi det er litt intense dager med prøveinnsamling og analysering, men også fordi båten rett og slett har sin egen tidssone. Når man driver med forskning i Arktis på dette tidspunktet på året er det viktig at man følger solen så godt det lar seg gjøre. En konsekvens av dette er at de høyere maktene om bord i FF Kronprins Haakon har bestemt seg for at vi skal ligge to timer foran vanlig tid på det norske fastlandet. Sol er en dyrebar ressurs i Arktis i mars, så dagene må utnyttes og da bestemmer vi like greit tiden selv.

I tillegg til at tid har blitt et abstrakt konsept, har livet begynt å bli definert av vann. Hvor mye vann skal vi samle inn? Hvor mye vann skal vi filtrere? Hvor lang tid vil det ta for en iskjerne å smelte til vi kan filtrere det? Er jeg egentlig tørst eller er det bare at jeg tenker for mye på vann? I løpet av oppholdet vårt om bord i FF Kronprins Haakon vil vi ha filtrert nærmere 1000 liter vann, en mengde som er vanskelig å forholde seg til. Men hva er egentlig vitsen med å filtrere så mye vann? I disse 1000 literne fra havet og is befinner det seg mye informasjon. Det kan være små levende celler (mikroorganismer), dødt materiale, ja, til og med rester fra barten til en hvalross. Alt som lever og spor etter alt som har levd er vi på jakt etter.

Ved å filtrere vann kan vi fange opp dette på små filtre. De små filtrene blir så kjapt fryst ned, og vil etter endt tokt bli med oss hjem på labben. Her ekstraherer vi arvestoffet DNA og studerer det ved bruk av en metode som kalles «DNA metabarcoding». Metoden tar utgangspunkt i sekvensering (se faktaboks), og går i store trekk ut på å beskrive rekkefølgen av DNA-bokstavene i et gen som mikroorganismene har til felles.

Faktaboks: Sekvensering
Ved sekvensering leser en maskin DNA-koden bokstav for bokstav. I motsetning til vårt alfabet har DNA kun fire bokstaver; A, T, G og C. I denne typen studier er den typiske lengden av sekvensene 400-500 bokstaver lange.

Generelt kan vi forvente at individer av samme art har en identisk rekkefølge av bokstaver, mens individer fra forskjellige arter har små forskjeller i koden. Hvor mange forskjeller det er mellom artenes sekvenser avhenger av hvor nært beslektet de er, og forskjellene øker med tiden som har gått siden artene skilte vei på livets tre. Sammenlikner vi de sekvensene vi har funnet på tokt med de som allerede er beskrevet og lastet opp på referanse-databaser kan vi bestemme artssammensetningen av organismer i vannet. I tillegg kan vi finne ut av hvilke arter som dominerer eller er fraværende og hvor høy diversitet det er vannmassen.

Denne typen informasjon er selvsagt ikke ny. I hundrevis av år har forskere og eventyrere som Fridtjof Nansen beskrevet mikroorganismer i Arktiske strøk. Metabarcodingen sin fordel er derimot at man ikke behøver å kikke gjennom uhorvelige mengder sjøvann i mikroskop.

Dermed får vi tid til å samle inn flere prøver som kan analyseres i etterkant. Dessuten utgjør mikroorganismene et utrolig flerfoldig fellesskap, og det krever flere år med erfaring og kursing for å kjenne igjen disse små krabatene med sikkerhet. DNA metabarcoding gjør sånn sett jobben litt enklere for oss som ikke har tiår med mikroskopi-erfaring på ryggen.

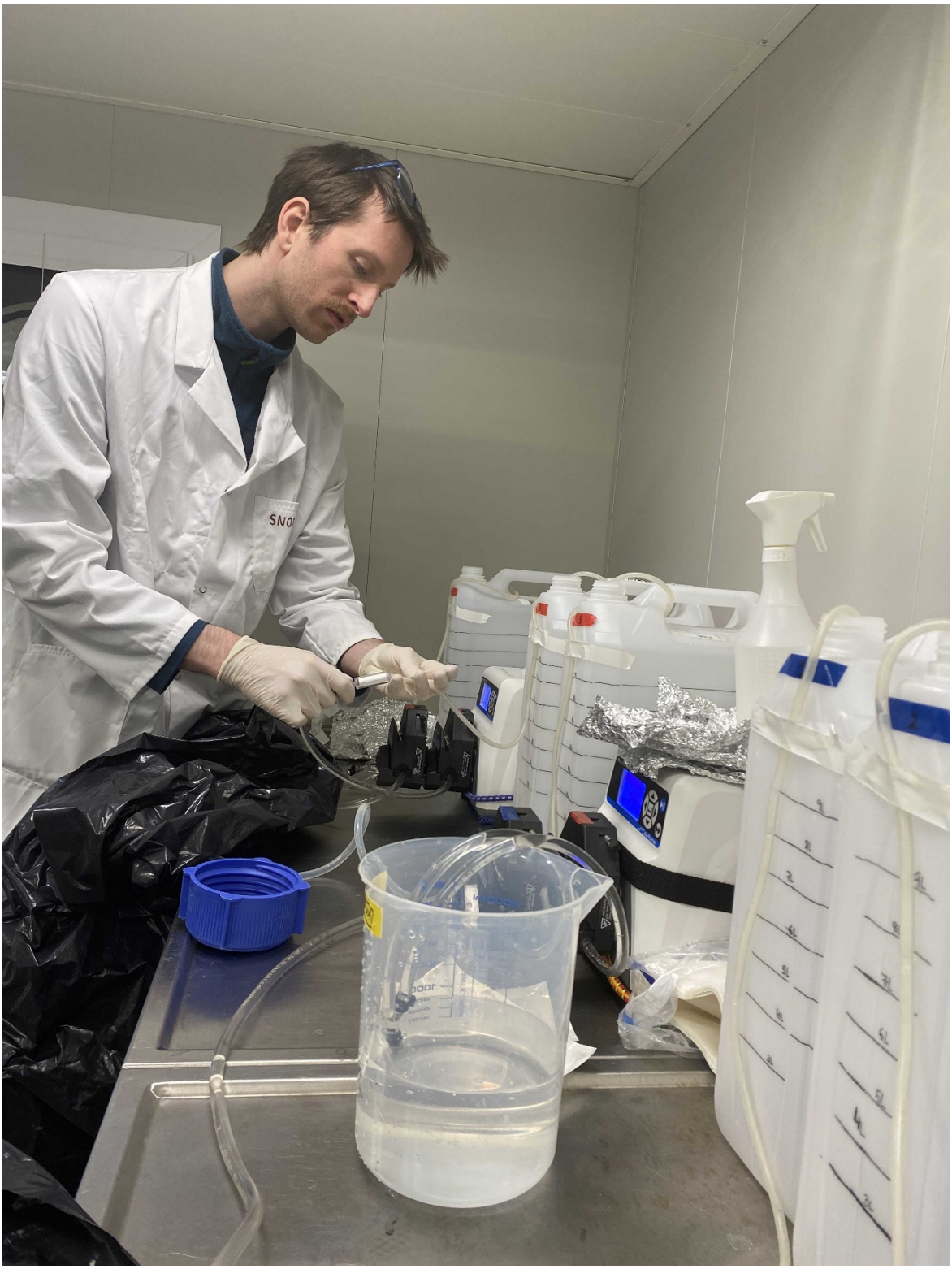
I tillegg lager vi algekulturer og andre vannprøver som vil bli analysert på forskjellige måter og kobles opp til resultatene fra DNA sekvenseringen fra metabarcodingen. Dette gjør at man forhåpentligvis kan danne et helhetlig bilde over sammensetningen av liv som befinner seg i vannmassene og isen i Arktis. I løpet av 2021 vil det være to forskjellige forskningstokt igjennom Arven etter Nansen prosjektet og vi befinner oss nå på Q1 toktet. Det er få alger i vannmassene, nesten som om livet er satt litt på vent til våren kommer og den store våroppblomstringen av algeplankton skjer. I Arktis har fortsatt vinteren taket og selv om dagene blir litt lengre og solen skinner litt mer, har ikke livet våknet helt til riktig enda. Ved å sammenligne resultatene fra arbeidet vi gjør om bord i båten nå på Q1 toktet med de resterende forskningstoktene Q2 (mai 2021), Q3 (gjennomført august 2019) og Q4 (gjennomført desember 2019), vil man kunne få oversikt over hvordan livet i vannet og isen endrer seg i løpet av året og sesongene. Dette vil også gi oss viktig kunnskap om effekten av klimaendringer på det arktiske økosystemet. Vil varmere havtemperaturer føre til at nye arter kan forflytte seg inn til Arktis? Hva vil effekten av nye arter være på de artene som allerede er til stede? Er lysforholdene såpass ekstreme at selv om klimaendringer gir gunstigere forhold, så vil arter som ikke er tilpasset det hindres i å få fotfeste her? Hvordan vil det Arktiske økosystemet se ut om 10 eller 20 år dersom man ikke bremser effektene av klimaendringer?

Det er mange spørsmål tilknyttet dette temaet, og arbeidet som gjøres om bord i FF Kronprins Haakon vil være et vesentlig bidrag til å kunne gi gode svar. Det er få steder på planeten som opplever effekten av klimaendringer til den grad man gjør i Arktis, og for å kunne forstå hvordan økosystemet vil bli påvirket er mer kunnskap absolutt nødvendig.
Litt som livet om bord i et forskningsfartøy, har livet i Arktis en rytme. Den følger sola og mørket, og venter på at våren skal komme også til 80 grader nord. Hvem vet i detalj hva morgendagen bringer for Arktis sin del. For oss i filtreringsteamet er i motsetning morgendagen ganske klar: vann og atter mer vann.

Å jobbe med DNA er sensitivt. Derfor måler vi vann fra smeltet iskjerner i et kjølerom i mørket. Det er viktig å måle mengden vann man filtrerer både før og etter, kanskje gir det oss et lite hint om hvor mye liv det er? Foto: Èric Jordà Molina (Nord universitet).

Selv om Arktis virker livløst, skjuler det seg mye liv både i og under isen. For å kunne ta vannprøver fra under isen borres det et hull og senkes ned en flaske som samler inn vann. Foto: Tristan Petit (Universitetet i Bergen/Norsk Polarinstitutt).

Å tappe vann er like gøy hver gang! Foto: Cheshtaa Chitkara (UNIS).



Her filtreres vann for harde livet! I det lille filteret samles millioner av celler, dødt materiale og spor av levende organismer. Foto: Cheshtaa Chitkara (UNIS).

Blog 6: Lost and (not always) found: the ups and downs of sediment trap deployments

Link: https://sciencenorway.no/biology-blog-nansen-legacy-project-blog/lost-and-not-always-found-the-ups-and-downs-of-sediment-trap-deployments/1839583

Martí Amargant Arumí and Yasemin Bodur (UiT The Arctic University of Norway)

Some days you win, some days you lose. Your car keys. A single sock out of your favorite pair. A 200-metre long rope worth hundreds of thousands of kroner in equipment and samples. No? Just us?

“Anything that you put into the sea is considered lost until you recover it” –Andreas Wolden, Assistant fishing master on R/V "Kronprins Håkon"

“Oh, no” –Yasemin and Martí, concerned PhD students

The road from idea conception to manuscript publication is peppered with setbacks. Bad weather prevents us from doing our work, samples are accidentally spilled or mislabeled, devices work slowly in the extreme cold (so do human brains, for that matter). For any unforeseen circumstance and occasional mishap, there is (almost) always a solution, and coming up with ingenious alternatives is a daily task. In field biology, most of these solutions involve duct tape and good intentions.

But what if the ocean claimed your scientific instruments right at the start of your field work? What if an apex predator in its natural habitat decided that it looked very appetizing? How much duct tape does one need to work around that?

First, let us introduce you to the instrument we are talking about: the sediment traps. As the name implies, it is not animals that we catch, but sedimenting material – i.e. sinking particles. Imagine a 200 meters long rope, hanging vertically in the water, floating with the currents. At different points of this rope (also called “mooring”), we attach simple Plexiglas jars. These are the traps. Material that sinks in the water column ends up in these jars and gets “trapped”, stuck at the bottom. Since particles do not just sink vertically in the water column but follow the currents, we cannot leave the mooring attached to the ship. Instead, we set it out with the traps into the ocean and let it drift on its own for 24 hours (does it not sound risky already?). To ensure its recovery, it is equipped with a large flagpole that floats at the surface and an AIS (a tracking device) so we can follow its motion and collect it. Or so we thought.

The “traps” are just jars: They are attached to the rope (“mooring”) at different depths, so they can collect the sinking material. Photo: Christine Gawinski, UiT.

Sail away, sail away

Everything started according to plan. We prepared the sediment traps and set them out (no small feat), and patiently waited for the 24 hours to pass until we could retrieve it.

It quickly became apparent, however, that the traps did not follow the currents but moved rather in the wind direction, with the flagpole acting as a sail. We steamed (boat-talk for “drove”) to its location and Yasemin’s keen mooring senses kicked in. The floating flagpole was there, but it seemed so light, bobbing up and down with the waves as if there was nothing underneath to drag it down.

“Highly suspicious behavior if you ask me”, is what the seasoned scientist declared. Tom, from the ever-helpful crew, fastened the mooring to the ship crane and proceeded to lift the pole – and nothing else.

Martí, a shocked bystander, likened it to the experience of dipping a cookie in tea and lifting it after a while, only to find that half of it has broken away and sunk. “Not ready for this lack of closure” was his on-site statement.

What happened? Was the attachment rubbing on the rope with the wave motions, creating a shear-like motion that sawed the rope? Did a Greenland shark use its last, century old teeth to set it free? We will never know, but by then the traps were impossible to recover. The mooring travelled with the currents; the pole went on with the wind, leading us far away from our precious samples.

We are not broken, just bent

Undeterred, we did what PhD students do best: improvise. The next station was approaching, and we were not going to miss it! The mooring we lost was a new, shiny model. We dug out the old, reliable rope that we had kept as a backup and attached it to the newly repaired pole. We had some replacements for our scientific equipment, enough for a reduced sampling effort. Cautiously hopeful, we deployed the sediment traps again. This time, attached to a sea

ice floe with heavy metal poles and a thick chain to prevent any breaking. The very image of solidity.

Attaching the sediment traps to an ice floe: Martí, Yasemin and Jørn as a polar bear guard are lifted onto the ice to secure the traps. Photo: Èric Jordà Molina (Nord University).

But alas a white, fluffy presence looms over all sea ice work. We all watched, mouths agape and cameras poised, as several polar bears visited the mooring over the course of the day. The scene we found the day after was a testament to the magnitude of these animals: two floatation buoys were ripped to pieces, the flagpole destroyed, the metal poles that we used for securing the chain to the ice were bent like twigs, the AIS on the ice.
Most impressively, the whole mooring was lifted 5 meters onto the ice! If the floe had broken, the weight would have dragged the whole mooring down, and the sediment traps would have been gone forever (again). From then on, our “flagpole” was a bamboo stick and a torn bedsheet. We make do.

Leftovers from the polar bear visit: The flagpole destroyed, the metal poles (on the left) bent, the AIS on the ice. Photo: Silje S. Wollberg (IMR).

Under pressure

And we could go on for a while, to be honest! We will spare you the tale of the time the mooring rope wrapped itself around an ice floe like a neat Christmas present, or of the time the AIS stopped sending its signal and we had to sail around looking with binoculars until a tiny buoy was spotted. Once again we thought it gone, with some polar bear tracks in the vicinity indicating viciously that the buoy was the only thing left from the mooring.

When the ship approached the tiny little buoy, gently removing the ice around it, a large ice floe shifted aside and all of a sudden, the flagged pole with the AIS plopped out from underneath. Understandable that our frozen, cooled and preserved samples that we recovered from all these adventurous deployments turned out invaluable to us.

Each deployment has taught us to expect the unexpected, and we have gotten as flexible as our trusty bamboo stick. We are sailing again in May, we will keep you updated!

Blog 7. Den ensomme algen - Livet i en dråpe

Link: https://blogg.forskning.no/arven-etter-nansen/den-ensomme-algen/1846292

Simon Kline, *Masterstudent Universitetet i Oslo (UiO)*

Forskningsfartøyet «Kronprins Haakon», et spektakulært skip som gjorde det utilgjengelige Arktis litt mer tilgjengelig for oss forskere. Foto: Simon Kline.

Det er en ny dag ved 82 grader nord. Solen reiser seg sakte, men sikkert opp over horisonten. Iskrystallene lyser mens de leker i lufta og isen rundt båten får en ny levende dimensjon. Med hver bevegelse i vannmassene under reagerer isen, opp og ned, i en pustende rytme.

Vi er i Arktis, et kongerike av kulde og ekstreme forhold. Lyset definerer livet her oppe, med mørket på vinteren og midnattsol på sommeren. Selv om solen står høyt på himmelen i dag og både isbjørn og sel har vært nysgjerrige på vår tilstedeværelse, har vinteren ikke sluppet grepet sitt rundt Arktis for i år riktig enda, og det meste av livet er fortsatt i dvale.

Utepils og våroppblomstring

Et klart og kjært vårtegn i Arktis er våroppblomstringen av alger som skjer i havet. På den måten er havet her oppe litt som en norsk by. I det våren bringer med seg lengre dager og vinterens kulde blir mer og mer et minne, skjer det en betydelig og merkbar endring blant innbyggerne. Man ser flere folk i gatene og hverdagen begynner å bli definert av utepils og stillestående med ansiktet rettet mot sola for å kunne kjenne på varmen. Byen og folket våkner litt mer til live.

Men i motsetning til byene i det langstrakte landet vårt, har innbyggerne i havet ved 82 grader nord fortsatt en stund å gå til de kryper ut i vårens omfang i årets våroppblomstring.

På jakt etter alt som lever

I snart to uker har jeg vært på forskningstokt som en del av Arven etter Nansen, et banebrytende forskningsprosjekt som blant annet prøver å finne ut av hvordan Arktis vil endre

seg i møte med klimaendringer. Målet mitt mens jeg er om bord i forskningsfartøyet «Kronprins Haakon» er å oppspore og søke etter mikroskopisk liv i vannmassene og sjøisen.

Dette innebærer at teamet jeg er en del av filtrerer store mengder vann, nærmere 1000 liter. I bare en dråpe av vann kan det skjule seg vanvittig mye liv, et helt univers for seg selv. Og det er en umulig oppgave å forestille seg hvor mange milliarder av dråper av vann vi filtrerer for å prøve å skape et bilde av livet til stede på tvers av disse dråpe-universene.

Vi jobber med flere forskjellige metoder som sammen kan danne et helhetlig bilde av alt det store som skjuler seg i det mikroskopiske. Den viktigste metoden går ut på å samle inn vannprøver, som vi kan gjøre med instrumenter om bord i båten ned til mer enn 5000 meter. Disse vannprøvene blir filtrert igjennom et lite filter, som fanger opp mesteparten av levende og dødt materiale. Filtrene blir satt i en fryser på -80C og man kan senere analysere DNAet til stede på filteret, spor etter alt som lever og har levd.

Selv om vi forskere setter pris på at solen skinner, er ikke livet i isen og havet helt fornøyd med mengden sollys enda. Foto: Simon Kline.

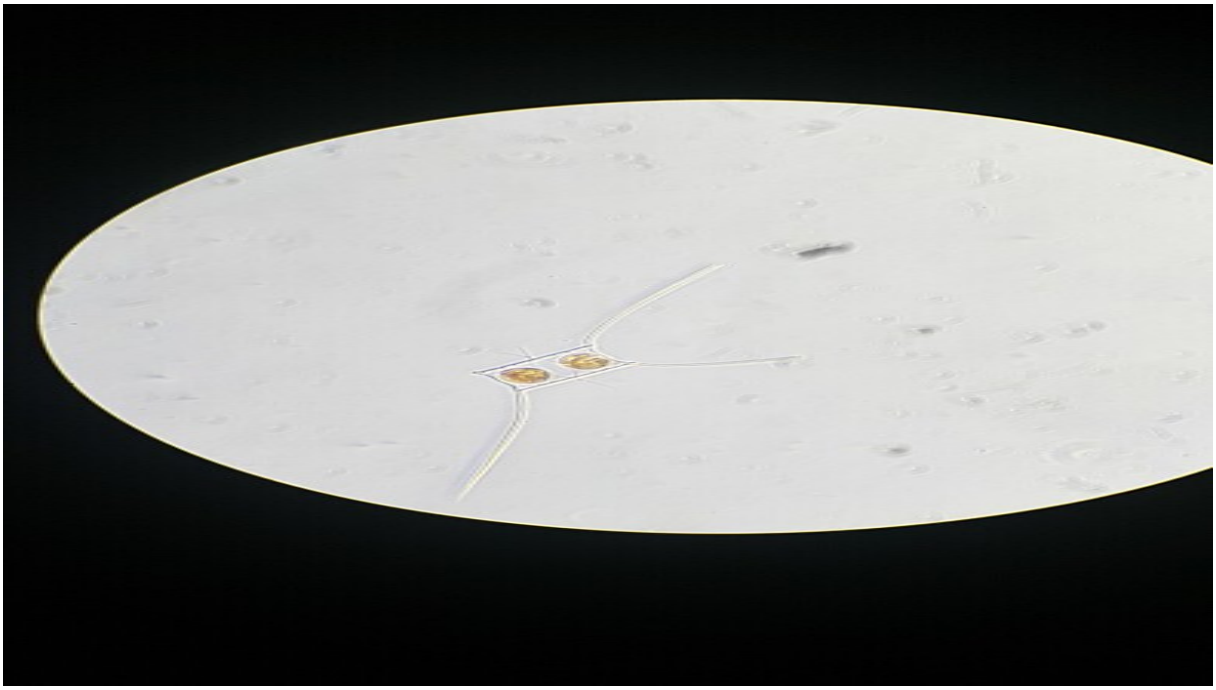
Livet i en dråpe

Ved forrige innsamling av vann tok jeg en dråpe for å sjekke under mikroskop, for å få et innblikk i det som skjuler seg. Men neida, ikke noe univers her. Ingenting som svømte, fløyt eller svevde. Ingen tegn på våroppblomstring.

Men så, plutselig, i det ene hjørnet i denne dråpen fant jeg noe. En ensom mikroalge, alene i dette voldsomme dråpe-universet. Med lange børster som strekker seg som antenner i hver sin retning og to store gyllenbrune sporer som stirrer tilbake på meg i mikroskopet, kunne jeg utrope: jeg ser en Chaetoceros decipiens! En liten og utrolig fascinerende alge som sammen med de andre artene i gruppen kiselalger gjør noe så unikt som å danne glass i celleveggen sin.

Kiselalgene utgjør en svært viktig del av våroppblomstringen, tidspunktet der forholdene mellom vinter og sommer blir akkurat perfekte til at hvilesporer spirer og de mikroskopiske algene våkner fullstendig. Våroppblomstringen fører til en dramatisk endring i antall

mikroalger til stede i vannmassene, som alle slåss om å kapre sollys. Ved å ha fotosyntese som gir dem evnen til å omgjøre solens energi til stoffer som kan brukes av andre organismer, danner mikroalgene fundamentet til hele næringskjeden i Arktis.
I det sommer går mot høst og høst går mot vinter, begynner lysforholdene å endre seg igjen. Med mindre lys blir det vanskeligere å drive fotosyntese og det er derfor en stor fordel for alger å danne sporer og andre hvilestadier som gjør at de kan overleve den evige mørke vinteren.



En ensom alge, Chaetoceros decipiens, som med sine to tydelige sporer viser at våren ikke er en realitet ved 82 grader nord. Hvor mye lengre må de vente, tro? Foto: Simon Kline.

Alt som skal til for å kunne blomstre i Arktis

Jeg lurer på hvordan reisen til denne Chaetoceros-algen har vært. Jeg prøver å forestille meg hvordan det er å være denne ensomme sjelen i mikroskopet (hvis du aldri har prøvd å forestille deg å være en mikroalge i havet anbefaler jeg det på det sterkeste!) Hvordan har den endt opp her? Har den blitt kapret av strømmen og ført hit? Eller ble den lurt ut av dvalen sin litt tidlig?
Mange mennesker vil kunne fortelle om dype og magiske øyeblikk med dyr. Øyeblikk som minner oss på hvordan alt og alle henger sammen, som tatt ut av Jane Goodall sitt liv eller en David Attenborough-dokumentar. Det er kanskje vanskelig å få samme følelse med en mikroalge, men i dette øyeblikket med meg og Chaetoceros-algen merket jeg en respekt over hva som kreves for å kunne overleve i disse tøffe omgivelsene definert av mørke, kulde, voldsomme krefter i havet og ekstreme forhold.
Vi finner mikroalger i alle hav og ferskvann, i is og alt som er fuktig. Kumulert sikrer de oss ca 50% av all oksygenet som blir produsert. Så selv om de fleste mennesker forståelig nok ikke har forestilt seg hvordan det er å være en mikroalge i havet, er det umulig å forestille seg hvordan det hadde vært for oss uten dem.

For å samle inn prøver av livet i isen borres det flere kjerner, et noe krevende arbeid i temperaturer over -30C. Foto: Simon Kline.

Selv om solen står høyt på himmelen i dag er den ikke nok til å dra de fleste algene ut av hvilestadiene sine enda. Fram til da er livet i vannet satt litt på vent, men med hver dag som går nærmer våren seg. Og det er nok ikke bare livet på land som gleder seg til at den har fått et skikkelig fotfeste.

The Nansen Legacy in numbers

6 years

The Nansen Legacy is a six-year project, running from 2018 to 2023.

1 400 000 km² of sea

The Nansen Legacy investigates the physical and biological environment of the northern Barents Sea and adjacent Arctic Ocean.

>10 fields

The Nansen Legacy includes scientists from the fields of biology, chemistry, climate research, ecosystem modelling, ecotoxicology, geology, ice physics, meteorology, observational technology, and physical oceanography.

>350 days at sea

The Nansen Legacy will conduct 15 scientific cruises and spend more than 350 days in the northern Barents Sea and adjacent Arctic Ocean between 2018 and 2022. Most of these cruises are conducted on the new Norwegian research icebreaker RV *Kronprins Haakon*.

280 people

There are about 230 researchers working with the Nansen Legacy, of which 73 are early career scientists. In addition, 50 persons are involved as technicians, project coordinators, communication advisers and board members.

10 institutions

The Nansen Legacy unites the complimentary scientific expertise of ten Norwegian institutions dedicated to Arctic research.

Universitas Oslo Mdccclxi
Universitas Bergensis
The Arctic University of Norway UIT
Institute of Marine Research
Norwegian Polar Institute
Norwegian Meteorological Institute
UNIS The University Centre in Svalbard
NTNU
NERSC
Akvaplan niva

50/50 financing

The Nansen Legacy has a total budget of 740 million NOK. Half the budget comes from the consortiums' own funding, while the other half is provided by the Research Council of Norway and the Ministry of Education and Research.

Norwegian Ministry of Education and Research

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