the Nansen LEGACY

JC2-1 Joint cruise part 1 2021

Cruise Report

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JC2-1 Joint cruise part 1 2021

Cruise 2021708

R/V Kronprins Haakon
Tromsø-Longyeabyen
12 – 29 July 2021

Authors:
Elizabeth Jones[1], Marit Reigstad[2], Nadjejda Espinel Velasco[3], Audun Gjerland[3], Lucie Goraguer[3], Helene Hodal Lødemel[1], Simon Kline[4], Sigrid Lind[3], Luke Marsden[5], Marius Maurstad[4], Oliver Müller[6], Jan Vidar Norstrand[1], Vanessa Pitusi[5], Hilde Stabell[6], Evelyn Strombom[4]

1: Institute for Marine Research (IMR)
2: UiT The Arctic University of Norway (UiT)
3: Norwegian Polar Institute (NPI)
4: University of Oslo (UiO)
5: University Centre in Svalbard (UNIS)
6: University of Bergen (UiB)

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Summary

The Nansen Legacy Joint Cruise 2, part 1 (JC2-1) 12-29 July 2021, continued the investigation of the interannual variability during the late summer season. At the same time will the cruise provide a late summer reference for the seasonal investigation that was separated to late summer and polar night 2019, and winter and spring 2021. The transect represents an environmental gradient going through the northern Barents Sea, and included 7 process stations (P1-P7) lasting 10-39 hrs. Additional CTD stations (NLEG) were taken between the process stations to increase the hydrographic resolution on the transect. The work started at 76°N at the open Atlantic Water dominated station P1, was sea ice covered from station P4 at 79 45.00 °N and included deep water stations at the P7 station at 82°N in the Nansen Basin.

The program included measurements and sampling from the atmosphere, sea ice, ocean and sea floor. Data collected includes several disciplines to map the physical environment, the chemical characterization and biological communities. Key parameters from the Nansen Legacy joint cruises were selected and included in this reduced sampling program, compared to the other joint cruises. An important aim was to characterize the northern Barents Sea to map the interannual variability, but also to see how the proceeding winter and spring conditions has impacted the environment and conditions this year. A third task is to carry out a shelf investigation that can complement the investigations in the deep Arctic Basin starting in late August. Tests and improvements of a modified pelagic trawl (Harstad) were carried out as preparations for the Arctic Basin cruise in late August 2021.

Introduction

Scientific goals and achievements

The R/V *Kronprins Haakon* cruise Nansen Legacy joint cruise JC2-1 in July 2021 followed up the seasonal investigation of the northern Barents Sea and adjacent Arctic Basin, as well as the investigations of interannual variability along the Nansen legacy transect in the late summer period. 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 in open waters and within the ice. As the cruise had limited participation due to Covid-19 restrictions, a reduced number of key parameters were selected for collection compared to the seasonal joint cruises. Experiments include production measurements for phytoplankton and bacteria, and ocean acidification impact on zooplankton. Increased number of CTD stations across the Polar Front and along the slopes of the banks facilitated improved resolution of the hydrography along the transect. Tests were run to calibrate fluorescence and carbon chemistry of underway measurements, and the effect thrusters on the depth of stratified layers with use of dynamic positioning during CTD sampling. Tests and improvements of a modified pelagic trawl (Harstad) for use in ice covered water were also done and proved successful. The routines for sampling, data management and data storing were followed. Many of the cruise participants were Master students, PhD and post docs and represent a new generation of Arctic scientists.

Brief description of the activity

R/V *Kronprins Haakon* left Longyearbyen on 12 July 2021 in the evening, with a science team of 14 persons. Cruise participants without survival suit training carried out the necessary exercise close to the vessel in the harbor of Longyearbyen while the vessel was loaded. A monitoring station outside Longyearbyen, IsG, was sampled with one CTD to serve collaboration projects. The first Process station, P1 (Fig. 1), in the Hopen deep south of the Polar Front at 76°N, was sampled on 14 July. Seven Process stations (P1-P7, Fig. 1) were planned along the Nansen Legacy transect that was established in 2018 and subsequently investigated in 2019 and 2021. The first process station (P1) was successfully finished on 14 July, after 15 hrs, as planned. Between the P stations, a series of CTD stations (NLEG 1-25) were distributed to get a higher resolution on hydrographical and biogeochemical parameters along the transect.

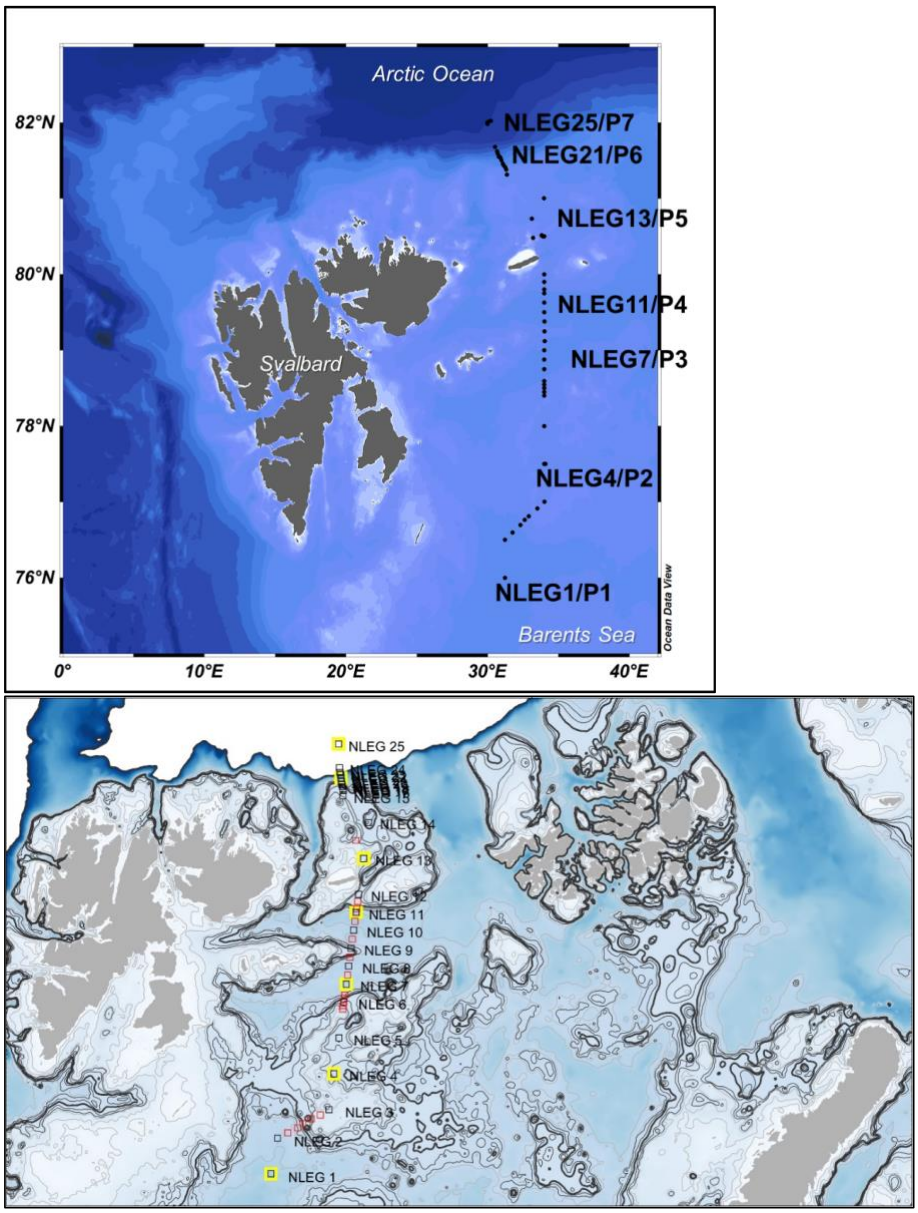

Figure 1. Upper panel: Station map for the Nansen Legacy joint cruise JC2-1. Process stations P1-P7 and intermediate CTD stations (NLEG) are shown. Lower panel: Bathymetry map showing position of P-stations

(yellow squares), NLEG-stations (black squares) and the extra NLEG CTD stations, named X.1, X.2, etc (red squares). The thicker black curve denote the 200 m isobath.

Between P1 and P2, additional CTD casts (NLEG2.1-NLEG2.5) were taken across the slope of Storbanken to better characterize the water masses and flow paths in this region (Fig. 1). The P2 station was sampled successfully on 15-16 July with a full pelagic program and two Campelen trawl hauls. In addition, the first of two CTD thruster experiments was carried out and a test of a modified Harstad trawl was successful. Between P2 and P3, additional CTD casts (NLEG5.1, NLEG5.2, NLEG6.1, NLEG6.2) were taken to enhance the resolution of hydrographic measurements across Storbanken. The P3 station was sampled successfully on 17 July with a full pelagic program, one Campelen trawl and a CTD Chl a experiment (finer resolution sampling across the sub-surface Chl a maximum depth). Between P3 and P4, additional CTD casts (NLEG7.1, NLEG8.1, NLEG9.1, NLEG10.1) were taken to enhance the resolution of hydrographic measurements in this region.

Trawling with the new modified Harstad trawl was carried out in open drift ice during transit to P4. At Station P4 south of Kvitøya, we met the sea ice, but floes were relatively small with large openings in between, and the station was sampled with the full open water sampling program including zooplankton experiments, on 18 July (10 hrs station). A Campelen trawl was taken a few nautical miles south of the station in more open waters. Transit time between stations increased and was more variable with the sea ice, but we kept about 5 knots and reached P5 north of Kvitøya on 19 July. The ice field was more compacted here, transitioning from open drift ice to more consolidated ice floes. A second CTD thruster experiment was carried out in the shallower and ice-influenced water column. An information meeting on sea ice safety and sampling was held prior to arrival at P5 to prepare all participants for the work on and associated to the sea ice.

Upon completion of the pelagic program, a Campelen and Harstad trawl (modified to work in sea ice) was carried out in the vicinity of P5 in open drift ice. The following day, the sea ice sampling program began (P5 ice) with search for a suitable ice floe and ice thickness tests and then ice and snow thickness survey, ice coring, under-ice water and melt pond sampling. The sea ice was warm and soft, and we experienced some difficulties in the ice coring. A Campelen trawl was deployed as we began transit to NLEG14, with an additional CTD cast (NLEG13.1) carried out in between. Further CTD casts were made at NLEG14 to NLEG20 with water sampling at NLEG14, NLEG15 and NLEG19. An additional CTD cast was made upon arrival at P6 to provide a continuum of the CTD measurements along the transect. Sampling at station P6 on the shelf break towards the Polar basin began on 22 July with the ice work (P6 ice). Ice floes were 100 m to > 1 km in size, 1 to 1.5 m thick, and suitable for sea ice work. We completed a full ice station and open water program, including a Harstad trawl within the ice. As for P5, the sea ice sampling program included ice cores, under-ice water and meltwater ponds. Following the success of P5 ice station, teams of experienced and unexperienced scientists were composed to carry out the P6 ice station in order to give new experiences and train a new generation of scientists in sea ice work (Table A4). The ice station was followed by a full ocean sampling program on 22-23 July. Transit to the final NLEG CTD stations began on 23 July, which included water samples. The sea ice became thicker, with larger and more consolidated floes showing signs of ridges and rafting and covered by many melt ponds and variable but generally thin snow cover. Open leads within the ice pack enabled efficient transit to the last process station P7 by 24 July. A similar program to P6 was carried out at P7 with the ice work followed by the pelagic program on 24-25 July.

Along track measurements carried out during the cruise

R/V *Kronprins Haakon* is equipped with several underway measurement systems to provide data along the cruise track.

Meteorological measurements from Vaisala AWS430 weather station

Air and sea temperature (8 m depth), air pressure, wind speed and direction, relative humidity and solar radiation is measured continuously by a Vaisala AWS430 weather station.

Radiosonde measurements

Vaisalla radiosondes were launched daily on behalf of the Deutcher Wetter Dienst to collect profiles of air temperature, wind speed, wind direction and air humidity. The sondes are launched daily at 10:30 UTC while in open sea and rise quickly to 20 000-30 000 above sea level before they explode. They provide valuable data for meteorological model validation.

Thermosalinograph

Temperature, salinity, density and fluorescence is measured from the clean water intake at 4 m depth, and continuously logged from departure Longyearbyen. During the transit to NLEG08 on July 17, at 18:30 UTC (Toktdagbok 60 in toktlogger), seawater intake to labs and the underway system were changed from 4 m to 8 m in the drop keel trunk. This is necessary as the clean water intake is sensitive to ice (filter gets clogged) or water at freezing temperature (–1.7 °C) and may cause pumps to shut down in shorter periods for ice removal. Data quality is lowered somewhat as there is a longer delay from the intake to the measurements when using the 8 m depth water intake. From 26 July, at 09:13 UTC the water intake was changed back to 4 m depth.

Samples for Chl a and carbonate chemistry analysis were taken during transit between stations in ice-free waters to calibrate or compare to the fluorescence sensor and pCO_2 underway systems, respectively.

Ocean current measurements from ADCP 150 kHz

Currents in the upper ~500 m of the water column were continuously measured during the cruise using a 150 kHz ADCP (RDI Instruments) mounted on the drop keel. The setup followed the setup in the test cruise. The instrument was synchronized with the EK80 using K-sync. The 38 kHz ADCP was not used due to interference with the 38 kHz of the EK80. The ADCP data was not processed during the cruise due to time constraints.

pCO_2 measurements

Using the 4 m sea water inlet, a pCO_2 underway system for autonomous high frequency surface water measurements provides data on pCO_2 in sea water and air, dissolved O_2 and O_2 saturation and sea water temperature during the entire cruise (Fig. 2).

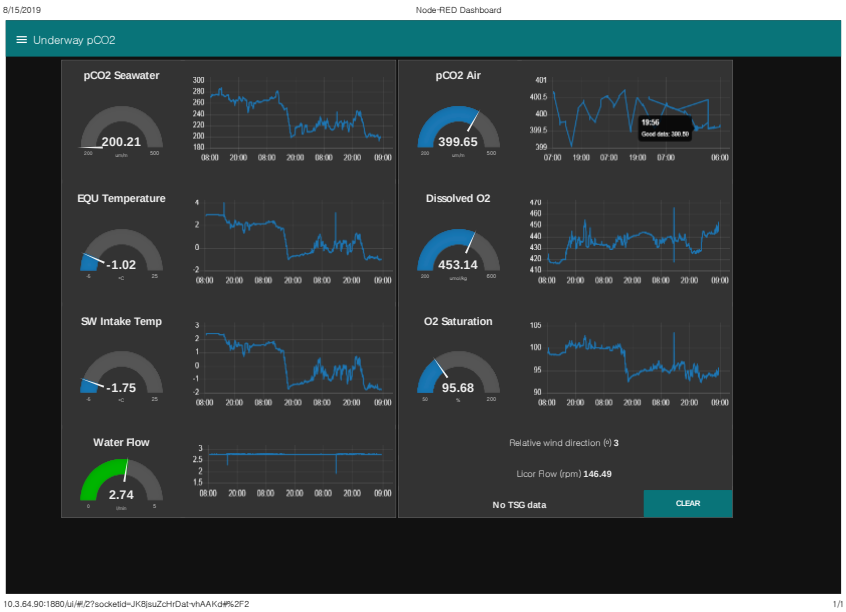

Figure 2. The pCO_2 underway measurements measures relevant parameters on CO_2, temperature and O_2 from the 4 m seawater intake.

Same water intake as thermosalinograph – and similar problems with ice at low temperatures. But intake depth shifted from 4 m prior to July 17 at 18:30 UTC (during transit between NLEG9 and NLEG10) to the drop keep trunk at 8 m.

Acoustics measurements of zooplankton and fish with the vessel´s EK80

Acoustic surveying of fish and zooplankton was conducted using the six scientific Simrad EK80 echo sounders (18 kHz, 38 kHz, 70 kHz, 120 kHz, 200 kHz, 333 kHz split beam systems), all mounted in Arctic tanks. The EK80 was operated in CW modus. Data were stored down to current bottom depth +20% (auto mode) depth, although electrical noise during transit prevented high-quality data below about 600 m depth. Multi-frequency scrutinization and target strength analysis was conducted for the 38kHz data using Korona allocating NASC into the category's capelin, plankton, cod, herring and others.

Station-based work

The Nansen Legacy transect (NLEG transect; Fig. 1) provides a climatic gradient from the southern Atlantic influenced region of the Barents Sea (P1) across the more Arctic influenced northern shelf (P2-P5), the shelf-break (P6) and into the deep Arctic Basin (P7). The Fram Strait branch of the Atlantic Water Current flows eastward into the Arctic Basin along the northern shelf break of the Barents Sea and is covered by the shelf break station (P6). The NLEG transect may also represent a space-for-time gradient. On a seasonal timescale, ice-free waters in the south can reflect a later seasonal stage compared to the ice-covered regions in the north where sea-ice presence may delay the productive onset in the water column. And a stronger stratification can limit heat, salt and nutrient fluxes to the upper ocean (Randelhoff et al., 2016; Lind et al., 2016) At the same time, this may be compensated by an early ice algal production.

On a longer timescale, the climatic conditions in the Barents Sea are strongly impacted by the warm and saline Atlantic Water inflow. However, north of the Polar Front the stratification is determined by the Arctic Water (corresponding to intermediate, cold Polar Water) salinity variations, governed in turn by the amount of melt water input from imported sea ice to the Barents Sea (Lind et al., 2016, 2018). The *Atlantification* process includes a weakening of ocean stratification and increased Atlantic Water impact on upper ocean characteristics further north and east in the Arctic Ocean (Årthun et al., 2012; Polyakov et al., 2017; Lind et al., 2018). The parts of the transect with weakest stratification and most Atlantic influence and turbulence/vertical fluxes may therefore represent elements of future conditions. However, the areas north of Storbanken are the most "true Arctic conditions" on the transect, and further north of Kvitøya and at the shelf-break, conditions are typically more "Atlantic influenced". Open water stations were carried out at P1–P4, while P5–P7, also included a sea ice station in addition to the pelagic work.

NLEG stations

T1-1.2 Hydrographic characterisation

Sigrid Lind (NPI), PIs: Randi Ingvaldsen (IMR), Arild Sundfjord (NPI)

To increase the observational resolution along the transect, 18 additional CTD stations (NLEG1–25) reduce the gaps between the process stations (P1–P7). The overview of NLEG and P stations are given in Table A2. A reduced biogeochemical sampling program was carried out on selected NLEG stations. In addition, a series of extra CTD casts were made to enhance the spatial resolution of hydroraphy to improve gradients of characterization at specific places of interest, i.e. Polar Front at southern end of Storbanken, transition to deeper trench area north of Storbanken and the transition to Kvitøyabanken. All NLEG stations were covered in full depth with CTD, with T, S, O_2, fluorescence and LADCP.

The hydrographic characterization along the transect with respect to temperature, salinity and fluorescence, is shown in Figure 3. The watermass characteristics for the different P-stations are illustrated in a TS-diagram in Figure 4, with comparison of a previous summer cruise (Q3, August 2019). The water mass characteristics have recovered to a more normal situation comparable to climatological values (Lind and Ingvaldsen, 2012; Lind et al., 2016). This is seen as water mass characteristics are less similar between Arctic (corresponding to intermediate, cold Polar Water) and Atlantic Water due to stronger stratification and less vertical mixing between the two layers. This corresponds with the recovery of import of sea ice to the Barents Sea in 2019 (Aaboe et al., 2021), also seen in 2020 and partly in 2021 (unpublished data), leading to freshwater input and recovered ocean stratification, in line with processes described in Lind et al. (2018).

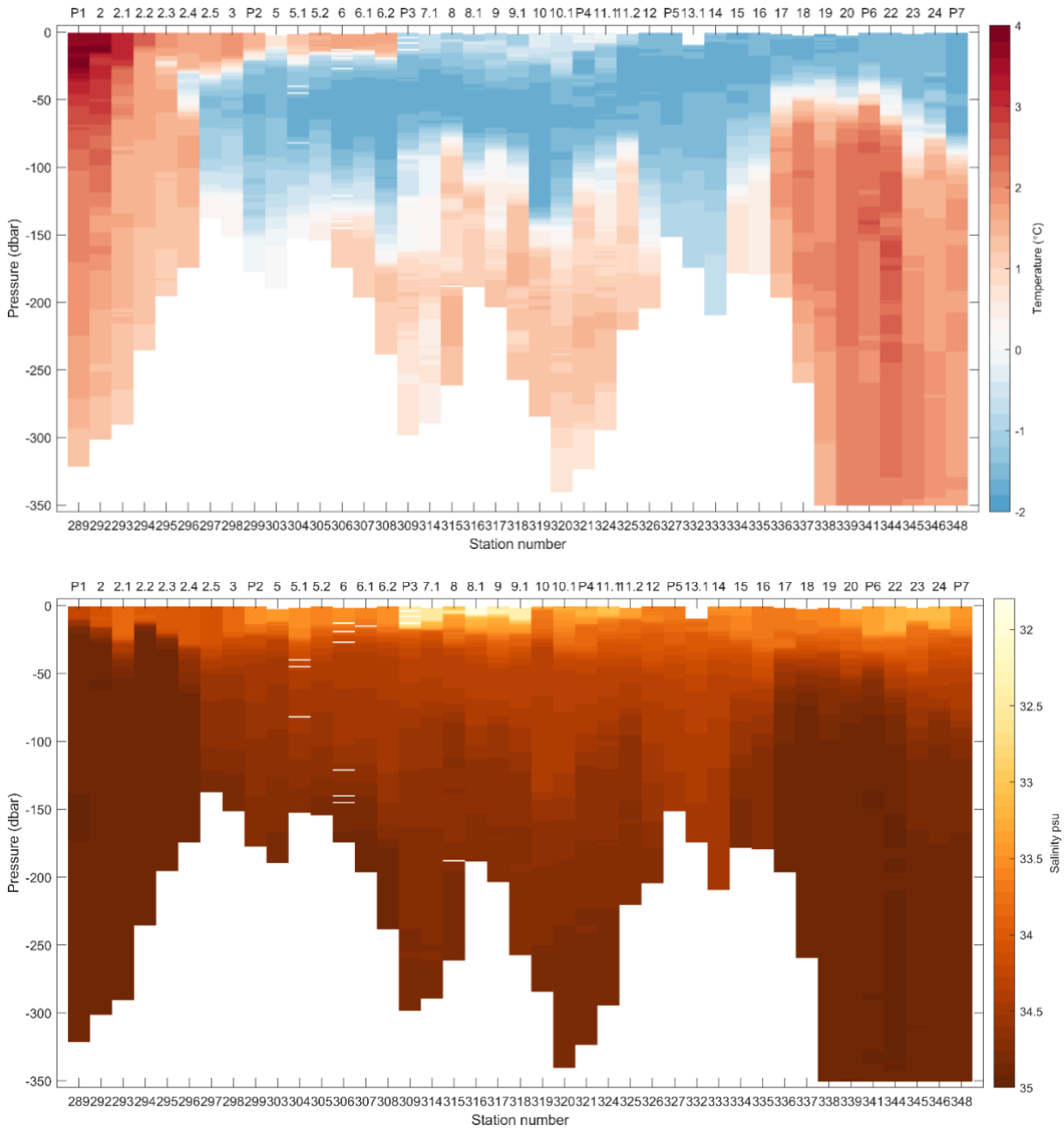

Figure 3. Upper panel: Temperature, Lower panel: salinity (psu) as measured along the Nansen Legacy transect from 76 to 82°N in July 2021. The process stations P1–P7 and NLEG stations numbers are marked on the upper x-axis. Corresponding station numbers from CTD file naming is marked on the lower x-axis. (P1 is to the south and left). Data from 0–350 m are plotted here, to show the variability in the upper and intermediate ocean, but the full water column down to > 3000 m was sampled north of the shelf-break. The transect is shown as a pcolor plot to not interpolate between stations, but better depict the actual measurements.

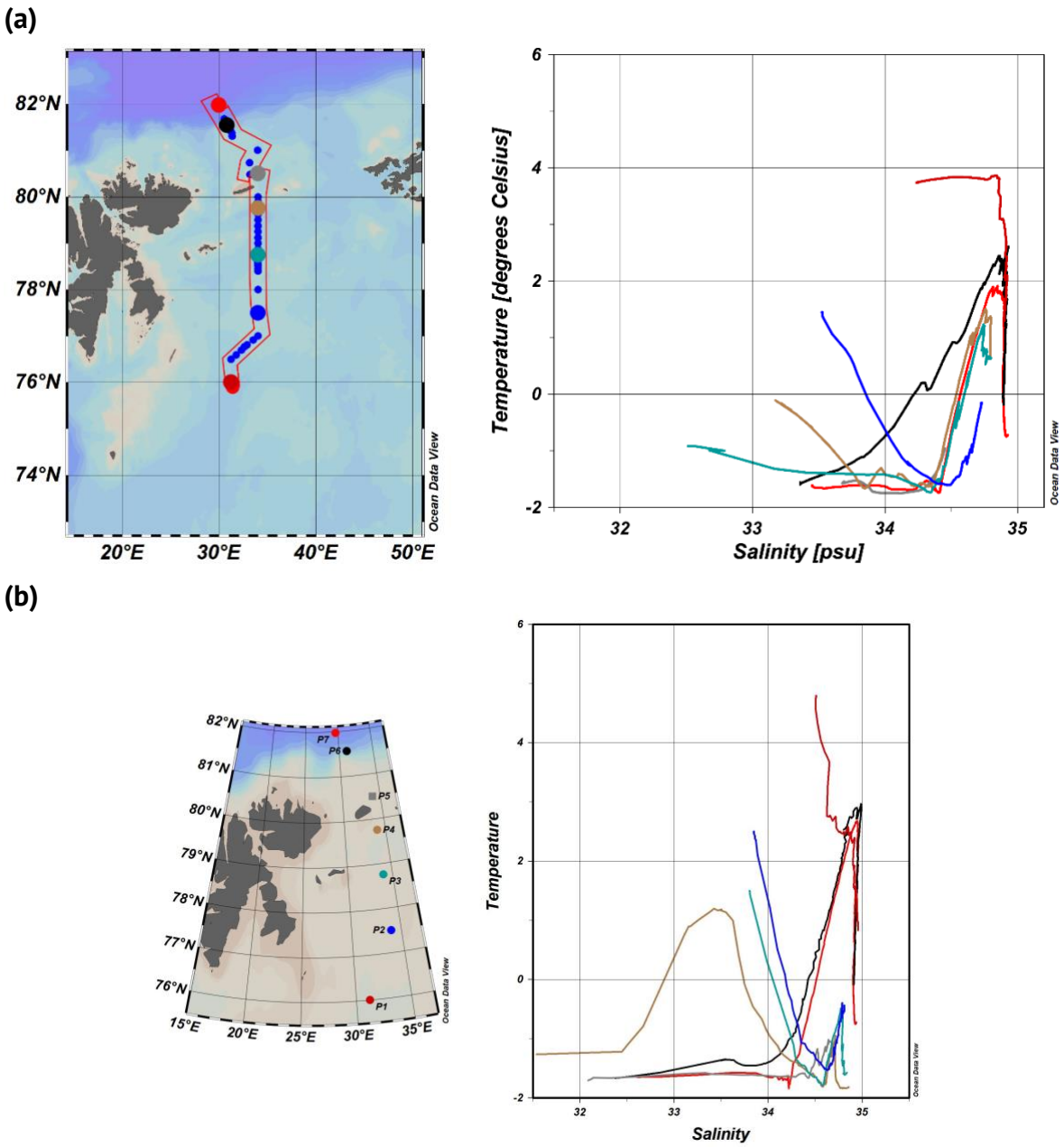

Figure 4. (a) Temperature-salinity plot (TS diagram) illustrating the difference in water masses present at the process stations P1–P7, showing reduced salinity and temperature moving northwards, but increases in the deeper Atlantic Water at the shelf break (P6). Smaller branches of this current enter the Barents Sea from the north (Lind and Ingvaldsen, 2012), giving also signatures of modified Atlantic Water in the deeper trenches of the northern Barents Sea (P3 and P4). Colors correspond to station colors on the maps. (b) Corresponding TS diagrams and map plot from the previous Nansen Legacy summer cruise (Q3, August 2019).

Investigations into the influence of the ship's thrusters on the water column were carried out during the cruise. The experiments were carried out with the CTD to detect potential effects of the dynamical positioning (DP) system of R/V *Kronprins Haakon*. The DP uses the thrusters in an automatic program to keep the vessel in position during sampling.

The first experiment (CTD experiment #1) on 16 July focused on the influence on the upper 1–50 m, one from 50–100 m and one on the change in the upper 1–50 m in the open drift sea ice, by allowing the CTD to sample continuously up and down during time intervals with and without

usage of thruster power. The setup of the first experiment is shown in Figure 5. The experiment was performed near P2 on Storbanken in ice-free conditions with quite typical wind speeds (8–9 m/s) and in a stratified environment with a bathymetric depth of 181 m. The CTD was lowered and taken up again between 1 and 50 m depth consecutively for 12 minutes x 5 periods, alternating between free drift and DP. The experiment was then repeated for the 50 to 100 m depth of the water column. In total the experiment lasted over two hours.

On 19 July, another CTD experiment was performed near P5 on Kvitøyabanken in partly sea-ice covered conditions and a shallow, quite strong ocean stratification and quite low wind speeds (4–5 m/s) (CTD experiment #2). The observed sea ice concentration was ~7/10, with wide leads of width ~100–200 m. In ice covered conditions such as these, the DP is not used, as that would lead to ship crashing into the sea ice which drifts. Rather the ship typically drifts with the wind and ice and may use some thruster power manually to flush any sea ice away from the starboard side of the ship (where the instruments are put in the water). We therefore made the experiment with alternating between free drift and some thruster power (10 and 20 %) to simulate flushing sea ice away from the starboard side. This time the experience was performed in the upper water column only.

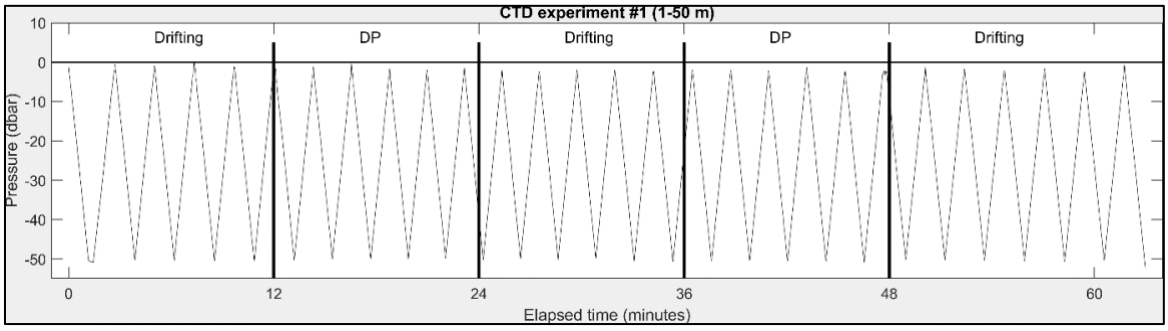

Figure 5. Experiment setup for the upper 1–50 m experiment at Storbanken.

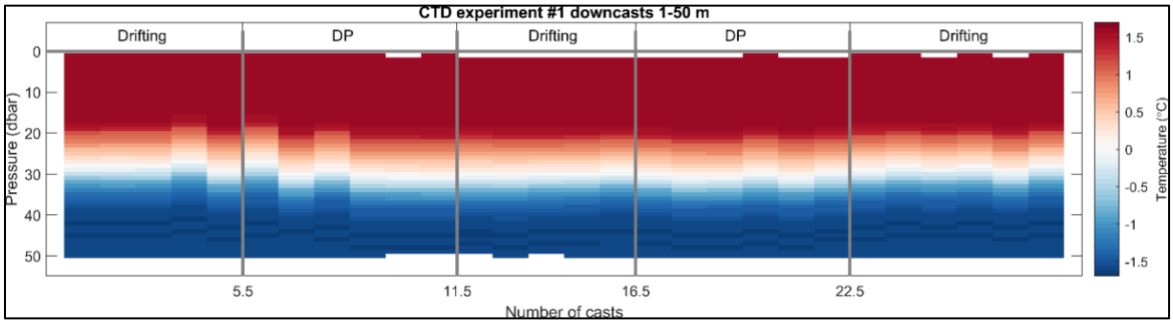

Figure 6. Preliminary results showing only small to negligible influence of thrusters, given the conditions during the experiment.

The preliminary results indicated little influence of thruster power, but the actual influence will depend on the conditions, with particular reference to stratification and wind influencing the forcing inhibiting vertical motion (mixing and lifting) and influencing the usage of power for the dynamical positioning (DP) system of the vessel (Fig. 6). In the sea ice, R/V *Kronprins Haakon* typically drifts with the ice and DP is not used. However, some thruster power can be used at occasions to hold smaller ice floes and pieces away from the vessels starboard side, where the

CTD and nets are deployed. Experiment #3 was performed to check the usage under these conditions.

T1-2.2 Sea ice

Sigrid Lind (NPI), Luke Marsden (UNIS), Marit Reigstad (UiT), PI: Sebastian Gerland (NPI)

Onboard sea ice observations were carried out during transit between stations according to the recommendations from the Ice Watch Program. The sea ice conditions, characteristics and weather during transit were registered every 3rd hour from the bridge accompanied with three photos. Data are uploaded and available at https://icewatch.met.no. Observations of fauna, algae presence, snow and ice thickness and melt water pond characteristics were given only if the observers had the possibility to give those with acceptable accuracy, as it takes training and occasional in situ measurements to give better estimates. In situ snow and sea ice thickness measurements were made at every ice station (P5–P7). It is difficult to assess pond width and depth from onboard-only observations. Additional melt pond depth and width measurements were therefore performed *in situ* on the ice station at P7 and will be made as a pdf guide to help assist future melt pond observations from onboard the vessel. Summer melt pond observations are important for improving satellite sea ice products (Fors et al., 2015).

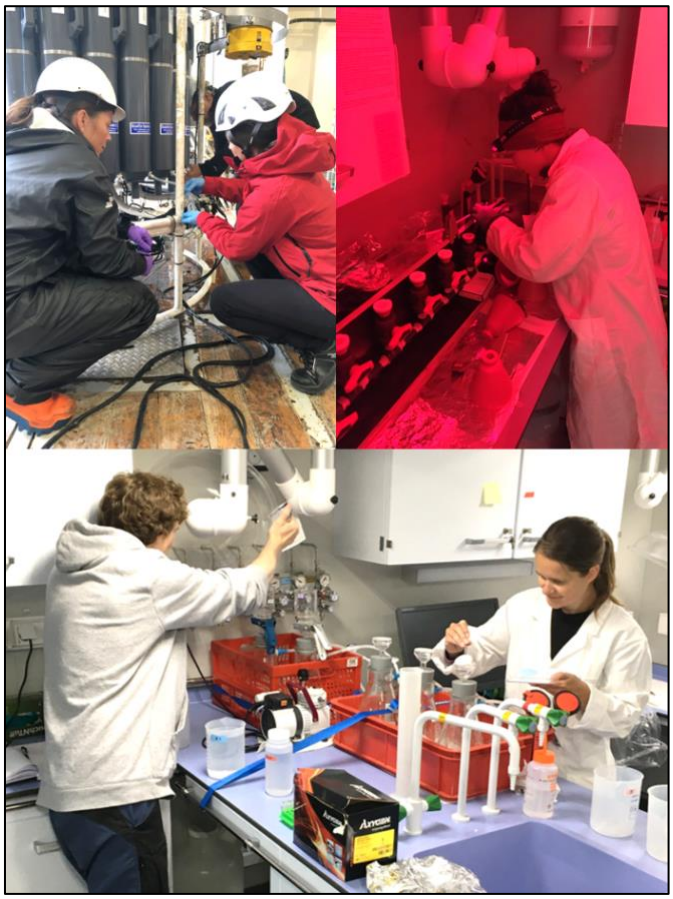

Figure 7. Water sampling from the CTD and sample filtration and processing in the laboratories. Photos: E. Jones.

T2-1.1 Carbonate chemistry, inorganic nutrients, stable oxygen isotopes and dissolved oxygen

Helene Hodal Lødemel (IMR), Elizabeth Jones (IMR), PIs: Melissa Chierici (IMR), Agneta Fransson (NPI).

Aims

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, melt ponds, 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 of seawater ($\delta^{18}O$). Analyses for the determination of dissolved oxygen were performed onboard.

Work onboard

The underway instrumentation for autonomous high-frequency surface water measurements of partial pressure of CO_2, pCO_2 (General Oceanics) and pH (HydroFia), was running in ice-free water from ship's seawater intake at 4 m depth. The raw data of partial pressure of CO_2, pCO_2 are calibrated against a series of reference gases (comprising different CO_2 concentrations) and will be quality controlled in post-cruise processing. Certified reference material (CRM batch 191 from Dickson et al) was analysed for pH on the HydroFia system and will be used to correct the raw data together with information on in situ temperature and salinity.

Seawater was sampled from Niskin bottles mounted onto a 24 bottle CTD-Rosette (Fig. 7) from a total of 21 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, preserved with saturated mercury chloride 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 in the dark for post-cruise analyses at IMR in Bergen.

Dissolved oxygen was sampled from 12 CTD stations, total of 87 measurements, ranging in depth between 5m to 2835m. The data from the Winkler titration showed that the oxygen sensor on the CTD had an offset ranging from –0.2 to –0.9 ml/l (Fig. 8). The largest offset was seen in surface samples with high concentrations of oxygen, ranging between 9 and 10 ml/l.

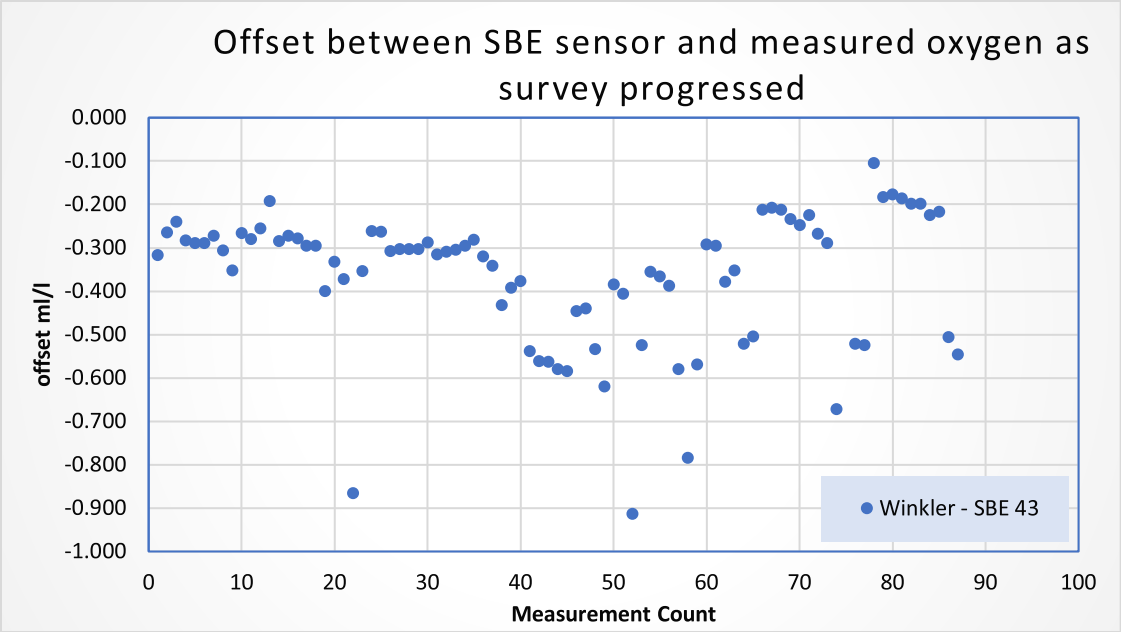

Figure 8. Offset between SBE 43 sensor and measured oxygen as survey progressed. The negative values mean the sensor estimates are elevated compared to the measured samples.

The average drift of the sensor compared to last calibration on 28 February 2020 was -4,5% and is within the accepted range defined by Seabird and no overall correction of the data are needed, see Figure 9.

	Drift outside ±15%. Apply correction. Remove sensor.
	Drift outside ±10%. Apply correction. Order/get a new sensor on board and replace.
	Drift outside ±5% but inside ±10%. Apply correction.
	Drift within ±5%. No correction needed.

Figure 9. Guidelines from Sea-Bird using SBE 43 oxygen sensor data.

Total samples for carbonate chemistry, inorganic nutrients and stable oxygen isotopes in seawater and sea ice were 770. Table 1 summarizes the seawater sampling from the CTD-Rosette.

Table 1. Seawater samples from the CTD-Niskin Rosette.

Station Name	CTD #	# AT/DIC/pH	# Nutrients	# $\delta^{18}O$	# $DO_{Winkler}$
P1	289	12	12	12	13
NLEG2	292	12	12	12	
NLEG3	298	10	10	10	10
P2	299	11	11	11	14
NLEG5	303	11	11	11	18
NLEG6	306	10	10	10	
P3	310	12	12	12	9
NLEG8	315	12	12	12	

NLEG9	317	11	11	11	
NLEG10	319	12	12	12	
P4	321	12	12	12	
NLEG12	326	11	11	11	
P5	327	10	10	10	4
NLEG14	333	9	9	9	4
NLEG15	334	10	10	10	4
NLEG19	338	12	12	12	6
P6	341	13	13	13	6
NLEG22	344				12
NLEG23	345	16	16	16	
NLEG24	346				10
P7	348	19	19	19	

T3-1.1 Characterisation of microbial communities

Oliver Müller (UiB), Hilde Marie Kristiansen Stabell (UiB), Simon Kline (UiO), Luke Marsden (UNIS), Lucie Goraguer (NPI), PI: Bente Edvardsen (UiO)

The activity contributes to tasks T3-1 and T3-2 and links to T3-3 and T3-4. Flow cytometry (FCM) samples were taken from the standard depths and bacterial production samples, and Durapore filters for DNA extraction were taken from the upper 90 m depths (5, 10, 20, 30, 40, 50, 60, 90, and/or chl a max) at several NLEG stations (NLEG2, NLEG3, NLEG5, NLEG6, NLEG8, NLEG9, NLEG12, NLEG14, NLEG15, NLEG19, NLEG23). 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.

Process stations

Research Foci 1: Physical drivers

Atmospheric data were collected launching a radiosonde balloon at noon at all P stations. Ocean currents in the upper ~500 m of the water column were continuously measured, also during the P stations, using a 150 kHz ADCP (RDI Instruments) mounted on the drop keel. The instrument was synchronized with the EK80 using K-sync. The 38 kHz ADCP was not used due to interference with the 38 kHz of the EK80. The ADCP data was not processed during the cruise due to time constraints and number of personnel onboard.

Sea ice observations and work supporting research in RF1, are included above and in a separate section on Sea Ice (below) together with the chemical and biological parameters.

Research Foci 2: Human drivers

T2-1.1; 1.4. Current variability and drivers of ocean acidification and ocean acidification effects on planktonic calcifiers and biological pump efficiency

Nadjejda Espinel Velasco (NPI), Vanessa Pitusi (UNIS) for Griselda Anglada-Ortiz (CAGE-UiT), PIs: Melissa Chierici (IMR), Tine Rasmussen (UiT).

Aims
To better understand the effects of ocean acidification on marine calcifiers, the abundance and carbonate contribution of different planktonic calcifiers (foraminifera, pteropods and coccolithophores) was studied in relation to the water chemistry (carbonate chemistry, inorganic nutrients). The main goal of the targeted sampling was to provide information on planktic foraminifera and pteropods seasonal, annual and regional variations in abundance and species distribution along a latitudinal environmental gradient in the Barents Sea.

Work onboard
Planktonic live specimens from different depths were collected with a multinet (64 µm) from all stations along the transect (P1 to P7), carrying out stratified sampling at each station (Table 2). The following depth intervals were chosen for sampling: 300-200m, 200-100m, 100-50m, 50-20m and 20-0 m. For the shallow stations (P2 and P5), the chosen sampling intervals were: 150 (140 for P5)-100 m, 100-50 m, 50-20 m and 20-0 m. Immediately after collection, the samples were sieved through 64 um mesh size, rinsed with sea water, transferred into 250 ml Whirl-Pak® *Nasco* plastic bags and frozen at -20 °C until further

Table 2. Overview of the samples collected and different depth intervals.

Station	Sampling interval (m)	Number of samples
P1	300-200-100-50-20-0	5
P2	150-100-50-20-0	4
P3	300-200-100-50-20-0	5
P4	300-200-100-50-20-0	5
P5	140-100-50-20-0	4
P6	300-200-100-50-20-0	5
P7	300-200-100-50-20-0	5

T2-1.3 Effects of ocean acidification on Arctic planktonic crustaceans

Nadjejda Espinel-Velasco (NPI), PI: Haakon Hop (NPI).

Aims
The main goal of the experiment 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 at two different temperatures (in situ and +3°).

Work onboard
Planktonic live specimens were collected with a WP3 net (1000 µm) from P4 for experimental use on board. *Calanus glacialis* females (60 individuals) were selected from the net haul for the measurements. 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. Two plates were used simultaneously for the measurements at in-situ temperature (one control and one with the treatments), while only one plate was used for the measurements at increased temperature (half plate was used for control water and half plate was used for treatment water). Each experiment consisted on exposing the organisms to a gradual decrease of seawater pH at the in-

situ temperature in P4. The pH decrease of 0.3 units was carried out every 12 hours, while continuously measuring the oxygen uptake. The experiment consisted of 5 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.

T2-2.5 Multi-stressors on key organisms: calorimetry of *Calanus glacialis*

Vanessa Pitusi (UNIS). PI: Janne Søreide (UNIS), Robynne Nowicki (UNIS).

Work onboard

Individual *Calanus* copepods were picked from 64 µm Bongo net samples at station P4 and P5 (Table 3). A net cast was taken at station P6 but did not yield sufficient organisms for analysis. At station P4 and P5, 4 g & 1.35 g of *Calanus glacialis* were picked, respectively. Copepods of all life stages were pooled for community analysis rather than single life stage picking. The samples were concentrated into a 50 mL Falcon tube and frozen at −80°C until analysis at UNIS. The samples will be used for calorimetry, which is the topic of Robynne Nowicki's PhD (UNIS). The samples will provide additional data points to the samples she collected on seasonal cruises Q1 and Q2 in 2021.

Table 3. Overview of samples collected for Calanus glacialis calorimetry.

Date	**Station**	**Gear Type**	**Sample depth (m)**	***Calanus* species**	**Weight (g)**
2021-07-18	P4	Bongo net 64 µm	310	*Calanus glacialis*	4 g
2021-07-19	P5	Bongo net 64 µm	140	*Calanus glacialis*	1.35 g

T2-3.1. Climate change and fisheries: Spatial environmental variables and genomics

Marius Filomeno Maurstad (UiO), Evelyn Strombom (UiO), PI: Sissel Jentoft (UiO).

Aims

The aim of this task is to investigate the roles of spatiotemporal population structure and possible local adaptations in three key fish species in the northern Barents Sea ecosystem: The Northeast Arctic population of the Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*) and polar cod (*Boreogadus saida*). If local adaptations are important for population dynamics and responses to climate change, it may be necessary to revisit the management of fisheries in order to maintain intact spatial and genetic structure. For this purpose, individual samples of these species will be collected at transect cruises in summer (2 years) and winter (1 year) for whole-genome sequencing. We will also include samples of the same species collected in associated projects at other locations, such as at their spawning grounds. From these data we aim to characterize the population sub-structure(s) for each of the species, as well as identify signatures of directional selection, for instance as a result of temperature adaptations. In addition to spatial structure, we will assess possible temporal structure, linked to seasonal partitioning of habitat use.

Figure 10. Sorting through the trawl catch. Photos: E. Jones.

During this cruise we have been collecting tissue samples of the Northeast Arctic cod, polar cod and capelin from the different process stations: P1, P2, P3, P3 vicinity, P5, and an extra trawl on the west side of Svalbard (Table 4; Fig. 10). At all stations except for P6, at least one demersal (Campelen) fish trawl was taken. During this cruise a modified Harstad trawl was used. This trawl made it possible to catch pelagic samples in areas with dense sea ice. The Northeast Arctic cod was observed at the first two stations P1, P2 and P3, and the extra trawl. Capelin was not caught in any good densities before P5, where we caught spawning ready males and females in the Campelen trawl. A combination of both the Campelen and modified Harstad trawl was done at some stations that were covered in sea ice to try to sample Polar cod from the whole water column.

For most sampled fish, a total of four tissue samples were taken, two for whole-genome DNA sequencing (aprox. 20x coverage), one for RNA sequencing, and one gut sample for metagenomic sequencing. Additionally, otoliths were collected for all fish sampled, except for capelin in order to determine age. Metadata was recorded for all fishes sampled, and includes the following parameters: fork length, total weight, sex, maturation stage and presence of ecto/endoparasites.

Table 4. Number of fish sampled at each of the stations during JC2-1. All trawls taken was demersal except P1 vicinity, which was a pelagic trawl.

Station/ Species	P1	P2	P3	P3 vicinity	P4	P5	Extra trawl, West Svalbard
Northeast Arctic cod	15	2			1		11
Capelin	11	24	1			54	10

Polar cod	25	15	25	11	40	55	15

Research Foci 3: The living Barents Sea

T3.1 and T3.4 Microbes: biodiversity, abundance, biomass, distribution and activity.

Oliver Müller (UiB), Hilde Stabell (UiB), Simon Kline (UiO), Luke Marsden (UNIS), Lucie Goraguer (NPI), PIs: Bente Edvardsen (UiO), Gunnar Bratbak (UiB).

Aims

The activities contribute to tasks T3-1 and T3-2 and links to T3-3 and T3-4.

Work onboard

Samples for microbial (viruses, prokaryotes and protists) community composition, abundance and activity were collected from three open water stations (P1, P2, P3) and four ice-covered stations, with varying ice concentrations (P4, P5, P6 and P7), see Table 5. A reduced sampling effort was conducted at P3. Pelagic samples were collected at all stations, while stations P5, P6 and P7 also included ice samples (ice-cores, under ice water, melt pond and brine samples). In addition, flow cytometry (FCM) samples were taken from the standard depths (FCM) and bacterial production (BP) samples, and Durapore filters for DNA extraction were taken from the upper 90 m depths (5, 10, 20, 30, 40, 50, 60, 90, and/or chl a max) at several NLEG stations (NLEG2, NLEG3, NLEG5, NLEG6, NLEG8, NLEG9, NLEG12, NLEG14, NLEG15, NLEG19, NLEG23). 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.

Several functional aspects of pelagic primary producers were studied during the cruise. At stations P1, P2, P3, P4, P5, P6 and P7, water was sampled from the chl a max (and surface sample at stations P1, P2 and P4) and spiked with radioactively labelled carbon in order to determine the carbon fixation rate (i.e. the primary production rate) of phototrophic organisms. This was done by incubating the water at different light intensities to study the photosynthetic response of the community to light intensity (P vs I curves).

Morphological analysis of phytoplankton diversity and isolation of cultures of Arctic microalgae. Samples were collected for the scanning electron microscopy (SEM) analysis of small phytoplankton and groups which are not well preserved in quantitative samples fixed in Lugol's solution. This includes primarily calcifying microalgae (coccolithophores) which are an important part of the Barents Sea phytoplankton. The samples for quantitative and qualitative SEM analysis were taken at each station at four depths which corresponded to depths sampled for molecular metabarcoding and metatranscriptomics.

A plankton net (mesh size 10 µm) was deployed at each station to obtain a concentrated phytoplankton vertical sample. The collected material was divided in three parts. One part was fixed in 2% formalin and one in 1% Lugol's for light microscopy to be used together as quantitative samples. Another part was fixed in 1% glutaraldehyde and these will be used for studying diversity of protists using scanning and transmission electron microscopy at UiO.

Sampling for protist and prokaryote community compositions (DNA metabarcoding) and activities (metatranscriptomics) was conducted as on previous cruises by Simon Kline (UiO) and Luke Marsden (UNIS). Samples for virus diversity and elemental analysis were taken at all process stations from chl a and bottom samples, and all standard depths respectively.

To calibrate the fluorescence sensor of the ships under way system additional water samples were taken by Lucie Goraguer (NPI) from the underway system for chl a measurements at stations P1 to P4: 4 m depth from the underway intake from the ship side and then P3 to P5: 8 m depth: from the dropkeel trunk (big tank at the bottom, not ideal because have a delay from the seawater that goes into the system but it is the best as the system is usually shutdown when sea ice floes present.)

Melt pond concentrated phytoplankton community through 20 um phytoplankton mesh size (sampled from melt pond 1 with 1 bucket filled with melt pond water).

Phytoplankton Net 20 um mesh size from 0 to 15 m under the ice at P5 and P7 and Phytoplankton mesh size 10 um from 0 to 5 m depth under the ice at P5, P6 and P7.

Protoozooplankton community samples took and fixed with Lugol with acid acetique 1 % solution. At P2, P3, P4, P5, P6, P7 at the standard depth (5, 10, 30, 60 and 90 m + Chlorophyll a max when present) and at the ice stations P5-ice: melt pond 1,2 and 3, UIW 0.5, 5 and 10m; P6 ice: Melt pond 1, UIW 0.5 and P7: meltpond 1 and UIW 0.5, 5 and 10m.

List of parameters sampled

Biodiversity
Genetic identification of community composition of protists and prokaryotes (Metabarcoding)
Genetic identification of (free) virus (Virus diversity)
Qualitative analyses of protists >10 µm from net hauls (Net)
Qualitative analyses of small protists for cultures and electron microscopy from water
Qualitative and quantitative analysis of plankton including coccolithophores by scanning electron microscopy (SEM)
Biodiversity of ice meiofauna (Barcoding)
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 (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 (producer's response to light intensity (P vs I curve))

Table 5: 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,
P1																			
	5											X							
	10	x						x	x	x	x	x	x	x	x				x
	20	x						x	x	X	x	x		x	x				x
	Chla max/35		x			x						x							
	30							x	x	x	x	x		x	x				
	40							x	x		x	x		x	x				
	50					x		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					
	bottom	x	x			x	X	x	x		x	x		x					
	0-50			x			x			X									
P2																			
	5											x							
	10	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		
	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					
	150											x							
	bottom	x	x			x	X	x	x		x	x		x					
	0-100			x			x			x									
P3																			
	5											x							
	10	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					
	Chla max/ 35					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					
	150											x							
	200	x					X	x	x		x	x		x					
	bottom	x				x	X	x	x		x	x		x					

	0-100			x			x			x									
P4																			
	5											x							
	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		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					
	bottom	x	x			x	X	x	x		x	x		x					
	0-100			x			x			x									
P5																			
	5											x							
	10	x					x	x	x	x	x	x	x	x	x	x			X
	Chla max /16		x			x						x							
	20	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				
	120					x		x	x		x	x		x					
	bottom	x	x			x	X	x	x		x	x		x					
	0-100			x			x			x									
P6																			
	5											x							
	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				
	Chla max /35		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					
	500							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																			
	5											x							
	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							
	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					
	500		x					x	x		x	x		x					
	750																		
	1000							x	x		x	x		x					
	1500								x		x	x		x					
	1750																		
	2000								x		x	x		x					
	2500							x	x		x	x		x					
	3000											x							
	bottom	x	x			x	X	x	x		x	x		x					
	0-100			x			x			x									

*Microscopy indicates phytoplankton community samples

T3-1.1. Characterize biological phytoplankton/ protist communities and seasonality in terms of biodiversity, abundance, biomass and distribution patterns

Simon Kline (UiO/ IBV), PI: Bente Edvardsen (UiO).

Aims

The main aim of our sampling during the 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. Our sampling also focused on Sea ice communities and we collected material from melt ponds, ice cores and under-ice water.

Work onboard: molecular analysis

For the molecular analysis of diversity (metabarcoding) and function (metatranscriptomics) of phytoplankton and protist communities along the transect. I took part in collection and filtration of the molecular samples as well as sampling and processing of ice-cores and sea water on ice. A complete list of which microbial parameters were collected at which depth and stations is presented elsewhere in the report. The molecular analysis was done with Luke Marsden (UNIS).

Work onboard: morphological analysis of phytoplankton diversity

Morphological analysis of phytoplankton diversity and isolation of cultures of Arctic microalgae. I also collected samples for the scanning electron microscopy (SEM) analysis of small phytoplankton and groups which are not well preserved in quantitative samples fixed in Lugol's solution. This includes primarily calcifying microalgae (coccolithophores) which are an important part of the Barents Sea phytoplankton. The samples for quantitative and qualitative SEM analysis were taken at each station at four depths which corresponded to depths sampled for molecular metabarcoding and metatranscriptomics.

A plankton net (mesh size 10µm) was deployed at each station to obtain a concentrated phytoplankton vertical sample. The collected material was divided in three parts. One part was fixed in 2% formalin and one in 1% Lugol's for light microscopy to be used together as quantitative samples. Another part was fixed in 1% glutaraldehyde and these will be used for studying diversity of protists using scanning and transmission electron microscopy at UiO.

At sea ice stations, water was sampled from 0.5 m below ice, a phytoplankton net haul (10µm) from 5 meters below the ice, a 0-10 cm ice core, and a phytoplankton net haul from melt ponds (10µm). For each parameter, a portion of the sample was fixed using formaldehyde, lugol and glutaraldehyde as mentioned above. Additionally, samples were prepared for SEM analysis as mentioned in the previous section.

T3-1.1; 2.1. Mesozooplankton taxonomy, abundance, biomass and genomics

Nadjejda Espinel Velasco (NPI), Vanessa Pitusi (UNIS), PI: Tove M. Gabrielsen (UNIS/UiA).

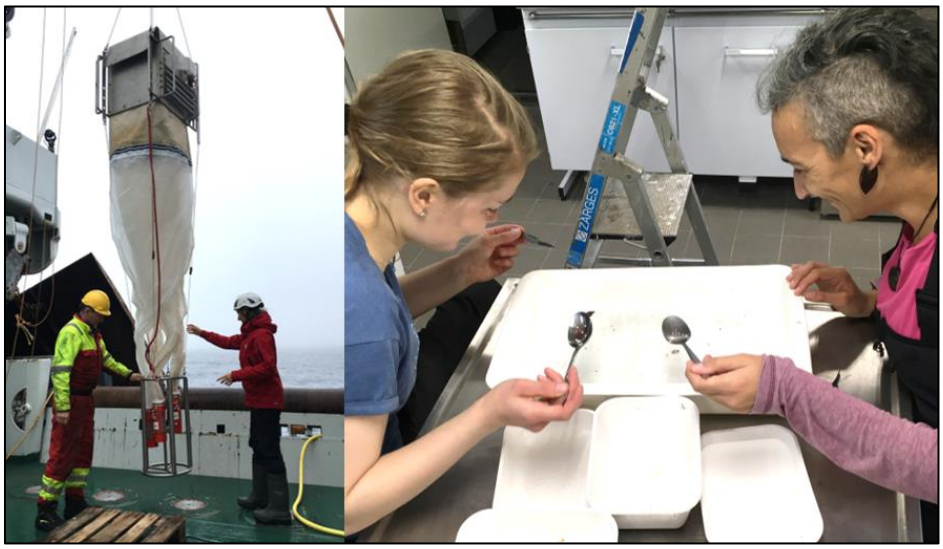

Figure 11. Zooplankton sampling with a multi net and sorting the sample. Photos: E. Jones.

Aims

The main objective of this sampling 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 expected to see a gradient in the of Atlantic and Arctic species composition in the water column. The data obtained during this cruise (JC2-1) is part of the seasonal investigation of zooplankton communities, complementing data collected in March 2021 (Q1), May 2021 (Q2), Aug 2019 (Q3) and December 2019 (Q4).

Work onboard

The sampling was carried out with Multinet Midi (HydroBios, opening: 0.25m^2, net length: 250 cm; Fig. 11) and Bongo nets (HydroBios, opening: 2 x 0.2827m^2, net lengths: 250 cm). Both nets were deployed with both 180 µm and 64 µm mesh size nets in order to be able to sample all size groups. The samples collected from these nets are referred to as “mesozooplankton” and “small mesozooplankton” respectively. Taxonomy and abundance were sampled at 5 standard depth intervals using the Multinet: bottom-200, 200-100, 100-50, 50-20 and 20-0 m. At the deep stations, the following intervals were sampled: 1000-600, 600-200, 200-50, 50-20 and 20-0 m. after collecting, all samples were preserved in 4 % formaldehyde free from acid.

Total biomass (dry weight) and metabarcoding samples were collected using Bongo nets deployed from the bottom to the surface and from 1000 m to the surface at the deep stations. Each Bongo net was 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. The biomass samples were dried and measured onboard. Genetic samples for metabarcoding were preserved in ice cold 96 % ethanol. The taxonomy samples, preserved in 4 % buffered formaldehyde, will be used to support the metabarcoding samples.

Gelatinous zooplankton was picked out from the samples collected with the MIK net at all stations. Pictures were taken of each taxa including all individuals. Individuals in good conditions were weighted, photographed and stored individually with ice cold 96 % ethanol.

Table 6: 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		P1, P2, P3, P4, P5, P6, P7	7
Mesozooplankton metabarcoding		P1, P2, P3, P4, P5, P6, P7	7
Mesozooplankton fatty acid (community)		P1, P2, P3, P4, P5, P6, P7	7
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.		P1, P2, P3, P4, P5, P6, P7	7
Small mesozooplankton fatty		P1, P2, P3, P4, P5, P6, P7	7
Gelatinous zooplankton	MIK net 1500 µm	P1, P2, P3, P4, P5, P6, P7	71 ind.

Table 7: 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-600-200-50-20-0m	0.5	0.5
Multinet 64 µm	Bot-200-100-50-20-0m	Bot-600-200-50-20-0m	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

*when lowering too 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 8. Overview of gelatinous zooplankton samples sampled from the MIK net.

Station	**Depth**	**Taxon**
P1	300-0 m	*Aglantha digitale, Berore Cucumis, Mertensia ovum, Sarsia princeps, Mitrocomella polydiademata & unidentified*

P2	170-0 m	*Sarsia princeps & Beroe cucumis*
P3	280-0 m	*Beroe sp., Mertensia ovum & Phytchogena lactea*
P4	310-0 m	*Beroe sp., Mertensia ovum* & *Sarsia sp.*
P5	150-0 m	*Aglanta digitale, Beroe cucumis* & *Beroe* spp., *Mertensia ovum, Sarsia sp.* & *Aeginopsis lautontii*
P6	880-0 m	*Aglantha digitale & Mertensia ovum*
P7	1000-0 m	*Aglantha digitale, Beroe* spp. & Mertensia sp.

T3-1.1; 2.1; 2.2; 4.2; 4.4. Characterize biological mesozooplankton communities and seasonality in terms of biodiversity, abundance, biomass and distribution patterns (1.1), secondary production (2.1), trophic ecology (4.2) and sympagic-pelagic-benthic coupling (4.4)

Nadjejda Espinel Velasco (NPI), Vanessa Pitusi (UNIS) PI: Janne Søreide.

Aims

The RF3 work package aims to describe zooplankton dynamics over season (summer, winter, and spring) and space (Atlantic, shelf, and Arctic). A further aim was to estimate grazing, egg production and hatching success of dominant zooplankton species. Experiments on mesozooplankton were conducted at three process stations: P1, P4, and P7. In addition, samples of zooplankton biomass and metabarcoding were taken at six stations: P1, P2, P4, P5, P6, and P7. Three different experiments were planned prior to the cruise: (i) an experiment to estimate the grazing on phytoplankton and microzooplankton by the most dominant zooplankton, (ii) experiments to estimate the egg production and the hatching of eggs *from Calanus glacialis, Calanus finmarchicus,* and the egg production of *Pseudocalanus sp*., (iii) an experiment to estimate respiration of the most dominant zooplankton species, and link the respiration to lipid storage and carbon nitrogen ration (C:N) of the animals.

Work onboard

Biomass and metagenomics samples were taken at the six stations. The grazing experiments were conducted at the three stations, samples of chlorophyll-a, particulate organic carbon, and community composition (phytoplankton and microzooplankton) were taken to be analyzed later on. Egg production and hatching were estimated on board the ship. However, very few animals produced eggs and none hatched. Experiments on respiration were unsuccessful because the Loligo sensor could not be calibrated. However, measurements of lipid storage and C:N ratio were taken.

T3-1.1; 2.1. Macrozooplankton

Nadjejda Espinel Velasco (NPI), Vanessa Pitusi (UNIS), Anette Wold (NPI), PIs: Bodil Bluhm (UiT), Tove M. Gabrielsen (UNIS/UiA).

Aims

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.

Work onboard

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 (Table 9). 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 9. Overview of macrozooplankton samples from MIK net.

Station	Depth	Main taxa in the sample
P1	300-0m	A lot of gelatinous zooplankton, *Calanus* spp.
P2	170-0m	*Chaetognat worms, amphipods, appendicularians, Clione limacine*, *Calanus* spp., krill, *Themisto sp.*
P3	280-0m	*Calanus* spp., *Sagitta* sp., *amphipods, mysids, fish larvae, Aglantha digitale*, *Phytchogena lactea*, *Beroe cucumis* & *Sarsia sp.*
P4	310-0m	*Chaetognat worms, Clione limacine*, *Calanus* spp., *Mertensia ovum*, *Themisto* spp.
P5	150-0m	*Calanus* spp., *Clione limacine*, *Themisto sp., krill, appendicularians*
P6	850-0m	*Calanus* spp., *Aglantha digitale*, *Sagitta* sp., *Thyssanoessa* sp. & *Themisto* spp.
P7	1000-0m	*Calanus* spp., *Sagitta* sp., *Themisto* sp., krill, *Gammarus* sp.

Sea ice work

Elizabeth Jones (IMR), Sigrid Lind (NPI), Audun Gjerland (NPI).

Sea ice work was organized to optimize the summer conditions and sampling efficiency, and the entire science party was involved. Firstly, ice floe reconnaissance was carried out by the officer on watch, the cruise leaders and the sea ice safety responsible to identify a suitable looking ice floe. Then the floe was checked for thickness by the sea ice safety responsible, after which a snow and ice thickness survey was carried out with a team of two people. The main sea ice work was planned in two phases: (1) two ice coring teams (physics-chemistry and biology) and 1 team making a water hole for under-ice sampling; (2) 1 melt pond team (Fig. 12). These teams were supported by 1 polar bear guard on the ice and a series of bridge watch, composed of 3 people looking out for polar bears and also reporting changes in sea ice and weather conditions. In addition, 1-2 people were responsible for handling the biological ice cores when onboard in order to prepare for appropriate melting prior to sub-sampling and analysis. The cruise leaders coordinated the sea ice work with the crew and safety personnel, and the sea ice safety responsible team checked the ice floe (thickness, condition) prior to the sea ice work.

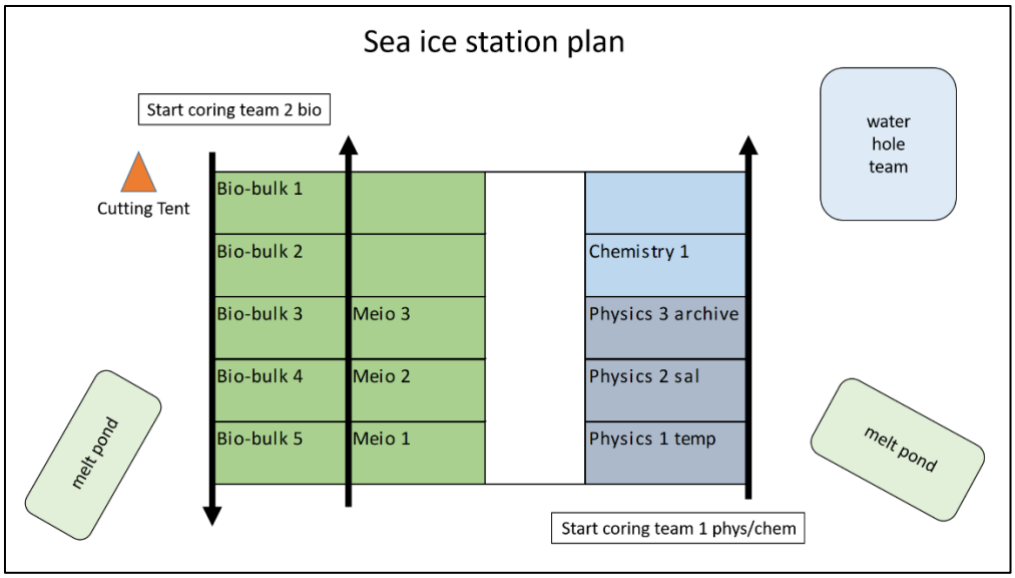

Figure 12. Sea-ice stations overview sampling plan.

Sea ice

Ice cores were collected within a 3 x 3 m grid by two teams of 2–3 people each, equipped with 9 cm diameter Kovacs ice corers (Fig. 13). The physics-chemistry team were responsible for the temperature, salinity, archive and chemistry (including carbonate chemistry, inorganic nutrients, stable oxygen isotopes) ice cores. The biology team were responsible for the bio-bulk, meiofauna and protist ice cores, which were sectioned every 10 cm (additionally, the lowest 10 cm of the bio-bulk and meiofauna cores were cut into 0–3 and 3–10 cm sections). Both the bio-bulk and meiofauna cores were cut under low light exposure inside a tent and sections stored in round plastic containers protected from the light.

For all cores that were taken, snow depths, ice thickness, freeboard and core length were measured and recorded. Coring work took approx. 2–3 hours at the 3 ice stations (P5, P6, P7). At all times 1 polar bear guard was on the ice next to the teams at work. In addition, there were three bridge watch covering the 360° view on the bridge. Ice core sections from bio-bulk and meiofauna cores were mixed with sterile filtered sea water (0.22 µm) in a ratio of 100 ml per one cm of core and slowly thawed in the dark in a moderately cool room (ca. 10°C, fish lab).

Under-ice water

In parallel to the ice-coring work, a team of 2 people led by Vanessa Pitusi (UNIS) drilled a hole in the ice with an auger that was large enough to deploy a 5 L Niskin bottle to collect under-ice water at stations P5, P6 and P7 (Fig. 13). Water samples were collected from 0.5-m, 5-m and 10-m with a hand-held 5 L Niskin bottle. At P6, water was only collected from 0 m (an extra sample for UiB) and 0.5-m, as due to strong current the Niskin bottle would not close. Most water was collected at 0.5-m for numerous chemical and biological parameters. Additionally, a hand-held CTD was lowered to 50-m depth to capture the upper surface layer that the CTD on R/V *Kronprins Haakon* is not able to capture. In addition, at each ice station, phytoplankton nets were used to sample the phytoplankton community in the upper 5 m underneath the ice using both a 10 µm (UiO) and 20 µm (NPI) net.

Melt ponds

Following the ice coring, a third team of 3–4 people collected water and accompanying measurements from melt ponds in the vicinity using a bucket and series of sampling bottles for biological and chemical variables (Fig. 13). Three separate melt ponds were sampled at all ice stations. All sensitive water samples were protected from the light by covering the canisters using black plastic bags.

Figure 13. Sea-ice stations teams sampling melt ponds, drilling holes in the ice and collecting and processing ice cores. Photos: E. Jones.

Table 10. Overview of ice cores collected, under-ice water and melt ponds sampled for the different parameters at the sea ice stations.

	P5 ice	P6 ice	P7 ice
Ice-cores			
Physics 1 (temperature)	1	1	1
Physics 2 (salinity)	1	1	1
Physics 3 (archive)	1	1	1
Chemistry (carbonate chemistry, nutrients, $\delta^{18}O$)	1	1	1
Bio bulk	5	5	5
Meiofauna/algae	3	3	3
Protists	1	1	1
Under-ice water (0.5 m / 5 m depth)			
Chemistry (carbonate chemistry, nutrients, $\delta^{18}O$)	x	x	x
Bio bulk	x	x	x

primary production	x	x	x
phytoplankton taxonomy	x	x	x
XRF	x	x	x
SEM	x	x	x
Phytoplankton net (0-5 m)	x	x	x
Melt ponds (3 ponds)			
Chemistry (carbonate chemistry, nutrients, $\delta^{18}O$)	x	x	x
Bio bulk	x	x	x
Primary production	x	x	x
Phytoplankton taxonomy	x	x	x
XRF	x	x	x
SEM	x	x	x

Physical sea ice conditions

Sigrid Lind (NPI), PI: Sebastian Gerland (NPI).

For each core, snow depth, core length, ice thickness and freeboard were measured. Three cores were taken for physical properties: 1) temperature measured on the ice, 2) salinity, (3) archive (core packed for later analysis). The temperature measurements were made immediately after the core was drilled. The salinity core was sectioned into 0-5, 5-10 cm sections and stored in melt cups for melting onboard. The archive cores were bagged whole in plastic ice-core sleeves and taken back onboard to be kept frozen for analysis in home laboratories.

T2-1.1 Carbonate chemistry, inorganic nutrients, stable oxygen isotopes in sea ice

Helene Hodal Lødemel (IMR), Elizabeth Jones (IMR), PIs: Melissa Chierici (IMR), Agneta Fransson (NPI).

Three sea ice stations were sampled (P5, P6, P7) for ice cores, under-ice water and melt ponds to investigate carbonate and nutrient chemistry in the sea ice environment (snow, ice, melt ponds, under-ice water). Samples were taken for carbonate chemistry (total alkalinity (AT), total inorganic carbon (DIC)), inorganic nutrients and stable oxygen isotopes of seawater ($\delta^{18}O$).

A total of 3 ice cores with a length from 103 cm to 167 cm 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 approx. 0.5 m below the ice surface. Ice cores were frozen whole for post cruise processing where they were sliced into 10-cm sections from the top (snow-air interface) to the base (ice-seawater interface) and were melted in airtight bags at laboratory temperature and subsampled for carbonate chemistry, nutrients and $\delta^{18}O$. Samples were preserved and stored for analysis as described *Nansen Legacy Sampling Protocol version 7*.

T3-1; T3-4 Sea ice microbes: biodiversity, abundance, biomass, distribution and activity

Oliver Müller (UiB), Hilde Stabell (UiB), Luke Marsden (UNIS), Lucie Goraguer (NPI), Simon Kline (UiO), PIs: Bodil Bluhm (UiT), Gunnar Bratbak (UiB).

Sea ice work at stations P5, P6, and P7 included the collection of 5 bio bulk (DNA, chl a, POC, FCM, BP, stable isotopes) replicate cores (bottom 0-3, 3-10,10-20, 20-30, 30-50, 50-70, 70-90, 90-110, 110 cm-top), 3 sea ice cores (bottom 0-3, 3-10,10-20 and 20-30 cm sections) for the study of meiofauna (sympagic meiofauna) abundance and biodiversity and one protist taxonomy core (bottom 0-10 cm), see Table 11. Sea ice sections were melted after addition of filtered (0.22 µm) sea water (100 ml per cm ice) at cold and dark conditions, within 24–48 hours.

Additionally, under-ice water (UIW) was sampled, and three melt ponds were sampled at each ice station (salinity in melt ponds ranged from 0-2). For UIW sampling, samples were collected from 0.5 m below ice, a phytoplankton net haul (10µm) from 5 meters below the ice, a 0-10 cm ice core, and a phytoplankton net haul from melt ponds (10µm). For each parameter, a portion of the sample was fixed using formaldehyde, Lugol and glutaraldehyde as mentioned above. Additionally, samples were prepared for SEM analysis as mentioned in the previous section. At ice-stations (P5, P6, P7) additional samples for metabarcoding were taken from under-ice water (UIW, 0.5 m), and from ice-core sections (bio bulk cores).

For a set of sub-parameters (FCM, BP, SEM, DNA) brine samples were taken by coring down to ca. 75 cm waiting until the core hole to fill and retrieving the water with 1L bottles. The hole filled within 3-4 seconds and was a mix of brine and fresh melt water indicated by salinities between 1.3 and 7.5 (1.3 [P5], 7.5 [P6], 2.4 [P7]).

Table 11. Sea ice sampling for microbes from sea ice cores (see text 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,
P5ice																			
	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									
	UIW 0.5	x			x	x	x	x	x	x	x	x		x					x
	UIW 0-5			X		x	X			x		x							
	Melt pond 1					x						x							
	Melt pond 2					x						x							

	Melt pond 3					x						x							
	brine					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					
	UIW 0.5	x			x	x	X	x	x	x		x		x					x
	UIW 0-5			X			X			x									
	Melt pond 1					x						x							
	Melt pond 2					x						x							
	Melt pond 3					x						x							
	brine											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									
	UIW 0.5	x				x	X	x	x	x	x	x		x					x
	UIW 5			X		x	X			x		x							
	Melt pond 1					x						x							
	Melt pond 2											x							
	Melt pond 3											x							
	brine					x						x							

*Microscopy indicates phytoplankton community samples.

List of parameters sampled:

Biodiversity
Genetic identification of community composition of protists and prokaryotes (Metabarcoding)
Genetic identification of (free) virus (Virus diversity)
Qualitative analyses of protists >10 µm from net hauls (Net)
Qualitative analyses of small protists for cultures and electron microscopy from water
Qualitative and quantitative analysis of plankton including coccolithophores by scanning electron microscopy (SEM)

Biodiversity of ice meiofauna (Barcoding)
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 (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 (producer's response to light intensity (P vs I curve))

T3-1; T3-4 Sea ice microbes: meiofauna and protists

Vanessa Pitusi (UNIS); PI: Philipp Assmy (NPI)

At P5, P6 and P7, three sea ice cores were collected for sea ice meiofauna and protists. The lower 30-cm were collected by cutting the core in the following sections – 0-3, 3-10, 10-20 & 20-30-cm. After sampling, 100-mL of sterile 0.22-µm filtered seawater was added to the cores per 1-cm. They were kept in the dark and at +4°C until melted. Once completely melted, the sample was mixed until homogenous and the total volume was measured. A 100-mL sub-sample was taken for protist analysis. This sample was fixed with 0.4-mL of GLA and a final concentration of 2 % formalin; the samples were stored dark and cool until taxonomic analysis at IOPAN in Poland. The rest of the sample was concentrated over a 20-µm sieve and transferred to 100-mL sampling bottles. Two samples were fixed with formaldehyde (final concentration 4%) and one was fixed with ice cold 96 % ethanol and kept at −20°C.

T3-1.3 Stable isotopes

Vanessa Pitusi (UNIS), PI: Philipp Assmy (NPI)

Stable isotopes will be used to study coupling/de-coupling of sympagic and pelagic primary and secondary producers. Stable isotope sub-samples were taken from the bio bulk core sections of 0-3 and 3-10-cm of ice cores at the ice stations P5, P6 and P7 (Table 12). Samples were filtered on pre-combusted filters and transferred into an aluminium pocket before freezing at −80°C.

Table 12. Overview of ice volume filtered for stable isotopes from bio bulk cores.

Station	Gear Type	Ice core depth (cm)	Volume filtered (mL)
P5	KOVACS ice corer	0-3	500
P5	KOVACS ice corer	3-10	1000
P6	KOVACS ice corer	0-3	450
P6	KOVACS ice corer	3-10	1100
P7	KOVACS ice corer	0-3	400

P7	KOVACS ice corer	3-10	1000

Logistics

Transport of equipment and samples

The logistic team of the Nansen Legacy project, Håvard Hansen and Simon Bjørvig, provided a guideline well ahead of the first cruise with information and deadlines for sending equipment to cruises, and for return of equipment, cooled samples (+4°C) and frozen samples (–20°C and –80°C). Pre-arranged transportation helps on both efficiency and costs prior to and after each cruise.

Equipment was sent to Tromsø, packed in a container, and shipped to Longyearbyen with Bring. Equipment stored in Longyearbyen after the seasonal Q2 cruise (May 2021) were taken onboard along with the container. Loading the ship in Longyearbyen went smooth and efficient helped by the Nansen Legacy logistics and the crew. Cruise participants carried the boxes to the designated laboratories. Lifting the container from the storage at deck 1 to deck 3 during unpacking increased the efficiency considerable as use of the elevator from deck 1 and 2 is a slow process.

Shipping of samples that required cooled or frozen transport was ordered in advance, including dry ice for transport of frozen samples (–80°C). To be picked up at arrival in Longyearbyen.

All equipment unloaded in Longyearbyen is sent to Tromsø by Nordbjørn/ Bring for use on Arctic Basin (JC2-2) cruise.

On board communication

Based on the experience from previous cruises, a key task was to address challenges in keeping people updated on ongoing and planned activities, and to keep the station activity plan updated with respect to timing and progress. The vessel is large and the distance from the instrument room at deck 7 to deck 3 is long.

- Cruise leader and co-lead had 8 and 4 hrs shifts to always be present, and to meet often enough to discuss program and respond to any issues regarding practical or overarching character. They planned the overall timing of cruise activities, station work, posted programs and adjusted activities when needed, and had close communication with the bridge, instrument personnel, crew and scientists.
- Station programs were posted and available on all screens in due time, updated continuously, and facilitated good preparations from crew and scientists, and efficient sampling on each station.
- A radio was provided from the vessel and used by the cruise leader on duty.
- Daily meetings were held after dinner for short science updates of ongoing work from scientists and cruise leaders, and to share practical information regarding science work, social life and routines onboard.

Station programs

A station program was prepared in the Excel file "Plan and status" and updated continuously (Table 13). This program was available on Info channel 1 on the TV screens in all common rooms, on the bridge, labs and cabins. Jan Vidar (instrument chief) had made another small script for automated posting, and Luke Marsden (Nansen Legacy/ UNIS/SIOS) adjusted a small script he had made in February on how the information was presented on the screen. Activities were marked grey when finished, or red if cancelled or postponed to a later time slot in the program due to technical problems. Green activities were ongoing and yellow activities had reached planned starting times. The availability of plans ~24 hrs ahead and regular updates, resulted in efficient sampling and work during the cruise, as both crew and scientists could plan and prepare for sampling activities, handling of sampling and rest. Helping hands were also provided from those knowing they had some available time in the program. The ability to plan the work was well received on the bridge, among the crew and the scientists.

Table 13. Example from station program set up, posted prior to each transit and station work, and updated with status and Ship log ID.

Date	Day	Time	Status	Station	Activity	Personnel	Comment	Ship sampl. ID	Duration (hrs)
20 July	Tuesday	12:30	c	P5 Ice	Sea ice work	Ice core teams, under-ice water team, polar bear guard and watch		61	4:00
20 July	Tuesday	13:30	c	P5 Ice	CTD	Instrument	Parallel to under ice CTD		11:00

The overarching structure of the station programs was planned to get experiments and incubation work started, as they needed time to set up (sorting and preparations) and/ or deployment time (PP and sediment traps) during the station. Water column work was carried out first, and benthic sampling "contaminating" the water column, started only after all pelagic samples including vertical flux were done.

Water budgets

Water budgets were planned in advance to optimize the utilization of the 24 Niskin bottles (10 L volume) on the CTD rosette (Table 14). Parameters were distributed on three different CTD casts to optimize co-sampling for related parameters, and timely sampling for those needing surface water close to noon at each P station. On deep water stations (> 3000 m), all deep-water requests were given priority on two CTD casts to avoid repeated deployment of the CTD to the sea floor. Excel sheets with water budgets for the NLEG and P station CTD sampling programs are available.

Table 14. Example water budget delivered to the instrument control room prior to each CTD deployment where water samples were requested.

CTD	Parameter	Vol (L)	Depth (m)	5	10	20	30	40	50	60	90	120	150	BOTTOM	CHLA MAX
P2			**190 m**												
Noon	metatranscriptomics	35,0	Noon	35											
Noon	P vs I curves	1,0	Noon												1
Noon	Virus-diversity	40,0	Noon											40	40
Std	Carbonate chemistry, dissolved oxygen, nutrients, oxygen isotopes	0,9	Std 1	1	1	1	1	1	1	1	1	1	1	1	1
Std	Chl a	2,0	Std 1	2	2	2	2	2	2	2	2	2	2	2	2
Std	POC/PON	3,0	Std 1	3	3	3	3	3	3	3	3	3	3	3	3
Std	Phytoplankton (ice algae) taxonomy	0,3	Std 1	0,3	0,3		0,3			0,3	0,3				0,3
Std	CDOM	0,2	Std 1	0,2	0,2	0,2	0,2		0,2		0,2			0,2	0,2
Std	Bacterial Production (BP)Flow cytometry (FCM)	0,1	Std 1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Std	SEM	0,5	Std 1									1		1	1
Std	XRF	5,0	Std 1	5	5	5	5	5	5	5	5	5	5	5	5
Std	metabarcoding incl bacteria	25,0	Std 2	25										25	25
Std	Coccolithophore diversity (same as metabarc.)	1,0	Std 2	1										1	1

Sample and data management

Luke Marsden (UNIS)

Routines for labelling and logging of samples and metadata for Nansen Legacy were developed prior to and established during the AeN Joint Cruise 1-2 of 2018 and built upon thereafter. The essential part of this system is that all samples and datasets are labelled with a UUID, and all information about each sample is logged in an excel sheet containing all relevant metadata and standardized parameters. The UUIDs are printed on stickers that can be attached to the samples. The stickers are available in different sizes. Two label printers were set up with a virtual server on the network onboard, so that they could be accessed from both stationary and personal computers. The excel sheet used for logging of sample information is generated using an excel template generator which was made available on the same virtual server along with an excel file checker, UUID generator and relevant documentation (the labelling manual, sampling protocol v4, and lists over the gear and sample types used in the project).

Universally unique IDs (UUIDs) for the individual gear used were assigned. Metadata about the gear cast was harvested semi-automatically from the cruise logger (Toktlogger v.1.1.2). Nansen Legacy and IMR used the same UUIDs for each activity. Additional relevant metadata was added (e.g. sample depths, station names, sampling protocols). This information was combined in an Excel file and shared in the cruise folder so that the scientists could grab the Parent IDs for their samples and also did not individually have to acquire metadata about the gear casts. Around 140 gear casts were registered (Appendix 1), and almost 7000 entries were uploaded to SIOS from the cruise. Sample and metadata information are accessible and searchable through the SIOS webpage (https://sios-svalbard.org/aen/tools). In addition to logging information about collected samples, information about planned datasets based on data collected from the cruise was collected (Appendix 3).

Communication and outreach

The locations and activities during research cruises are well suited to visualize the Arctic environment as well as the research activities in the project. Pictures and movies of work (under-ice water, time lapse videos etc.) provided by students, researchers and crew can be used in a project context as illustrations and science communications and outreach of different kinds (Fig. 14).

Figure 14. Stories from the sea ice. Photos: S Lind.

Posts about science and life onboard were made to Instagram and Twitter before, during and after the cruise by the Cruise Leader. Blog texts from the cruise activities were produced during the cruise, and by the end of the cruise, 3 were published on Forskning.no (Appendix 2).

References

Årthun, M., Eldevik, T., Smedsrud, L. H., Skagseth, Ø., & Ingvaldsen, R. B. (2012). Quantifying the influence of Atlantic heat on Barents Sea ice variability and retreat. *Journal of Climate*, *25*(13), 4736-4743.
https://journals.ametsoc.org/view/journals/clim/25/13/jcli-d-11-00466.1.xml?tab_body=pdf

Polyakov, I. V., Pnyushkov, A. V., Alkire, M. B., Ashik, I. M., Baumann, T. M., Carmack, E. C., ... & Yulin, A. (2017). Greater role for Atlantic inflows on sea-ice loss in the Eurasian Basin of the Arctic Ocean. *Science*, *356*(6335), 285-291. https://www.science.org/doi/abs/10.1126/science.aai8204

Fors, A. S., Doulgeris, A. P., Renner, A. H., Brekke, C., & Gerland, S. (2015, July). On the relation between polarimetric synthetic aperture radar (SAR) features and sea ice melt pond fraction. In *2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)* (pp. 3438-3441). IEEE.

Lind, S., Ingvaldsen, R. B., & Furevik, T. (2018). Arctic warming hotspot in the northern Barents Sea linked to declining sea-ice import. *Nature climate change*, *8*(7), 634-639. https://www.nature.com/articles/s41558-018-0205-y?fbclid=IwAR2kcUvLPw94dWJ1m6V22dkUaav6MhO-MwTpDLXQO2E2Kg3ijK7wf2pI25g

Randelhoff, A., Fer, I., Sundfjord, A., Tremblay, J. É., & Reigstad, M. (2016). Vertical fluxes of nitrate in the seasonal nitracline of the Atlantic sector of the Arctic Ocean. *Journal of Geophysical Research: Oceans*, *121*(7), 5282-5295. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016JC011779

Lind, S., Ingvaldsen, R. B., & Furevik, T. (2016). Arctic layer salinity controls heat loss from deep Atlantic layer in seasonally ice-covered areas of the Barents Sea. *Geophysical Research Letters*, *43*(10), 5233-5242. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL068421

Appendix 1: Tables

Table A1. Full station list with locations and sampling gear (modified from cruise log)

Station Name	Date & Time	Latitude	Longitude	Local station ID	PI	Gear
ISG/SVR1	2021-07-12T19:01:37.358Z	78.1282	14.0033	288	Janne Søreide	CTD w/bottles
P1 (NLEG01)	2021-07-14T06:51:43.165Z	76.0078	31.1303	53	Bodil Bluhm	Campelen trawl
P1 (NLEG01)	2021-07-14T08:15:29.72Z	76.0000	31.2198	289	Elizabeth Jones	CTD w/bottles
P1 (NLEG01)	2021-07-14T09:01:01.478Z	76.0000	31.2198	301	Philipp Assmy	Phytoplankton net 10 um
P1 (NLEG01)	2021-07-14T11:12:05.71Z	76.0000	31.2203	290	Elizabeth Jones	CTD w/bottles
P1 (NLEG01)	2021-07-14T12:02:30.403Z	76.0000	31.2204	302	Anette Wold	Multinet 64 um
P1 (NLEG01)	2021-07-14T12:44:26.595Z	76.0000	31.2197	303	Janne Søreide; Kim Præbel	Bongonet 64 um
P1 (NLEG01)	2021-07-14T13:03:25.528Z	76.0000	31.2195	304	Anette Wold	Multinet 64 um
P1 (NLEG01)	2021-07-14T13:31:00.96Z	76.0000	31.2192	305	Janne Søreide; Kim Præbel	Bongonet 180 um
P1 (NLEG01)	2021-07-14T14:12:57.875Z	76.0000	31.2200	306	Espen Bagoien	MIK-net 1500 um
P1 (NLEG01)	2021-07-14T17:25:39.824Z	76.0000	31.2195	307/308	Anette Wold	Multinet 64 um
P1 (NLEG01)	2021-07-14T18:52:01.345Z	76.0000	31.2196	309	Janne Søreide; Kim Præbel	Bongonet 64 um
P1 (NLEG01)	2021-07-14T19:34:46.26Z	76.0000	31.2196	311	Janne Søreide; Kim Præbel	Bongonet 64 um
P1 (NLEG01)	2021-07-14T19:53:49.483Z	76.0000	31.2196	291	Elizabeth Jones	CTD w/bottles
P1 (NLEG01)	2021-07-14T20:16:43.953Z	76.0000	31.2196	312	Anette Wold	Multinet 180 um
NLEG02	2021-07-14T23:57:31.2Z	76.5000	31.2200	292	Elizabeth Jones	CTD w/bottles
NLEG02_1	2021-07-15T02:01:07.38Z	76.5960	31.7569	293	Sigrid Lind	CTD
NLEG02_2	2021-07-15T03:34:17.278Z	76.6932	32.3037	294	Sigrid Lind	CTD

NLEG02_3	2021-07-15T04:44:22.191Z	76.7646	32.6173	295	Sigrid Lind	CTD
NLEG02_4	2021-07-15T05:54:39.602Z	76.8123	32.8982	296	Sigrid Lind	CTD
NLEG02_5	2021-07-15T07:24:16.667Z	76.9147	33.5165	297	Sigrid Lind	CTD
NLEG03	2021-07-15T08:42:59.422Z	77.0003	34.0023	298	Elizabeth Jones	CTD w/bottles
P2 (NLEG04)	2021-07-15T12:29:37.163Z	77.5000	34.0000	299	Elizabeth Jones	CTD w/bottles
P2 (NLEG04)	2021-07-15T12:57:58.079Z	77.5001	34.0002	313	Anette Wold	Multinet 64 um
P2 (NLEG04)	2021-07-15T13:32:39.35Z	77.5000	34.0000	314	Anette Wold	Multinet 64 um
P2 (NLEG04)	2021-07-15T13:32:43.201Z	77.5000	34.0000	315	Philipp Assmy	Phytoplankton net 10 um
P2 (NLEG04)	2021-07-15T15:15:27.902Z	77.5509	33.7973	54	Bodil Bluhm	Campelen trawl
P2 (NLEG04)	2021-07-15T17:09:43.375Z	77.4999	33.9995	300	Elizabeth Jones	CTD w/bottles
P2 (NLEG04)	2021-07-15T18:10:42.722Z	77.4999	33.9995	316	Janne Søreide; Kim Præbel	Bongonet 64 um
P2 (NLEG04)	2021-07-15T18:29:56.526Z	77.4999	33.9995	317	Janne Søreide; Kim Præbel	Bongonet 180 um
P2 (NLEG04)	2021-07-15T18:44:03.088Z	77.4999	33.9995	318	Anette Wold	Multinet 64 um
P2 (NLEG04)	2021-07-15T19:13:38.795Z	77.4999	33.9995	319	Anette Wold	Multinet 180 um
P2 (NLEG04)	2021-07-16T04:15:08.612Z	77.5015	33.7701	55	Bodil Bluhm	Campelen trawl
P2 (NLEG04)	2021-07-16T06:16:08.616Z	77.5000	33.9999	320	Espen Bagoien	MIK-net 1500 um
P2 (NLEG04)	2021-07-16T07:16:35.384Z	77.5016	34.0751	301	Sigrid Lind	CTD
P2 (NLEG04)	2021-07-16T10:30:21.551Z	77.5001	33.9999	302	Elizabeth Jones	CTD w/bottles
NLEG05	2021-07-16T14:30:30.068Z	77.9201	34.1141	56	Sissel Jentoft	Harstad trawl
NLEG05	2021-07-16T15:19:20.18Z	77.9032	34.1677	57	Sissel Jentoft	Harstad trawl
NLEG05	2021-07-16T17:20:48.085Z	78.0000	33.9999	303	Elizabeth Jones	CTD w/bottles
NLEG05_01	2021-07-16T20:32:31.334Z	78.4000	34.0000	304	Sigrid Lind	CTD
NLEG05_02	2021-07-16T21:16:31.734Z	78.4505	33.9966	305	Sigrid Lind	CTD
NLEG06	2021-07-16T22:05:36.467Z	78.4994	33.9961	306	Elizabeth Jones	CTD w/bottles

NLEG06_01	2021-07-16T23:08:10.575Z	78.5462	33.9981	307	Sigrid Lind	CTD
NLEG06_02	2021-07-16T23:55:41.324Z	78.5935	33.9896	308	Sigrid Lind	CTD
P3 (NLEG07)	2021-07-17T01:28:52.016Z	78.7500	34.0004	309	Sigrid Lind	CTD
P3 (NLEG07)	2021-07-17T04:19:21.566Z	78.6831	34.0593	58	Bodil Bluhm	Campelen trawl
P3 (NLEG07)	2021-07-17T05:59:01.776Z	78.7501	34.0008	310	Elizabeth Jones	CTD w/bottles
P3 (NLEG07)	2021-07-17T06:42:31.264Z	78.7501	34.0008	321	Philipp Assmy	Phytoplankton net 10 um
P3 (NLEG07)	2021-07-17T07:05:10.706Z	78.7501	34.0008	322	Janne Søreide; Kim Præbel	Bongonet 180 um
P3 (NLEG07)	2021-07-17T07:07:19.355Z	78.7501	34.0008	323	Anette Wold	Multinet 64 um
P3 (NLEG07)	2021-07-17T07:34:40.138Z	78.7501	34.0008	324	Janne Søreide; Kim Præbel	Bongonet 64 um
P3 (NLEG07)	2021-07-17T07:48:45.959Z	78.7501	34.0008	325	Anette Wold	Multinet 64 um
P3 (NLEG07)	2021-07-17T08:58:36.766Z	78.7501	34.0009	326	Anette Wold	Multinet 180 um
P3 (NLEG07)	2021-07-17T10:34:32.772Z	78.7501	34.0008	311	Elizabeth Jones	CTD w/bottles
P3 (NLEG07)	2021-07-17T11:09:37.774Z	78.7501	34.0007	327	Espen Bagoien	MIK-net 1500 um
P3 (NLEG07)	2021-07-17T11:36:46.984Z	78.7500	34.0001	312	Elizabeth Jones	CTD w/bottles
P3 (NLEG07)	2021-07-17T12:44:42.607Z	78.7500	34.0001	313	Oliver Muller	CTD w/bottles
NLEG07_01	2021-07-17T15:13:11.511Z	78.8767	33.9935	314	Sigrid Lind	CTD
NLEG08	2021-07-17T16:40:18.772Z	79.0001	34.0002	315	Elizabeth Jones	CTD w/bottles
NLEG08_1	2021-07-17T18:31:31.436Z	79.1169	34.0309	316	Sigrid Lind	CTD
NLEG09	2021-07-17T20:04:25.603Z	79.1408	34.1615	59	Sissel Jentoft	Harstad trawl
NLEG09	2021-07-17T22:17:59.216Z	79.2485	34.0042	317	Elizabeth Jones	CTD w/bottles
NLEG09_1	2021-07-18T00:26:35.051Z	79.3753	34.0090	318	Sigrid Lind	CTD
NLEG10	2021-07-18T02:16:20.184Z	79.5007	33.9962	319	Elizabeth Jones	CTD w/bottles
NLEG10_1	2021-07-18T04:16:14.715Z	79.6252	33.9966	320	Sigrid Lind	CTD
P4 (NLEG11)	2021-07-18T06:04:41.822Z	79.7120	33.9983	60	Sissel Jentoft	Harstad trawl

P4 (NLEG11)	2021-07-18T08:50:42.806Z	79.7500	34.0000	321	Elizabeth Jones	CTD w/bottles
P4 (NLEG11)	2021-07-18T09:31:02.083Z	79.7500	34.0000	328	Philipp Assmy	Phytoplankton net 10 um
P4 (NLEG11)	2021-07-18T10:41:25.495Z	79.7500	34.0000	322	Elizabeth Jones	CTD w/bottles
P4 (NLEG11)	2021-07-18T11:20:09.268Z	79.7500	34.0000	329	Anette Wold	Multinet 64 um
P4 (NLEG11)	2021-07-18T12:04:02.894Z	79.7500	34.0000	330	Anette Wold	Multinet 64 um
P4 (NLEG11)	2021-07-18T12:21:59.085Z	79.7500	34.0000	331	Janne Søreide; Kim Præbel	Bongonet 64 um
P4 (NLEG11)	2021-07-18T13:16:15.747Z	79.7500	34.0000	323	Elizabeth Jones	CTD w/bottles
P4 (NLEG11)	2021-07-18T13:50:02.682Z	79.7502	33.9975	332	Anette Wold	Multinet 180 um
P4 (NLEG11)	2021-07-18T14:23:46.05Z	79.7502	33.9974	333	Espen Bagoien	MIK-net 1500 um
P4 (NLEG11)	2021-07-18T14:54:49.545Z	79.7502	33.9976	334	Janne Søreide; Kim Præbel	Bongonet 180 um
P4 (NLEG11)	2021-07-18T16:58:57.543Z	79.7502	33.9965	335	Janne Søreide; Kim Præbel	Bongonet 64 um
P4 (NLEG11)	2021-07-18T17:34:55.53Z	79.7524	33.9677	336	Janne Søreide; Kim Præbel	Bongonet 64 um
P4 (NLEG11)	2021-07-18T18:35:56.09Z	79.7502	34.0048	61	Bodil Bluhm	Campelen trawl
NLEG11_1	2021-07-18T20:13:52.803Z	79.8000	34.0001	324	Sigrid Lind	CTD
NLEG11_2	2021-07-18T21:26:34.468Z	79.9004	33.9996	325	Sigrid Lind	CTD
NLEG12	2021-07-18T22:36:58.333Z	79.9999	33.9993	326	Elizabeth Jones	CTD w/bottles
P5 (NLEG13)	2021-07-19T05:05:32.937Z	80.4426	33.8979	62	Sissel Jentoft	Harstad trawl
P5 (NLEG13)	2021-07-19T06:59:52.092Z	80.5016	33.9964	327	Elizabeth Jones	CTD w/bottles
P5 (NLEG13)	2021-07-19T07:32:09.103Z	80.5020	33.9808	337	Philipp Assmy	Phytoplankton net 10 um
P5 (NLEG13)	2021-07-19T07:51:18.634Z	80.5022	33.9711	338	Janne Søreide; Kim Præbel	Bongonet 180 um
P5 (NLEG13)	2021-07-19T07:52:34.404Z	80.5022	33.9705	339	Anette Wold	Multinet 64 um

P5 (NLEG13)	2021-07-19T08:05:18.127Z	80.5021	33.9646	340	Janne Søreide; Kim Præbel	Bongonet 64 um
P5 (NLEG13)	2021-07-19T08:14:41.745Z	80.5020	33.9606	341	Anette Wold	Multinet 64 um
P5 (NLEG13)	2021-07-19T08:35:33.839Z	80.5015	33.9527	342	Anette Wold	Multinet 180 um
P5 (NLEG13)	2021-07-19T08:56:16.939Z	80.5011	33.9449	343	Espen Bagoien	MIK-net 1500 um
P5 (NLEG13)	2021-07-19T10:30:42.911Z	80.4988	33.9071	328	Elizabeth Jones	CTD w/bottles
P5 (NLEG13)	2021-07-19T10:50:53.189Z	80.4983	33.8975	344	Janne Søreide; Kim Præbel	Bongonet 64 um
P5 (NLEG13)	2021-07-19T13:03:28.082Z	80.5028	33.8423	329	Elizabeth Jones	CTD w/bottles
P5 (NLEG13)	2021-07-19T14:28:24.789Z	80.5121	33.8150	330	Sigrid Lind	CTD
P5 (NLEG13)	2021-07-19T17:08:05.885Z	80.5380	33.7941	63	Bodil Bluhm	Campelen trawl
P5 (NLEG13)	2021-07-19T18:23:46.736Z	80.5464	33.8416	64	Sissel Jentoft	Harstad trawl
P5 (NLEG13) Ice	2021-07-20T06:57:50.765Z	80.5002	33.4216	61	Elizabeth Jones	Ice station
P5 (NLEG13)	2021-07-20T13:53:23.846Z	80.4801	33.2068	331	Sigrid Lind	CTD
P5 (NLEG13)	2021-07-20T16:07:05.76Z	80.4989	33.2602	65	Bodil Bluhm	Campelen trawl
P5 (NLEG13)_1	2021-07-20T19:57:45.801Z	80.7326	33.1215	332	Sigrid Lind	CTD
NLEG14	2021-07-21T02:47:07.734Z	81.0013	33.9755	333	Elizabeth Jones	CTD w/bottles
NLEG15	2021-07-21T09:45:53.843Z	81.3122	31.3609	334	Elizabeth Jones	CTD w/bottles
NLEG16	2021-07-21T11:43:27.426Z	81.3791	31.3021	335	Sigrid Lind	CTD
NLEG17	2021-07-21T12:41:42.977Z	81.4106	31.2447	336	Sigrid Lind	CTD
NLEG18	2021-07-21T13:26:01.421Z	81.4316	31.1471	337	Sigrid Lind	CTD
NLEG19	2021-07-21T14:12:58.342Z	81.4567	31.0743	338	Elizabeth Jones	CTD w/bottles
NLEG20	2021-07-21T15:53:26.716Z	81.5027	30.9622	339	Sigrid Lind	CTD
P6 (NLEG21/NPAL15)	2021-07-21T17:33:33.842Z	81.5479	30.8587	340	Sigrid Lind	CTD
P6 (NLEG21/NPAL15) Ice	2021-07-22T06:15:51.936Z	81.5255	30.8165	62	Elizabeth Jones	Ice station
P6 (NLEG21/NPAL15)	2021-07-22T13:56:19.641Z	81.5469	30.7965	341	Elizabeth Jones	CTD w/bottles

P6 (NLEG21/NPAL15)	2021-07-22T15:08:31.507Z	81.5474	30.7766	345	Philipp Assmy	Phytoplankton net 10 um
P6 (NLEG21/NPAL15)	2021-07-22T15:17:58.548Z	81.5474	30.7757	346	Anette Wold	Multinet 64 um
P6 (NLEG21/NPAL15)	2021-07-22T16:40:28.495Z	81.5479	30.7703	347	Janne Søreide; Kim Præbel	Bongonet 64 um
P6 (NLEG21/NPAL15)	2021-07-22T18:03:11.328Z	81.5487	30.7697	349	Janne Søreide; Kim Præbel	Bongonet 64 um
P6 (NLEG21/NPAL15)	2021-07-22T18:35:49.166Z	81.5485	30.7691	350	Janne Søreide; Kim Præbel	Bongonet 180 um
P6 (NLEG21/NPAL15)	2021-07-22T19:13:48.383Z	81.5487	30.7683	351	Anette Wold	Multinet 64 um
P6 (NLEG21/NPAL15)	2021-07-22T20:44:58.736Z	81.5488	30.7324	352	Anette Wold	Multinet 180 um
P6 (NLEG21/NPAL15)	2021-07-22T21:53:42.568Z	81.5472	30.7257	353	Espen Bagoien	MIK-net 1500 um
P6 (NLEG21/NPAL15)	2021-07-23T06:09:00.041Z	81.5425	30.8903	342	Elizabeth Jones	CTD w/bottles
P6 (NLEG21/NPAL15)	2021-07-23T08:20:33.378Z	81.5119	30.8954	66	Sissel Jentoft	Harstad trawl
P6 (NLEG21/NPAL15)	2021-07-23T09:24:23.847Z	81.5427	30.8460	343	Elizabeth Jones	CTD w/bottles
NLEG22	2021-07-23T11:15:41.762Z	81.5873	30.7132	344	Elizabeth Jones	CTD w/bottles
NLEG23	2021-07-23T13:32:54.848Z	81.6207	30.6566	345	Elizabeth Jones	CTD w/bottles
NLEG24	2021-07-23T17:06:18.43Z	81.6789	30.5153	346	Elizabeth Jones	CTD w/bottles
P7 (NLEG25/NPAL16)	2021-07-24T01:02:26.035Z	82.0011	29.9828	347	Sigrid Lind	CTD
P7 (NLEG25/NPAL16) Ice	2021-07-24T06:15:00.268Z	81.9845	30.0223	63	Elizabeth Jones	Ice station
P7 (NLEG25/NPAL16)	2021-07-24T14:30:11.584Z	81.9816	29.9784	348	Elizabeth Jones	CTD w/bottles
P7 (NLEG25/NPAL16)	2021-07-24T17:43:38.886Z	81.9862	30.0586	354	Philipp Assmy	Phytoplankton net 10 um
P7 (NLEG25/NPAL16)	2021-07-24T18:21:15.299Z	81.9862	30.0648	355	Anette Wold	Multinet 64 um
P7 (NLEG25/NPAL16)	2021-07-24T19:00:39.112Z	81.9861	30.0666	357	Anette Wold	Multinet 64 um
P7 (NLEG25/NPAL16)	2021-07-25T02:59:19.457Z	82.0034	30.0387	349	Elizabeth Jones	CTD w/bottles
P7 (NLEG25/NPAL16)	2021-07-25T05:57:46.322Z	82.0144	30.1785	358	Janne Søreide; Kim Præbel	Bongonet 180 um

P7 (NLEG25/NPAL16)	2021-07-25T07:11:11.009Z	82.0172	30.2051	359	Janne Søreide; Kim Præbel	Bongonet 64 um
P7 (NLEG25/NPAL16)	2021-07-25T08:33:08.776Z	82.0201	30.2151	360	Janne Søreide; Kim Præbel	Bongonet 64 um
P7 (NLEG25/NPAL16)	2021-07-25T09:21:43.515Z	82.0219	30.2108	350	Elizabeth Jones	CTD w/bottles
P7 (NLEG25/NPAL16)	2021-07-25T10:00:16.871Z	82.0241	30.2039	361	Espen Bagoien	MIK-net 1500 um
P7 (NLEG25/NPAL16)	2021-07-25T11:20:44.484Z	82.0294	30.1979	362	Anette Wold	Multinet 180 um
P7 (NLEG25/NPAL16)	2021-07-25T16:12:37.199Z	81.9848	30.1224	67	Sissel Jentoft	Harstad trawl
708_Extra_Trawl	2021-07-27T03:47:57Z	79.7616	10.0350	68	Sissel Jentoft	Harstad trawl

Table A2. Nansen Legacy transect. Full station list including Process stations (P) and transect CTD stations (NLEG)

Nansen Legacy transect stations							
Station name	**Longitude (decimal)**	**Latitude (decimal)**	**Longitude (degrees)**	**Latitude (degrees)**	**Depth (m)**	**Type of station**	**Comment**
P7/ NLEG25	**30,0000**	**82,0000**	**030 00.00 E**	**82 00.00 N**	**3000**	**Process study station P7**	
NLEG24	30,5258	81,6828	030 31.55 E	81 40.97 N	2807		*A-TWAIN*
NLEG23	30,6647	81,6165	030 39.88 E	81 36.99 N	1913		*A-TWAIN*
NLEG22	30,7667	81,5895	030 46.00 E	81 35.37 N	1551		*A-TWAIN*
P6/ NLEG21	**30,8548**	**81,5463**	**030 51.29 E**	**81 32.78 N**	**865**	**Process study station P6**	***A-TWAIN, shelf-break***
NLEG20	30,9618	81,5025	030 57.71 E	81 30.15 N	698		*A-TWAIN, shelf-break*
NLEG19	31,0775	81,4580	031 04.65 E	81 27.48 N	486		*A-TWAIN, shelf-break*
NLEG18	31,1448	81,4318	031 08.69 E	81 25.91 N	264		*A-TWAIN, shelf-break*
NLEG17	31,2468	81,4107	031 14.81 E	81 24.64 N	204		*A-TWAIN, shelf-break*
NLEG16	31,2933	81,3822	031 17.60 E	81 22.93 N	189		*A-TWAIN, shelf-break*
NLEG15	31,3487	81,3098	031 20.92 E	81 18.59 N	195		*Arctic Price near-shelf-station*
NLEG14	34,0000	81,0000	034 00.00 E	81 00.00 N	216		*Vardø-N, Kvitøybanken*
NLEG13.1	33,1215	80,7326			179	Extra CTD station	*Taken in moonpool*
P5/ NLEG13	**34,0000**	**80,5000**	**034 00.00 E**	**80 30.00 N**	**167**	**Process study station P5**	***Vardø-N, Kvitøybanken***
NLEG12	34,0000	80,0000	034 00.00 E	80 00.00 N	209		*Vardø-N, Kvitøybanken*
NLEG11.2	34,0000	79,9000			229	Extra CTD station	
NLEG11.1	34,0000	79,8000			298	Extra CTD station	
P4/ NLEG11	**34,0000**	**79,7500**	**034 00.00 E**	**79 45.00 N**	**332**	**Process study station P4**	***Vardø-N, trench east of Kong Karl***
NLEG10.1	34,0000	79,6250			345	Extra CTD station	
NLEG10	34,0000	79,5000	034 00.00 E	79 30.00 N	293		*Vardø-N, trench east of Kong Karl*
NLEG09.1	34,0000	79,3750			264	Extra CTD station	
NLEG09	34,0000	79,2500	034 00.00 E	79 15.00 N	215		*Vardø-N, trench east of Kong Karl*
NLEG08.1	34,0000	79,1250			196	Extra CTD station	
NLEG08	34,0000	79,0000	034 00.00 E	79 00.00 N	266		*Vardø-N, trench east of Kong Karl*
NLEG07.1	34,0000	78,8750			295	Extra CTD station	
P3/ NLEG07	**34,0000**	**78,7500**	**034 00.00 E**	**78 45.00 N**	**301**	**Process study station P3**	***Vardø-N, trench east of Kong Karl***
NLEG06.2	34,0000	78,5500			240	Extra CTD station	

NLEG06.1	34,0000	78,6000			201	Extra CTD station	
NLEG06	34,0000	78,5000	034 00.00 E	78 30.00 N	180		*Vardø-N, Storbanken*
NLEG05.2	34,0000	78,4000			160	Extra CTD station	
NLEG05.1	34,0000	78,4500			158	Extra CTD station	
NLEG05	34,0000	78,0000	034 00.00 E	78 00.00 N	193		*Vardø-N, Storbanken*
P2/ NLEG04	**34,0000**	**77,5000**	**034 00.00 E**	**77 30.00 N**	**190**	**Process study station P2**	***Vardø-N, Storbanken***
NLEG03	34,0000	77,0000	034 00.00 E	77 00.00 N	154		*Vardø-N, Storbanken*
NLEG02.5	31,7570	76,5960			140	Extra CTD station	
NLEG02.4	32,2850	76,6880			180	Extra CTD station	
NLEG02.3	34,5670	76,7560			200	Extra CTD station	
NLEG02.2	34,0080	76,8380			240	Extra CTD station	
NLEG02.1	34,5220	76,9120			294	Extra CTD station	
NLEG02	31,2200	76,5000	031 13.20 E	76 30.00 N	308		*Vardø-N, Storbanken*
P1/ NLEG01	**31,2200**	**76,0000**	**031 13.20 E**	**76 00.00 N**	**322**	**Process study station P1**	***Vardø-N, Hopendjupet***

Table A3. Cruise participants (team leaders in bold)

Cruise Leader: Elizabeth Jones, IMR
Co-lead: Marit Reigstad, UiT

Captain: Hallgeir M. Johansen

	Name	**Inst.**	**Nansen Legacy tasks**	**email**
1	**Elizabeth Jones**	IMR	Cruise Leader / carbonate chemistry / inorganic nutrients / $\delta^{18}O$ / dissolved oxygen / water budget / sea ice work planning	elizabeth.jones@hi.no
2	**Marit Reigstad**	UiT	Co-Lead / filtration (Chl a POC/PON)	marit.reigstad@uit.no
3	Sigrid Lind	NPI	Hydrography / CTD / CDOM / sea ice work planning / ice observations	Sigrid.Lind@npolar.no
4	**Helene Hodal Lødemel**	IMR	Carbonate chemistry / inorganic nutrients / $\delta^{18}O$ / dissolved oxygen	helene.hodal.loedemel@hi.no
5	Lucie Goraguer	NPI	CTD sampling / Chl a POC/PON filtration / phytoplankton nets	Lucie.Goraguer@npolar.no
6	**Nadjejda Espinel Velasco**	NPI	Zooplankton sampling / respiration experiments	Nadjejda.Espinel@npolar.no

7	Vanessa Pitusi	UNIS	Zooplankton sampling / under-ice water planning and sampling	vanessap@unis.no
8	Evelyn Strombom	UiO	Fish population genetics	evelyn.strombom@gmail.com
9	**Marius Maurstad**	UiO	Fish population genetics	marimaur@student.ibv.uio.no
10	**Oliver Müller**	UiB	Microbiology / virus / bacterial production / flow cytometry / P vs I curves / sea ice work planning	oliver.muller@uib.no
11	Hilde Stabell	UiB	Microbiology / virus / bacterial production / flow cytometry	Hilde.Stabell@uib.no
12	Luke Marsden	UNIS	Filtration / activity logs	lukem@unis.no
13	Simon Kline	UiO	DNA/RNA filtrations / phytoplanlton net / taxonomy	simonhk@student.ibv.uio.no
14	Audun Gjerland	NPI	Sea ice safety / safety training / polar bear guard / sea ice observations / technical support	Audun.Gjerland@npolar.no
	Jan Vidar Nordstrand	IMR	Instrument chief KPH	
	Hanna	IMR	Instrument technician KPH	

Table A4. Internship on sea ice

List of non- or less experienced PhDs and post docs and technicians that took part in sea ice-based sampling, handling, data collection and safety duties and achieved competence on methodologies and practical work.

Name	**Sea ice work practice**
Lucie Goraguer (NPI)	Physical and biological sea ice coring, meltwater filtration, bridge watch
Vanessa Pitusi (UNIS/UiT)	Water hole drilling, under-ice water sampling, hand-held CTD, bridge watch
Nadjejda Espinal Velasco (NPI)	Under-ice water sampling, hand-held CTD, filtered sea water addition onboard, bridge watch
Oliver Müller (UiB)	Lead of biological sea ice coring, core processing, bridge watch
Hilde Stabell (UiB)	Melt pond sampling, bridge watch
Simon Kline (UiO)	Biological sea ice coring, core processing, melt pond sampling, meltwater filtration, bridge watch
Luke Marsden (UNIS)	Snow depth measurements, melt pond sampling, meltwater filtration, bridge watch
Evelyn Strombom (UiO)	Ice core handling, filtered sea water addition onboard, under-ice water sampling, bridge watch
Marius Maurstad (UiO)	Melt pond sampling, bridge watch

Table A5. Working hours and cabin distributions

Working hours 0400-1200, 1600-2000	**Working hours 2000-0400, 1200-1600**	Cabin
Libby Jones		605
	Marit Reigstad	419
Audun Gjerland		421
		468
Sigrid Lind		456
	Hilde Stabell	458
Helene Hodal Lødemel		327
Luke Marsden		329
Lucie Goraguer		330
	Evelyn Strombom	332
	Marius Maurstad	333
		335
Oliver Muller		377
Simon Kline		379
	Nadjejda Espinel	380
	Vanessa Pitusi	382
		383
		385
		386

Table A6. Laboratory, cold room and freezer allocation

Lab no.	Name of laboratory	General description	Use on JC2-1
102	Clean seawater sample room	Seawater intake room and TSG, pCO_2 underway instrumentation	Helene
202	Gravity meter room	-	-
301	Chilled lab 4-8°C	Mesozooplankton, microbial exp. preparation lab	Nadjejda, Vanessa,
302	Dry lab	Instrumentation for analyses of AT, pH and oxygen, salinity.	Helene
303	Wet lab, Thermax 1+2	Meso- and macrozooplankton	Nadjejda, Vanessa,
307	Isotopic lab	Primary and bacterial production	Oli, Hilde
308/309	Wet lab biology (fish lab)	Fish sampling	Marius, Evelyn
310	Catch sample room	Trawl first sampling (open water) Cleaning and storage sea ice equipment	Marius, Evelyn Sea ice teams
311	Environmental toxicology lab	Virus filtration	Oli, Hilde
316	Filtration lab	Filtration (metabarcoding/transcriptomics, coccolithophores)	Simon
317	Education lab	Common use, sample labeling	All
319	Wet Lab Geology/Benthos	Sea ice safety gear, sea-ice sampling equipment, salinity.	Audun
320	Microbiology lab	Filtration (Chl a, POC/PON, fatty acids, stable isotopes), fluorometer	Lucie
321	Dry lab		
322 North Pole	Ice Lab −25°C	Processing ice cores	All
312 Barents Sea	Cooler room (inside fish lab) 1-2°C	Processing and storage of catch samples	Marius, Evelyn Oli
313 Antarctica	Freezer room (inside fish lab) −20°C	Frozen fish samples storage	Marius, Evelyn
314 Svalbard	Cooler room (by benthos lab) 2-4°C	Chemistry samples storage	Helene
315 Fram Strait	Cooler room (by benthos lab) 0°C	Samples storage	Nadjejda
323 Greenland	Cooler room (2-4°C)	Ice core melting	All
325 Lake Vostok	Freezer ice samples −25°C	For ice and other samples	All
701	Observation Central	Ice observations	Sigrid, Audun

Thermax Fridge 1	303 Wet lab	Zooplankton	Zooplankton sorting
Thermax Fridge2	303 Wet lab	Zooplankton	

Appendix 2: Blogs

Blogs written by cruise participants in collaboration with the project office and published on the Nansen Legacy Blog at Forskning.no and UNIS.no during the Nansen Legacy cruise JC2-1, July 2021.

Published on Forskning.no/blogg-Arven etter Nansen

No	Title	Author(s)	Status
1	Er sommeren i Barentshavet varm i år? - Is the summer in the Barents Sea hot this year? https://blogg.forskning.no/arven-etter-nansen/er-sommeren-i-barentshavet-varm-i-ar/1892672	Marit Reigstad and Elizabeth Jones	Publ. 22/7
2	Sommer i en smeltedam https://blogg.forskning.no/arven-etter-nansen/sommer-i-en-smeltedam/1892715	Simon Kline	Publ. 22/7
3	Aliens in the Arctic? The outer-worldly life that resides within sea ice https://www.unis.no/aliens-in-the-arctic-the-outer-worldly-life-that-resides-within-sea-ice/	Vanessa Pitusi	Publ. 19/8
4	From your home to the lab: household items in the life of a marine scientist https://www.unis.no/from-your-home-to-the-lab-household-items-in-the-life-of-a-marine-scientist/	Nadjejda Espinel-Velasco and Vanessa Pitusi	Publ. 31/7

Appendix 3: Planned datasets

PI	Dataset	When are analyses planned for	RF	Sharing within project	Publishing data	Ask for embargo of data?	If yes, why?
Melissa Chierici and Agneta Fransson	DIC/Alkalinity, inorganic nutrients, stable oxygen isotopes, dissolved oxygen	2021	RF2	2022	2022-2023	No	
Bente Edvardsen and Anna Vader	SEM Filters, Fixed Samples, Filters with DNA/RNA	2021	RF3				
Sissel Jentoft		2021					
Marit Reigstad, Gunnar Bratbak	POC/PON	2021/22	RF3	2022-2023	2023/24		
Anna Vader	Chl a total and > 10um biomass	During cruise	3	October 2021	Nov-21	No	
Philipp Assmy, Rolf Gradinger, Bente Edvardsen (?)	Phytoplankton/protist abundance	2022	RF3	Late autumn 2022		Yes	Part of several PhD projects
Nicole Aberle-Malzahn	protist abundance		RF3				
Janne Søreide & Camilla Svensen	Mesozooplankton abundance (ind/m3), biomass (mg dry mass/m3) and species compositi	2021/2022	RF3				

	on (species list)						
Janne Søreide	Total biomass of mesozooplankton	2021	RF3				
Anette Wold	Gelatinous zooplankton abundance (ind/m3), volume & species composition (species list)	2021/2022	RF3				
Espen Bagøyen		2021/2022	RF3				
Kim Præbel							
Robynne Nowicki and Janne Søreide	Seasonal variation in Calanus energy content	2021	RF2		2022	Unsure	PhD project
Miriam Marquardt		2021-2022		Do not know	Do not know		
Gunnar Bratbak	Bacterial production rate	2021/2022	RF3	2022	2022-2023	Need to ask PI	
Gunnar Bratbak, Aud Larsen	Abundance tables	2021/2022	RF3	2022	2022-2023	Need to ask Pis	
Gunnar Bratbak	Plankton diversity, dynamics and distribution	2021/2022	RF3	2022	2022-2023	Need to ask PIs	
Gunnar Bratbak, Jorun K. Egge, Tatiana Tsagaraki	Concentration of total particulate O, P, Na, Mg, Si, S, Ca, Mn,	2021/2022	RF3	2022	2022-2023	Need to ask PIs	

	Fe, Zn (µM)						
Gunnar Bratbak, Ruth-Anne Sandaa	Virus diversity across season based on metabarcoding	2021/2022	RF3	2022	2022-2023	Need to ask PIs	

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
Helene Hodal Lødemel, Libby Jones	Melissa Chierici and Agneta Fransson	Water samples from CTD and sea ice environment	Chemical analyses of carbonate chemistry, inorganic nutrients, stable oxygen isotopes, dissolved oxygen	DIC/Alkalinity, inorganic nutrients, stable oxygen isotopes, dissolved oxygen	Version 8 Nansen Legacy Sampling Protocol	DIC/Alkalinity, inorganic nutrients, stable oxygen isotopes, dissolved oxygen	Onboard, IMR and external laboratories	2021	RF2	T2-1.1	2022	2022-2023	No		Confirm with PIs
Simon Kline, Luke Marsden	Bente Edvardsen and Anna Vader	Water samples from CTD and sea ice samples	Metatranscriptomics, Metabarcoding, Scanning Electron Microscopy,	SEM Filters, Fixed Samples, Filters with DNA/RNA	Version 8 Nansen Legacy Sampling	SEM Filters, Fixed Samples, Filters with DNA/RNA	Onboard, UiO, and UNIS	2021	RF3						Confirm with PIs
Marius Filomeno Maurstad, Evelyn Strombom	Sissel Jentoft	Whole and dissected fish samples	DNA/RNA preservation		Version 8 Nansen Legacy Sampling Protocol		UiO	2021							Confirm with PIs
Lucie Goraguer/ Marit Reigstad	Marit Reigstad, Gunnar Bratbak	POC/PON	CN analyses	POC/PON	Nansen Legacy Sampling Protocol 8.0	POC/PON	UiT/UiB	2021/22	RF3		2022-2023	2023/24			
Lucie Goraguer	Anna Vader	Chlorophyll a	Fluorometric measurements	Chl a total and > 10um biomass	NL protocol 8.0	Chl a total and > 10um biomass	Onboard KPH	During cruise	3	T3-1.1	October 2021	nov.21	No		
Lucie Goraguer	Philipp Assmy, Rolf Gradinger, Bente Edvardsen(?)	Fixed (formaldehyde+GA) water samples from Niskin bottles 6 (?) depths and ice stations	Utermöhl cell counts under the microscope	Cell abundances of protists > 10 µm	NL protocol 8.0	Phytoplankton/protist abundance	IOPAN	2022	RF3	T3.1.1	Late autumn 2022		Yes	Part of several PhD projects	We would like to compare metabarcoding results with micoscopical cell counts in Karoline Saubrekkas PhD-project
Lucie Goraguer	Nicole Aberle-Malzahn	Fixed (acid Lugol) water samples from Niskin bottles 6 (?) depths and ice stations	Utermöhl cell counts under the microscope	Cell abundances of protists > 10 µm		protist abundance			RF3	T3.1.1					
Vanessa Pitusi & Nadjejda Espinel	Janne Søreide & Camilla Svensen	Mesozooplankton taxonomy; Small mesozooplankton taxonomy	Species identification & counts using a stereomicroscope.	ind/m3 & mg dry mass/m3 using species-specific dry mass values from published sources	Version 8 Nansen Legacy Sampling Protocol	Mesozooplankton abundance (ind/m3), biomass (mg dry mass/m3) and species composition (species list)	IOPAS	2021/2022	RF3	T3-1.1 & 2.1 T3-2.1 & 2.2					
Vanessa Pitusi & Nadjejda Espinel	Janne Søreide	Mesozooplankton biomass; Small mesozooplankton biomass	Dry total sample at 60 C & weight	Total biomass (mg dry weight/m3)	Version 8 Nansen Legacy Sampling Protocol	Total biomass of mesozoopankton	UNIS	2021	RF3	T3-1.1 & 2.1 T3-2.1 & 2.2					
Vanessa Pitusi & Nadjejda Espinel	Anette Wold	Gelatinous zooplankton	Species identification & counts	ind/m3; ml/m3	Version 8 Nansen Legacy Sampling Protocol	Gelatinous zooplankton abundance (ind/m3), volume & species composition (species list)	NTNU	2021/2022	RF3	T3-1.1 & 2.1 T3-2.1 & 2.2					
Vanessa Pitusi & Nadjejda Espinel	Espen Bagøyen	Macrozooplankton	Species identification & counts using microscope, metabarcoding		Version 8 Nansen Legacy Sampling Protocol		IMR	2021/2022	RF3						
Vanessa Pitusi & Nadjejda Espinel	Kim Præbel	Small mesozooplankton metagenomic; mesozooplankton genomics	Metabarcoding of zooplankton samples		Version 8 Nansen Legacy Sampling Protocol		UiT		RF3						
Vanessa Pitusi	Robynne Nowicki and Janne Søreide	*Calanus* copepods for bomb calorimetry	Energetics analysis using bomb calorimetry	Energy content	Version 8 Nansen Legacy Sampling Protocol	Seasonal variation in *Calanus* energy content	UNIS	2021	RF2	T2-2.5		2022	Unsure	PhD project	
Vanessa Pitusi	Miriam Marquardt	Sea ice meiofauna from 9 ice cores; 3 per ice station	Microscopy & barcoding	Total abundance	Version 8 Nansen Legacy Sampling Protocol		UiT	2021-2022	RF3		Do not know	Do not know			
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	Version 8 Nansen Legacy Sampling Protocol	Bacterial production rate	UiB	2021/2022	RF3	T3-2.3/T3-3.1/	2022	2022-2023	Need to ask PI		Confirm with the PI
Oliver Müller	Gunnar Bratbak, Aud Larsen	Microbial abundance	Flow cytometry	Planktonic cell per ml	Version 8 Nansen Legacy Sampling Protocol	Abundance tables	UiB	2021/2022	RF3	T3.1.1, T3.1.2, T3.2.1	2022	2022-2023	Need to ask PIs		Confirm with the PI
Hilde Stabell	Gunnar Bratbak	SEM filter	Scanning electron microscoppy (SEM)	Qualitative analysis of small plankton	Version 8 Nansen Legacy Sampling Protocol	Plankton diversity, dynamics and distribution	UiB	2021/2022	RF3	T3.1.1, T3.1.2, T3.2.1	2022	2022-2023	Need to ask PIs		Confirm with the PI
Hilde Stabell, Oliver Müller	Gunnar Bratbak, Jorun K. Egge, Tatiana Tsagaraki	XRF filter	X-Ray Fluorescence (XRF)	Concentration of total particulate elements in µM	Version 8 Nansen Legacy Sampling Protocol	Concentration of total particulate O, P, Na, Mg, Si, S, Ca, Mn, Fe, Zn (µM)	UiB	2021/2022	RF3	T3.1.1, T3.1.2, T3.2.1	2022	2022-2023	Need to ask PIs		Confirm with the PI
Hilde Stabell	Gunnar Bratbak, Ruth-Anne Sandaa	Virus diversity	Recover viruses from natural waters via iron chloride precipitation	Virus diversity	Version 8 Nansen Legacy Sampling Protocol	Virus diversity across season based on metabarcoding	UiB	2021/2022	RF3	T3.1.1, T3.1.2, T3.2.1	2022	2022-2023	Need to ask PIs		Confirm with the PI

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.

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

With funding from The Research Council of Norway

nansenlegacy.org

nansenlegacy

nansenlegacy@uit.no

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