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Cruise report SI_ARCTIC/Arctic Ecosystem Survey R/V *Helmer Hanssen*, 21 August-7 September 2017

Survey: 2017856

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Content

Introduction

The survey was a combination of SI_ARCTIC and the Arctic Ecosystem survey. Regarding SI_ARCTIC, it was the fourth and last survey. The main goal of the survey was:

- To conduct baseline investigations of the marine ecosystem in the deeper basin north of Svalbard
- Diet investigations of harp seals
- Extend the investigations/sampling in the marginal ice zone, above the deeper basins, and further east than earlier years
- Obtain data for evaluating inter-annual variations 2014-2017
- To conduct annual monitoring of the slope and shallower areas as part of the Arctic Ecosystem survey.
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There was substantially more ice than in 2015 and about the same as in 2014 and 2016. Thus, an extension into the deeper parts of the Arctic Ocean was not possible. The survey covered the ice edge zone north of Svalbard as well as the Hinlopen section and one station in the Fram Strait North section (Figure 1). In addition, we sampled the shallow shelf north of Nordaustlandet to about 30°E, conducted two case study stations, aimed for hunting seals for biological sampling along the ice edge and partly in the drift ice. The case studies and the sections are conducted to, among other things, have direct comparable stations during all years (to evaluate inter-annual variations). Details of equipment and samples taken at each station are given in Table A1. Underway meteorological and sea surface temperature measurements, and visual observations of marine mammals and sea birds were conducted. List of participants are given in Table A2.

Description of activity

The cruise commenced on August 21, 2017 from Longyearbyen, Svalbard. We started with calibration of echo sounder and shake-down of the Campelen trawls inside Isfjorden before heading for Case study 1 located in Atlantic Water at the shelf break at approximately 480 m bottom depth to the west of Isfjorden (Figure 1). The station was extensively sampled (Table A1). Thereafter we headed northwards for the Fram Strait North section where we deployed two moorings at 1000 m depth. Then we headed for the ice edge zone on the western flank of the Yermak Plateau before following the ice edge eastwards, looking for seals and undertaking stations along the way (about every 2.5°E). When approaching the Hinlopen section, we sampled this from south to north (including Case study 2) as far north as the ice allowed for (same extent as in 2014 and 2016).

After the Hinlopen section we resumed working eastwards along the ice edge zone taking stations underway. At about 30°E the ice prevented us from reaching any further. Going westwards again, we undertook Ecosystem survey station at a regular, predefined grid (Figure 1). In addition, some demersal trawl hauls aiming for Greenland Halibut were conducted, as well as hunting for seals. The ice edge zone was followed as far as possible westwards. The survey ended with recovering the moorings deployed near the Fram Strait North section, and conducting Ecosystem survey stations west of Spitsbergen.

Due to the overall ice conditions, the survey coverage in 2017 resembles the coverage in 2016 except that we covered more of the shallow regions in the north-east. Case studies 1 and 2 and the Hinlopen section were sampled in the same way as earlier, but only one station was sampled at the Fram Strait North section.

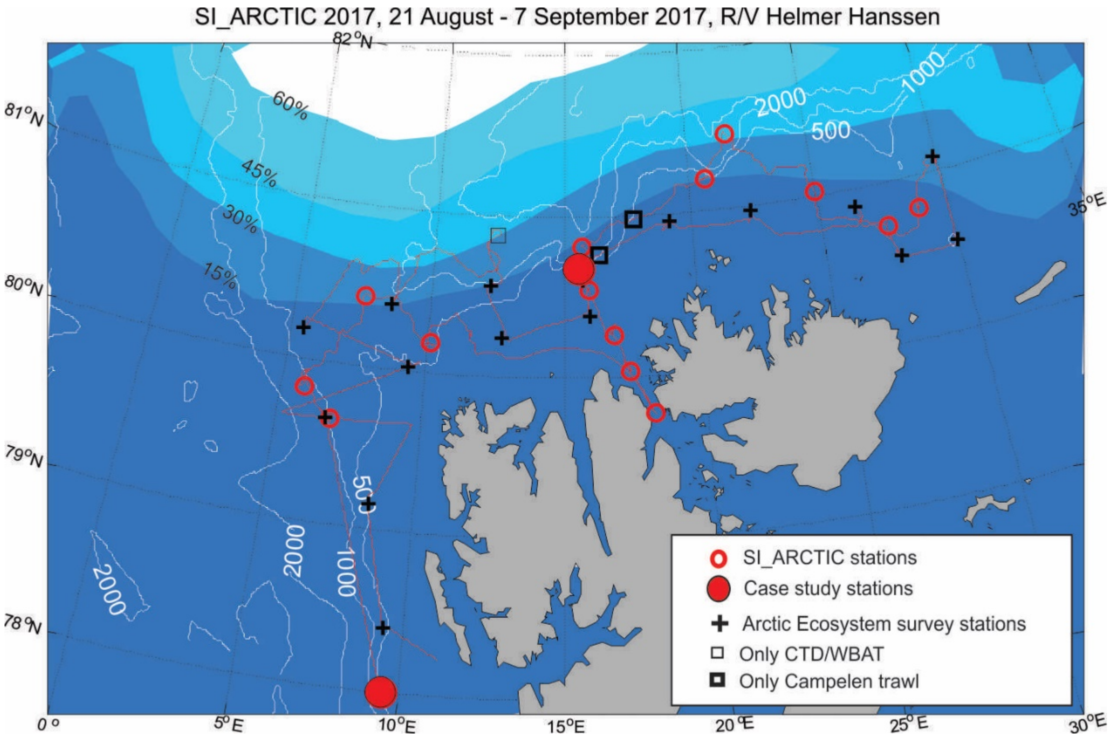

Figure 1. Cruise map showing cruise track, stations, bathymetric lines (white lines) and average sea ice conditions during the survey. See table A1 for details on sampling on the stations.

Methods

Sea ice distribution

Sea Ice images were downloaded as netCDF files from a University of Hamburg website (ftp://ftp-projects.cen.uni-hamburg.de/seaice/AMSR2/3.125km/). For information about the images see Kaleschke et al., 2001; Spreen et al, 2008; Beitsch et al., 2013). The NetCDf files were read into Matlab and the data plotted using the M_Map toolbox (Version 1.4f - http://www.eos.ubc.ca/~rich/).

Underway meteorological and oceanographic measurements

Along-track measurements of sea surface temperature (SST) from water intake at 4 m were recorded. Air temperature, air pressure (PTP220 sensor), wind speed and direction (Gill wind sensor) from the meteorological station on bridge roof were collected along with time, latitude, and longitude at one-minute intervals. Data were not logged for a period spanning 26-28 August due to failure with the program.

Light

Along-track measurements of surface irradiance, PAR (400-700 nm), were acquired using a spherical QSR-2100 sensor (Biospherical Inst.) deployed on the vessel bridge roof, measuring mean light intensity every minute. Data from the sensors were logged using "LoggerLight" (Biospherical Inst).

In addition, light measurements where performed at every CTD stations using a SPAR/Surface Irradiance QSR-240 sensor (calibrated 25 April 2014) for surface PAR and a PAR/Logarithmic

Satlantic SAT-QR-99019 underwater sensor (sensor calibrated 7 April 2016) on the CTD for *in situ* light measurements. Both sensors logged data using Sea-Bird software and observations were stored in the CTD *.CSV-files. The units of both these sensors were $\mu E/m^2/s$.

Light measurements (with a TriOS multichannel light meter) were performed at selected stations (Table A1 and A3). The Trios system includes an underwater and a surface sensor. Surface light was collected with a TriOS Ramses hyperspectral irradiance sensor (SAM_82C5) every 1 minute. The sensor was mounted side by side with the QSR-2100 on the vessel bridge roof. Vertical profiles of irradiance were collected with a TriOS Ramses hyperspectral irradiance underwater sensor (SAMIP-5057), set up to integrate data over 5 second intervals, hence output the spectrum every 5 seconds. If possible, the underwater system was deployed as close as possible to solar noon, but in practice measurements were conducted frequently also at other times through the diel cycle. The TriOS instrument has a spectral resolution of approximately 3.3 nm, and measures light intensities from ~310 to 1150 nm. Units are in $mW/(m^2 nm)$.

Moorings

Two moorings were deployed on 23 August and recovered at the 5 September near the Fram Strait North section (coinciding with the B21 station) to measure diel vertical migration (Figure 1 and Table A1). Both moorings were deployed at the 1000 m isobath with one at 79°39.1'N, 06°44.2'E and one at 79°39.6'N, 06°42.6'E. Each mooring contained a Nortek Signature 250 kHz instrument. The mooring at 79°39.6'N had the Signature deployed in 150 m while the mooring at 79°39.1'N had it deployed in 250 m.

Oceanographic measurements (physical and chemical)

Hydrography

Temperature and salinity was measured on 35 stations using a Seabird 911plus CTD with water carousel sampler (Figure 2 and Table A1). The CTD was lowered to ~5 m above seafloor. The conductivity and temperature sensors were mounted on the CTD 2 January 2017. The sensors were calibrated 18. March. 2014 (conductivity) and 4 September 2014 (temperature), but not used before mounted in January). The pressure sensor was calibrated 28 November 2007. The conductivity sensor was calibrated against in situ salinity samples from the bottom of each cast. The accuracies of the pressure, temperature, and salinity measurements are estimated to be 0.3 db, 0.001°C, and 0.002, respectively.

Current speed and direction

During the cruise currents were measured with two acoustic doppler current profilers (ADCP). A 75 kHz ADCP (RDI, Instruments) mounted to the vessel continuously measuring the currents in the upper 500m of the water column (VM-ADCP), and another ADCP (300 kHz, RDI, Instruments) mounted to the CTD frame profiling current velocities all the way to the sea floor (L-ADCP). The VM-ADCP data was post-processed using the CODAS ADCP processing software to remove misalignment bias and artifacts from vessel operations. The L-ADCP data was post-processed using the LDEO LADCP Processing Software Version IX. The tidal components were removed from the processed data using the Arctic Ocean Tidal Inverse Model (AOTIM-5, Padman and Erofeeva, 2004).

Nutrients

On all CTD stations waters samples was collected from specific depths, using 5 L Niskin water bottles on the CTD-carousel sampler. At all stations, the ICES standard depths were used from surface to maximum depth. For a higher and better resolution of nutrients and chlorophyll, fixed depths were selected for the upper 200 m (5, 10, 20, 30, 50, 100, 150 and 200 m) at all stations. A total of 34 CTD stations were sampled for nutrients. The nutrient samples were preserved with chloroform and stored in a refrigerator. The samples will be analyzed at the chemistry laboratory at IMR after the cruise. The water samples will be analyzed for nitrate, nitrite, silicate, and phosphate. Figure 2 shows the CTD stations (see Table A1 for details).

Oxygen

Oxygen data were collected at all stations using oxygen sensor (SBE 43) mounted on the CTD. No samples were taken for calibration using Winkler's method. The sensor was calibrated 23 March 2017. Last time the sensor was calibrated was 13. February 2013, and there had been a substantial drift/change in the calibration coefficients. The 2017 oxygen data showed in general much higher (~1.2-1.3 ml/l) values compared to the 2014-2016 data (which were all processed with the 2013 calibration coefficients). To evaluate the effect of changing the calibration coefficients, the 2017 data were also processed with the 2013 calibration coefficients. The differences in oxygen level using 2013 coefficients and 2017 coefficients were about ~1.2-1.3 ml/l indicating that most, or all, of the difference between 2014-2016 and 2017 were due to changing calibration coefficients.

The carbonate system (total alkalinity, A_T, and total dissolved inorganic carbon, C_T)

Water sampling was performed in whole water column at standard depths from a CTD-Rosette system with 12-Niskin flasks attached. Water samples for C_T and A_T was taken at 27 stations (Table A1). The sample flasks were filled using tubing in the bottom of the flask to provide minimal contamination with air in borosilicate glass bottles (250 ml) following standard protocols (Dickson et al., 2007). Determination of A_T and C_T will be performed after the survey. The full carbonate system (*i.e.* pH at *in situ* temperature, calcium carbonate saturation state (Ω)) will be calculated using C_T and A_T in the chemical equilibrium program CO2SYS (Pierrot et al., 2006). Samples for nutrients were taken in parallel to C_T and A_T for post-cruise analysis. Phosphate and silicic acid will also be used in CO2SYS for proper calculation of derived parameters. Samples for $\delta^{18}O$ were collected at the same stations at C_T and A_T in HDPE 25 ml vials, lids were wrapped with parafilm, and stored cold and dark in cooling room onboard until post-cruise analysis.

Phytoplankton

Quantitative samples

At all standard CTD stations (Figure 2) an approximately 100 ml water sample from 5, 10, and 20 m depth were transferred to a glass bottle (34 stations). The samples were preserved with a neutralized lugol solution. The samples will be analyzed at the algae laboratory at IMR and worked up using the Uthermöl method (IOC Manual and Guides, no 55.2010) after the cruise.

Qualitative samples

At all standard CTD stations (Figure 2) a vertical phytoplankton net haul was made from 30 to 0 m (34 stations). The phytoplankton net has a mesh size of 10 µm and was hauled in with a vertical velocity of 0.1 m/s. The samples were preserved with 20% neutralized formalin. The samples will be analyzed using light microscope after the cruise.

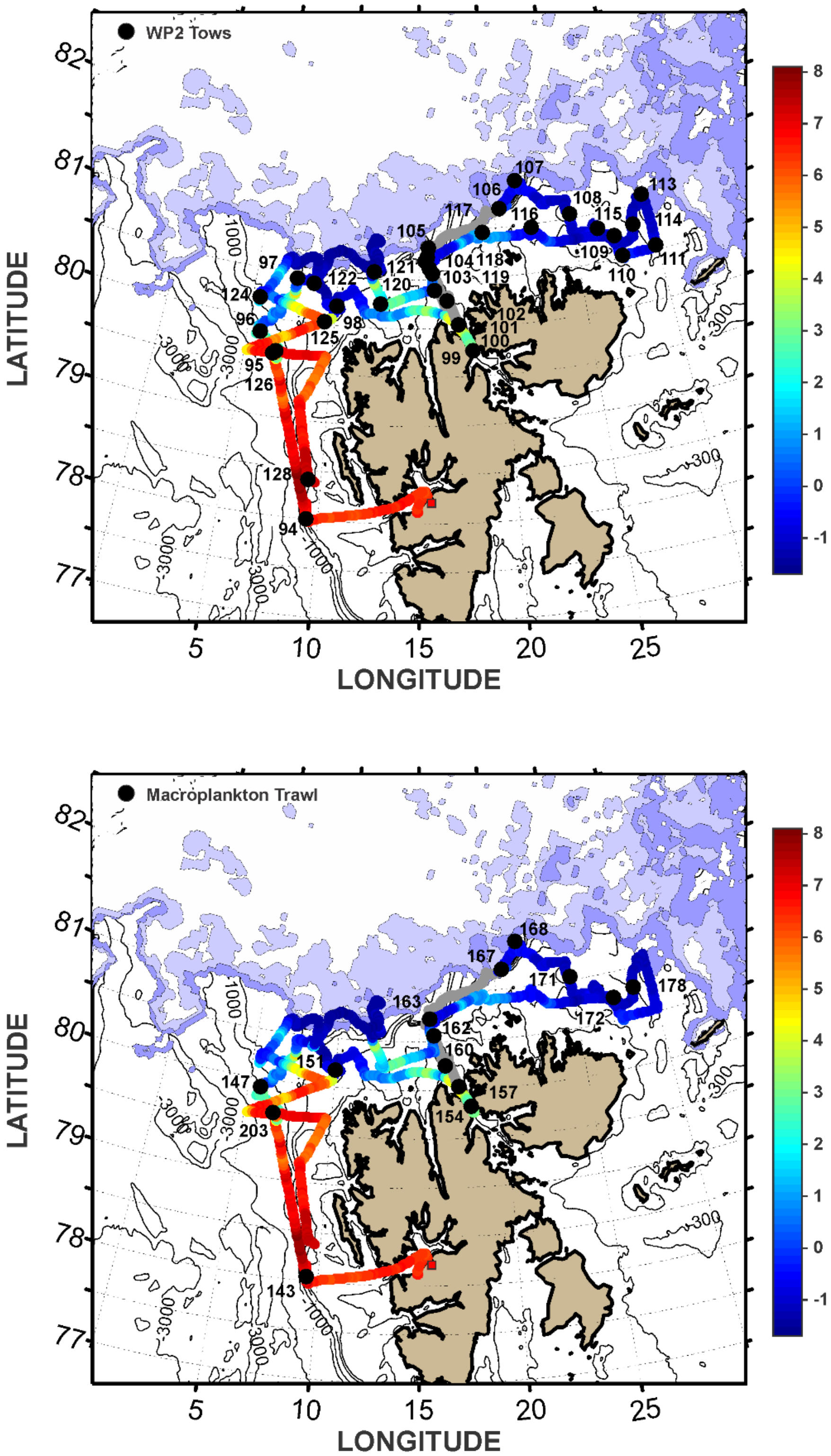

Figure 2. Location of stations with WP2, water samples for nutrients and phytoplankton, LADCP, WBAT (on some stations) and algae net (upper). Location of Macroplankton trawl (lower).

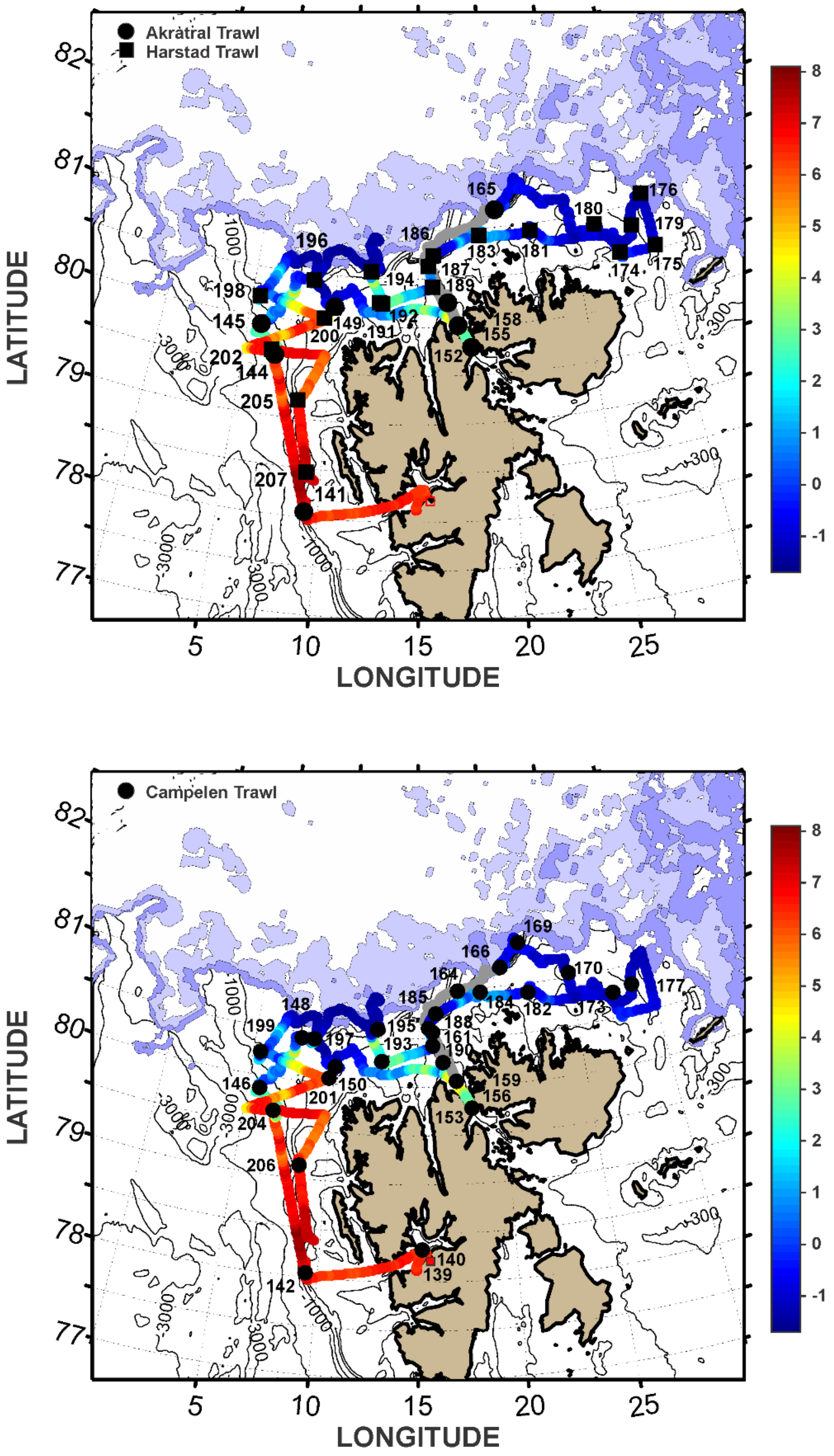

Figure 2 continues. Location of Åkra trawl with Multisampler (circles - only the uppermost net is shown) and Harstad trawls (squares). Location of Campelen trawl (lower).

Biomass – chlorophyll a

Samples for chlorophyll *a* were collected at 34 stations (Figure 2). Chlorophyll samples have been collected using ICES standard depth from 0-100 m. Samples have been taken from the same bottles and stations as the nutrient samples (Table A1). 265 ml water samples have been filtered onto GF/F filters (0.45 µm mesh), placed in vials and frozen at -20°C. All chlorophyll samples will be analyzed after the cruise at the IMR chemistry laboratory.

Fluorescence

Fluorescence data (Seapoint sensor) from the CTD can be considered a proxy of (relative distribution) phytoplankton chlorophyll distribution. Fluorescence profiles were obtained from all CTD stations. The sensor was last calibrated 13 March 2008. Turbidity were measured with a Seapoint Turbidity Meter calibrated 01 April 2008.

Zooplankton collections (meso and macro)

Zooplankton and micro-nekton were sampled with two different sampling systems, a WP2/Juday net pair and a Macroplankton trawl, targeting the meso- and macrozooplankton community respectively.

Mesozooplankton

A WP2/Juday net pair was used to target the mesozooplankton component. The principal mesozooplankton sampling system was a combined WP2 and Juday net pair mounted on a single frame with two rings on which the net mouths were tied. The tow pair was used at most stations where a CTD was deployed that collected water samples for nutrients and chlorophyll measurements (Figure 2, Table A1). The frame was attached to the end of the towing wire and the nets deployed vertically, usually to within 10 m of the seafloor. Both nets had 180 µm mesh. A total of 31 paired WP2/Juday net hauls were conducted, that sampled the whole water column from about 10 m above the bottom to surface. The samples were processed using a standard IMR procedure. The WP2 sample was split and 50% was fixed in 4% formaldehyde for identification and enumeration purposes. The other 50% was used for biomass estimation. This part was divided into 3 size fractions using sieves with mesh-sizes 2000, 1000 and 180 µm. Most animals retained on the 2000 µm sieve were sorted, identified, counted, and individual lengths of amphipods, fish, krill, and shrimps were measured prior to rinsing in fresh water. The biomass retained on the 1000 and 180 µm sieves as well as the identified animals belonging to specific groups; Chaetognaths, Amphipods, fish, krill, shrimps, and the copepods *Paraeuchaeta* sp. and *Calanus hyperboreus* retained on the 2000 µm sieve were put on pre-weighed aluminum dishes and dried in an oven at 60°C overnight, where after they were packed and stored in a freezer at -20 degrees awaiting new drying and weighing in the onshore laboratory at IMR. After drying the summed dry biomass per group is measured. The Juday net catch was preserved in 95% alcohol for later genetic analyses. After 24-48 hours, the alcohol fixative for the Juday net samples was replaced with new alcohol to assure proper fixation of samples.

At most stations, the WP2/Juday net pair was also used to obtain live samples of the pelagic snails *Limacina retroversa* and *L. helicina* (Thecosomata) for assessment of shell susceptibility to ocean acidification. These hauls were conducted in the upper 0-75 m of the water column, the exact depths of each haul were determined by the vertical position of the pycnocline. Living individuals were preserved in buffered ethanol for later analysis of shell thickness.

Macrozooplankton

A Macroplakton trawl were used to target the slightly larger and more motile macrozooplankton like krill, amphipods, and mesopelagic shrimps. This trawl also makes it possible to quantify the mesopelagic fish component. The trawl was used on 14 stations (Figure 2, Table A1), and three of the hauls were targeted trawling to verify organisms associated with observed acoustic scattering structures. The trawl has a ~38 square meter opening and a net with a stretched mesh size of 4 mm all the way from trawl opening to the cod-end. The velocity of the trawl through water and depth of the trawl were initially monitored acoustically using Scanmar trawl speed/symmetry and depth sensors, although the speed/symmetry sensor did not operate as intended on several occasions. The trawl was most of the time towed in a V-haul fashion with a ship speed of 2.5-3 knots. Most hauls were conducted down to 800 m depth when bottom depth allowed. Some stations were sampled to shallower depths in a similar manner, but also with the trawl towed horizontally at a specific depth for 15−20 minutes, in order to aid the identification of acoustic scattering structures observed underway. Upon completion of hauls the catches were weighed, and either the entire catch or a representative subsample was sorted, weighed, and length measurements undertaken of the largest components like fish, squid and crustacean macrozooplankton. Species identification were undertaken to the nearest possible taxonomic unit, usually to genus or species level.

Fish and zooplankton acoustics

The Simrad EK60 echo sounders were equipped with transducers of three frequencies: 18 kHz, 38 kHz and 120 kHz at 1 ms pulse duration. The echo sounders were connected to transducers mounted on a protruding instrument keel with transducer faces ~3 m below the hull, usually ~8.5 m below the sea surface. Only area backscattering values (s_A) from the 38 kHz was allotted to various species or groups of scatterers, but the same allocation to species was assumed also for the other two frequencies, and data from all frequencies were stored in the acoustic database. The frequency response of scatterers and inspection of echograms at other frequencies were used in addition to the catch from near-by trawl hauls as auxiliary information when scrutinizing and interpreting the echograms. The s_A-values were distributed to the following groups: capelin, herring, polar cod, blue whiting, Norway pout, cod, haddock, redfish, saithe, O-group mixed, plankton mixed and other scatterers, according to the protocol for acoustics during the ecosystem survey. The LSSS post-processing software was applied for scrutinizing acoustic data, while the data were stored in the LSSS database as well as in the S2D Echosounder database with 10 m (vertical) by 1 nautical mile (nmi) horizontal resolution. This year, the "Korona" preprocessing software was run on all raw acoustic data files before they were loaded in LSSS. The preprocessing consisted of a number of filters for removal of various kinds of noise, including spike-filtering (to remove unwanted acoustic temporal noise from e.g. trawl sensors during trawl operations), compensation for the placement of transducers, and other noise removal. The main tool for identifying plankton and fish was the frequency response and trawl data were used to corroborate the interpretation of the acoustic data. More information about the scrutinizing can be found in the SI_ARCTIC 2015 cruise report (Ingvaldsen et al., 2016). The acoustic backscattering data were in the form of s_A, Nautical area scattering coefficient (NASC) in units of (m^2 nmi^{-2} – MacLennan et al. 2002).

A SIMRAD WideBand Autonomous Receiver (WBAT) with two center frequencies (70 kHz and 200 kHz) was mounted on the CTD (23 stations). The WBAT was set to work in the frequency bands 50-90 kHz and 150-250 kHz. At most of the stations the instrument was lowered and lifted with about 0.5

cm/s to increase the number of pings per meter, but at some stations the speed through the water was 1 cm/s.

Fish sampling

Pelagic fish

Sampling of pelagic fish was conducted with an Åkra trawl (353) which is a medium large (538 m circumference) pelagic trawl with a net with a mesh size of 8 mm in the net in the cod-end. The trawl was equipped with a Multisampler; a device with three nets (8 mm) who could be opened and closed at predefined times (depths). The three nets were as a standard deployed at 1) lower base of the deep scattering layer (400-450 m depth), 2) high concentrations/particular scatters in deep scattering layer (300-350 m depth) and 3) at 50 m depth. Each depth layer was trawled for 30 min (23 hauls, most of them with 3 nets, Figure 2 and Table A1). The trawl geometry was determined/visually inspected by a trawl sonar placed over the mouth of the trawl, attached to a cable to the vessel, which showed that the trawl geometry was good.

This year, the rigging of the Harstad trawl, which has been used for special 0-group hauls as well as for targeted trawling for fish for several years, was somewhat changed. The sweeps were shortened from 110 m to 60 m, and the steel wire was replaced by “spectra” ropes. In the lower frontal panels, an extension of 4 m steel chains with 140 kg weights were connected to the sweeps. The cod end was also new, with knotless linen and a fish-lock mounted in the front end of the cod end. The trawl (1603) was tested before use and a short report of the performance is given in Appendix B (in Norwegian). When used for standardized 0-group hauls, two “A7” floats, six “A4” floats, and 20 8” floats were attached to the top front of the trawl. These hauls are standardized with trawling for 0.5 nautical miles in each of the depths 0, 20 and 40m. 19 number of hauls were made with the Harstad trawl, 17 0-group hauls and 2 targeted hauls for fish (Figure 2, Table A1).

Demersal fish and benthos

Sampling of demersal fish and benthos was conducted with a Campelen trawl which is a small demersal trawl originally designed for catching shrimps. The trawl was rigged with deep water floats according to standard specification by IMR. Two trawls (1604 and 1042) were tested before use and a short report of the performance is given in Appendix B (in Norwegian). Trawl 1042 were used throughout the survey. Trawling time was 15 min at seabed. 28 hauls were conducted with this trawl (Figure 2, Table A1).

Sorting and sampling

Trawl catches (full catches or subsamples) were sorted to species level. Individual sampling (length, weight, age, stomach content) according to IMR standard procedures were conducted for cod, capelin, polar cod, Greenland halibut, haddock and redfish caught in Campelen trawl.

Benthos

Benthos was collected and identified on board on all Campelen stations (Figure 2, Table A1).

Marine mammals

Visual observations of marine mammals were conducted by 3 experienced observers on the bridge covering approximately the front 90° sector (45° each). Species were recorded along the cruise transects when steaming between stations, provided visibility and weather conditions were acceptable. Species were also recorded when the ship was cruising along the ice edge and even when it was working its way through the ice. Observations were made during some of the station work – primarily when weather and visibility permitted.

The spatial coverage of the sightings is obviously completely determined by the cruise track (see Figure 1) as well as by visibility and suitable sighting conditions. Thus “no sightings” does not mean that there were no marine mammals present.

Results

Sea ice distribution

Temporal development of the sea ice distribution and cruise tracks are shown in Figure 3. The sea ice retreated northwards during the survey. The shallow shelves northeast of Nordaustlandet was ice covered in the beginning of the survey, but become free of ice during the survey period.

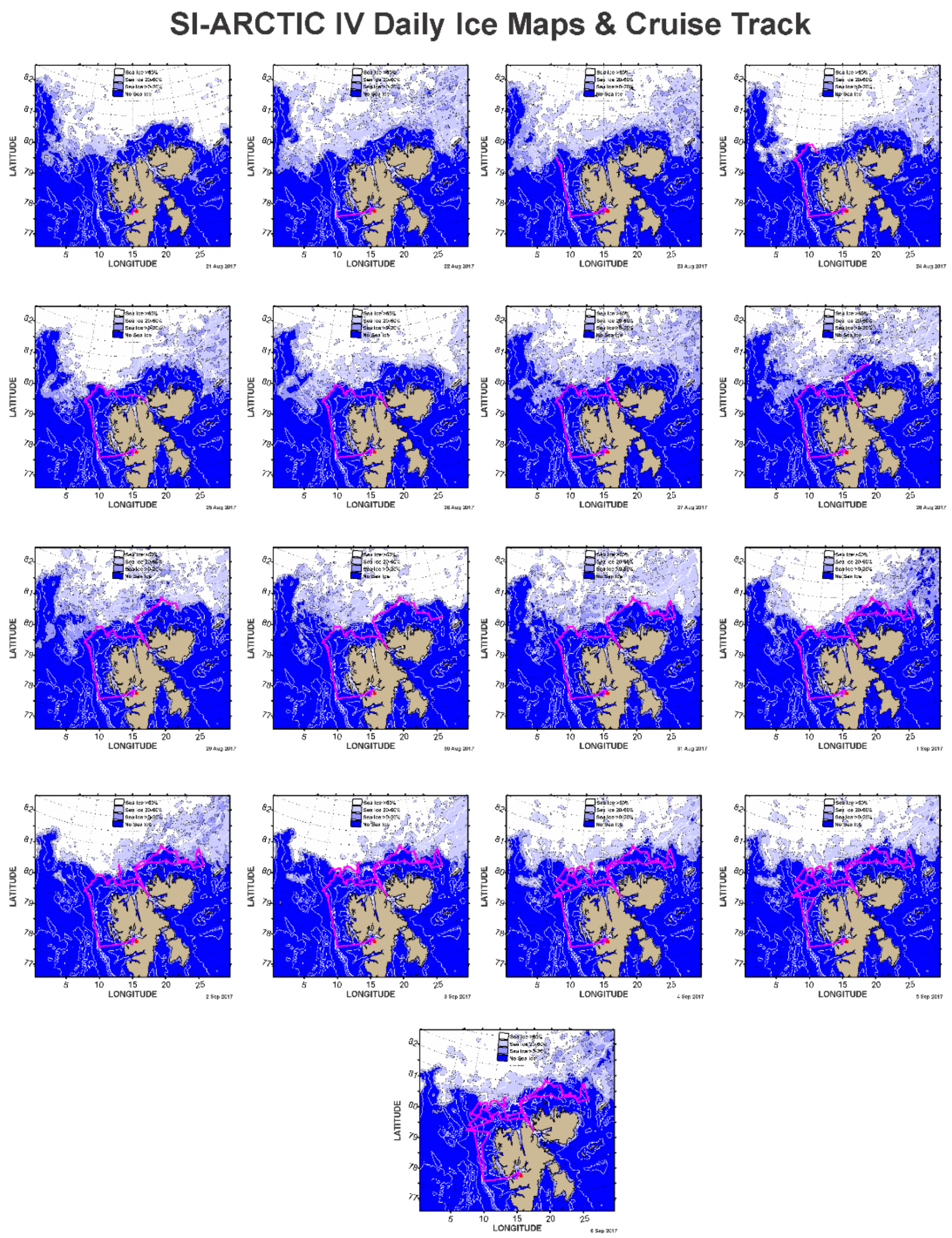

Figure 3. Sea ice concentration and cruise track for each day of the cruise.

Underway meteorological and oceanographic measurements

Along-track sea surface temperature (SST), air temperature, air pressure, wind speed and wind direction are shown in Figure 4. SST were 6-8°C in Isfjorden and along the western Spitsbergen coast, but decreased rapidly to sub-zero temperatures when reaching the sea ice at the western Yermak Plateau (25 August). The lowest SSTs (-1.7°C) were observed at the western Yermak Plateau when reaching this location heading south (on 3-4 September). Relatively high temperatures (~4°C) were observed on 2-3 September north of Svalbard, and at the end of the survey when reaching the region northwest of Isfjorden. Note that no data were logged when conducting the Hinlopen section (on 26-28 August). The air pressure was relatively high (>990 mbar) most of the time. The wind speed was varying between 0 and 18.5 m/s, and the dominating wind direction was southerly.

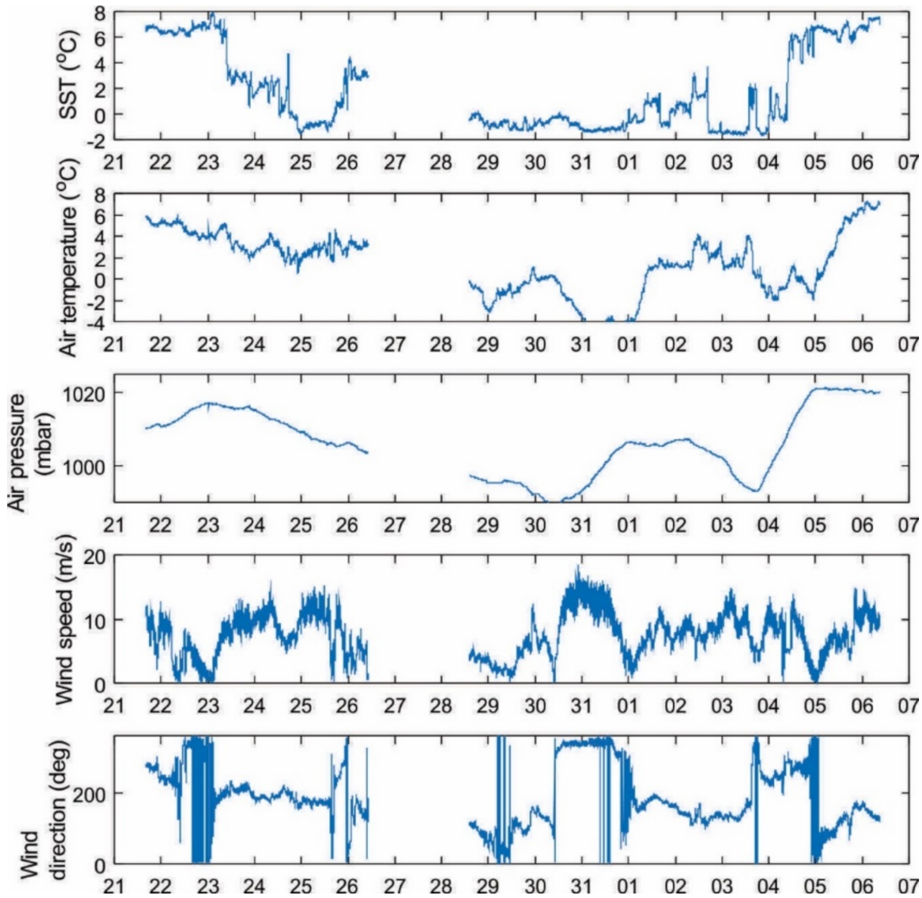

Figure 4. Along-track sea surface temperature, air temperature, air pressure, wind speed and direction during the survey 21 August-7 September 2017.

Light

Measurements of surface PAR during the cruise is shown in Figure 5. There were observed a substantial daily variation in surface PAR during the survey. During days with no or low cloud cover the PAR range between approximately 1500 µmol $m^{-2}s^{-1}$ during daytime and ~50 µmol $m^{-2}s^{-1}$, with the lowest intensity around midnight. A weaker daily variation was observed in period with cloudy weather and in days with fog (300 to 13 µmol $m^{-2}s^{-1}$).

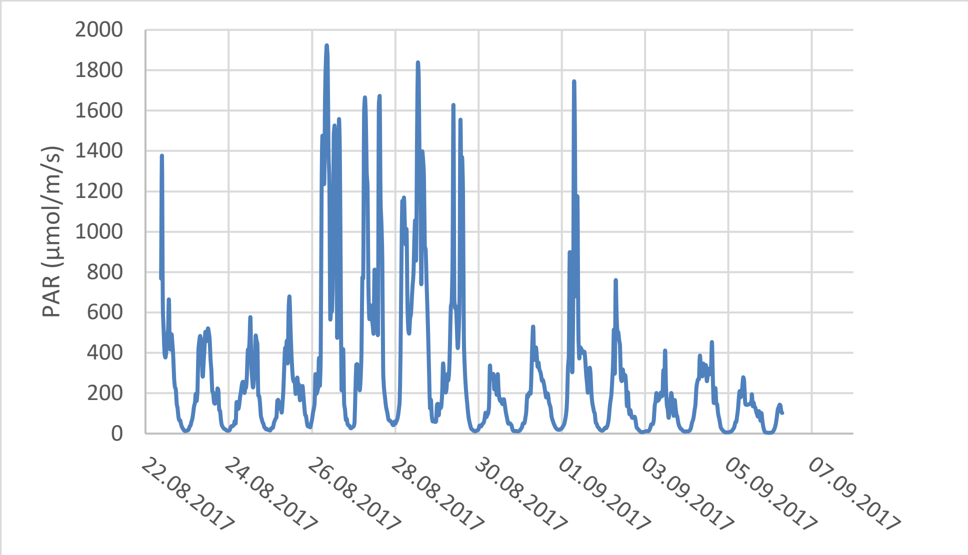

Figure 5. Light intensity. Measurements of surface PAR from 22 august to 6 September 2017. Average light intensity for every 30 minutes as µmolm^{-2}s^{-1} based on the Biospherical sensor QSR2100.

Physical oceanographic measurements and fluorescence and oxygen

Interannual variability

Case study 1 (west of Isfjorden) and Case study 2 (Hinlopen) have been sampled every year 2014-2017 and are thus the most suitable we have for investigating interannual variability (although each of them is only one station on the slope and should therefore be used with caution). The figure implies that the region west of Svalbard (Case study 1) were about as warm as in 2016 and with substantially higher temperatures as compared to 2014 and 2015 (Figure 6). North of Svalbard on the other hand (Case study 2), 2017 were about as in 2014 and 2015, and colder than in 2016. This indicates that in 2017, substantial amounts of heat have been lost from the upper 300 m during advection from west of Svalbard to north of Svalbard.

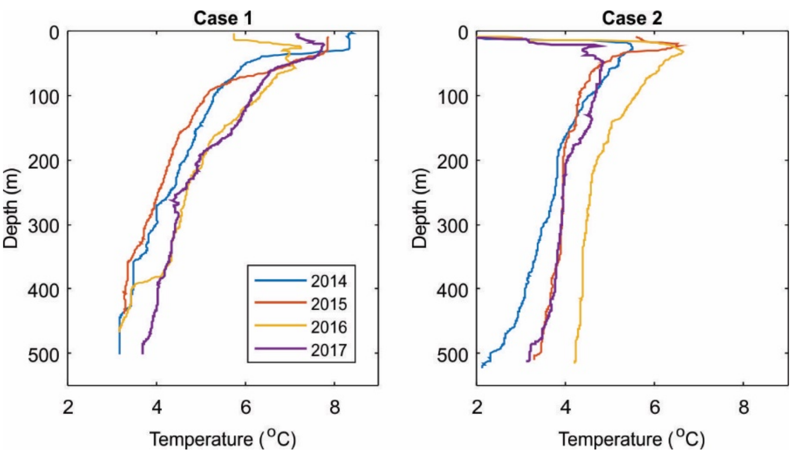

Figure 6. Temperature in Case study 1 (left) and Case study 2 (right) all years 2014-2017.

Investigating all stations in the Hinlopen section, it is evident that from Hinlopen 5/Case study 2 and northwards (Hinlopen 6 and 7), 2017 was colder than the three former years (Figure 7). In the Hinlopen trench on the other hand (i.e. Hinlopen 4 and southwards), the conditions were similar to 2014 but in general colder than in 2015 and 2016.

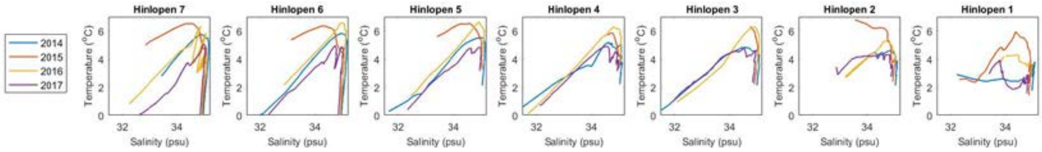

Figure 7. Temperature-salinity plots of all single stations in the Hinlopen section for all years 2014-2017. Hinlopen 5 and case study 2 are the same station.

<u>Shallow shelves northeast of Nordaustlandet</u>

As part of the Arctic Ecosystem survey, several stations were sampled on the shallow shelf northeast of Nordaustlandet (Figure 1). These areas were not covered during the 2014-2016 surveys due to sea ice and time limitations. Most of the areas were ice covered when this year survey started, but the ice retracted during the survey making the shelves newly ice free when arriving (Figure 3). Thus, these waters have been isolated from the atmosphere possibly since ice started to form during autumn/winter 2016. Vertical profiles of the stations east of 25^{o}E and with bottom depths shallower than 200 m are shown in Figure 8. All profiles show negative temperatures in the entire water column, and some stations show a cold halocline. Atlantic Water (T>0^{o}C and S>34.9) is not present at all. High values of fluorescence, oxygen and turbidity are evident in 20-30 m depth.

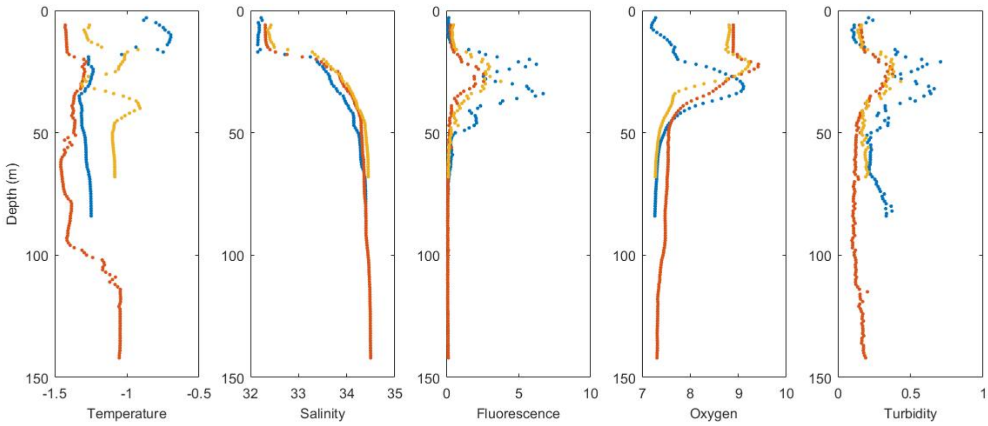

Figure 8. Vertical profiles of temperature, salinity, fluorescence, oxygen and turbidity for the stations on the northeastern shelf of Nordaustlandet (east of 25^{o}E and with bottom depths shallower than 200m depth).

The Kvitøya Trough is a narrow, deeper (~500 m) trough between Nordaustlandet and Kvitøya. When crossing this trough, highly interesting recordings were evident on the eco sounder thereby motivating a station on registration on this location. The station was put in the middle of the trough and was partly ice covered at the time. The profiles show substantial vertical gradients (Figure 9). There was a vertical homogenous upper layer (15-20 m) of Polar Surface Water (PSW) with salinities close to 32.3 psu and temperatures around -1.3^{o}C. Below this the salinities increased causing a strong halocline, while the temperatures decreased weakly to a minimum of -1.4^{o}C at 50 m depth. The cold halocline was evident with a high stability (i.e. Brunt-Vaisala frequency), and maximum fluorescence and turbidity as well as elevated oxygen levels were found just below the halocline (25-30 m depth). PAR decreased rapidly from surface towards the halocline/level of maximum fluorescence, being close to zero just below it. Below the halocline, temperature and salinity increased, but never above 1.6^{o}C and 34.77 psu. Several temperature and salinity inversions were present, giving unstable conditions at those levels (Brunt-Vaisala in Figure 9). The TS-diagram show that the upper 50 m of the water column had properties following the freezing line, while the waters below were mostly confined to the 27.8 isopycnal indicating isopycnal mixing (Figure 10 left). The instabilities in the TS-properties (Figure 10 right) indicate mixing with diffusion (salt fingering).

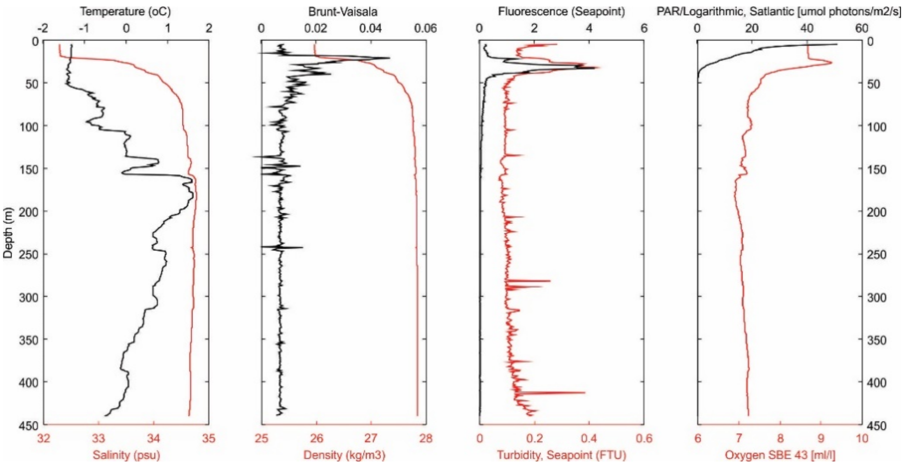

Figure 9. Vertical profiles of temperature and salinity (leftmost panel), Brunt-Vaisala frequency and density (second left), fluorescence and turbidity (second right), and PAR and oxygen (right panel) at CTD station 114 in the Kvitøya Trough.

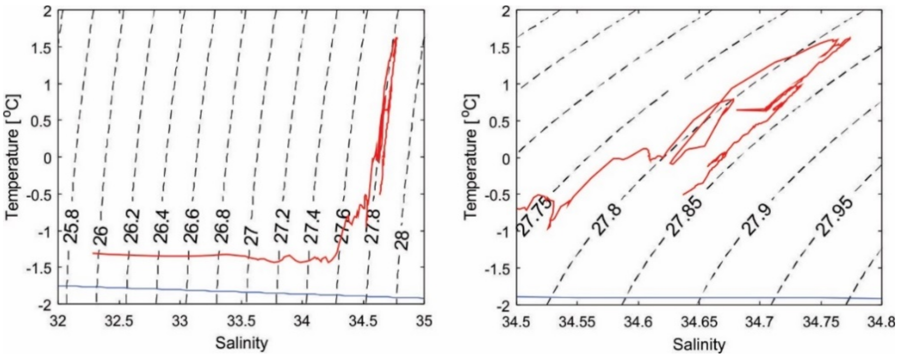

Figure 10. TS-plot of CTD 114 in the Kvitøya Trough. Left figure shows full profile, while right figure shows a zoom of the profile below 50 m depth.

Current measurements

Figure 11 shows the de-tided (tides removed) VM-ADCP current vectors measured during the survey and Figure 12 an interpolated circulation pattern derived from the data. We crossed the West Spitzbergen Current (WSC) just outside of Isfjorden, and measured a corresponding strong northward flow of Atlantic Water. Following the shelf break northwards revealed irregular patterns of strong and weak northward flow, which are likely related to recirculation and eddies. On the western shelf break of the Yermak Plateau (around 80^{o}N), currents became even more variable. We recorded a counter clockwise rotating eddy and a strong on-shelf flow event. Interestingly we also recorded a strong northward along slope flow of Atlantic Water, which likely represents the branch of Atlantic Water that follows the shelf break around the Yermak Plateau. Upon reaching the southwestern edge of the Yermak Plateau the Atlantic boundary current became visible again as strong eastward flow between the 1000 and 200 m depth contours. In the Hinlopen strait we observed a northward flow throughout most of the strait, with a minor southwards flow event towards the inner end of the transect, that are likely related to tides and frontal areas. The Atlantic inflow (~ 0.2-0.3 ms^{-1}) into Nansen Basin was again detected along the shelf break north of the Hinlopen strait and Nordaustlandet. Currents were weaker and more variable on the shelf east of the Hinlopen Strait, and partly followed topographical patterns (hill and valley structures). The crossing of the Kvitøya Trough approximately reproduced the circulation pattern proposed by Pérez-Hernández et al, 2017.

The L-ADCP data (Figure 13) indicate that the majority of profiles was barotropic, meaning that the current velocity was relatively constant with depth. This is also reflected in the T-S plot in the right-hand panel of Figure 13. The strongest northward currents were measured in Atlantic Water, and partially in warm Polar Surface Water. We observed < distinct baroclinic current profile within Hinlopen strait, with much stronger southward velocities in the warm Polar Surface Water layer. In the T-S plot it is visible as black-blue line between 1-4^{o}C.

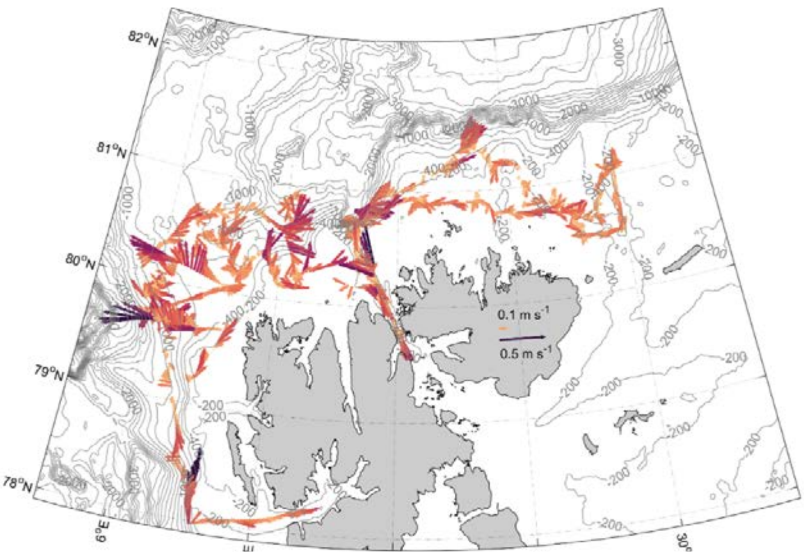

Figure 11. Map of de-tided and depth averaged current vectors within the range of the VM-ADCP (approx. 0-500m depth). Color scale ranges from 0 to 0.5 ms^{-1}.

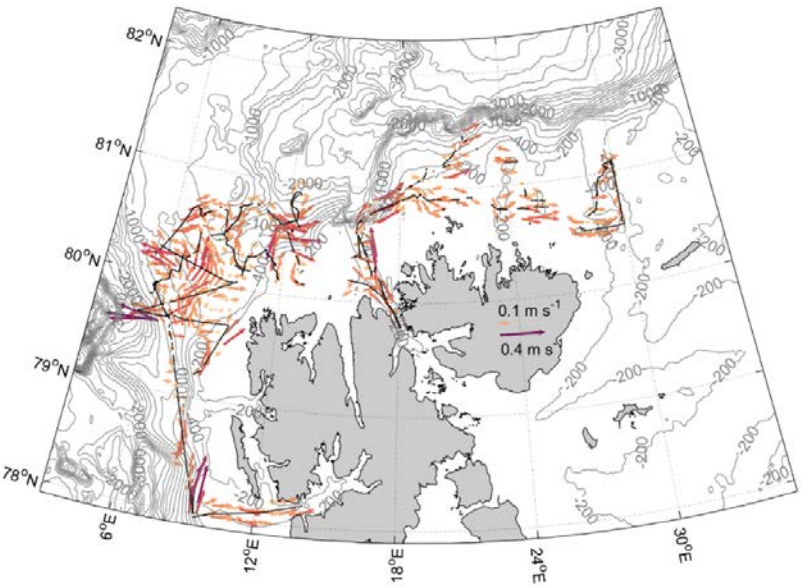

Figure 12. Objective mapping interpolation of the VM-ADCP current profiles gathered along the survey track. The color scale represents the absolute velocity from 0 to 0.4 ms^{-1}. The black line indicates the location of the VM-ADCP data used for the interpolation.

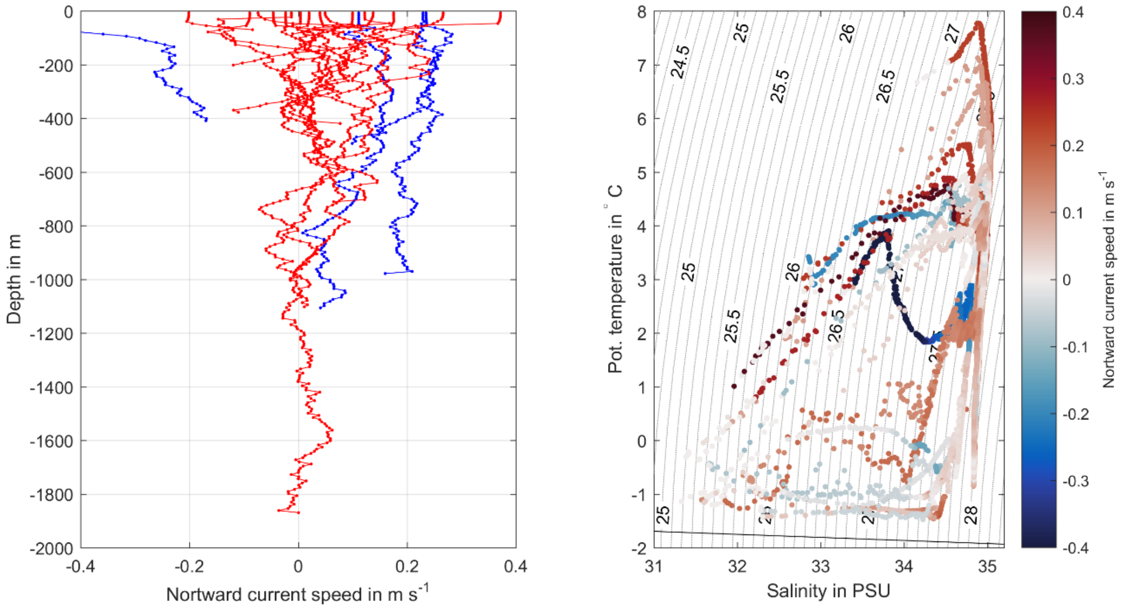

Figure 13. Overview of the L-ADCP data. The left panel displays the depth profile of northward velocity, blue colors highlight profiles south of 80 deg. N and red colors profiles north of 80°N. The right panel displays the northward current velocity data within a temperature and salinity plot.

Zooplankton collections (meso and macro)

One of the target groups during this field campaign, as the previous three seasons, was the highly important *Calanus* complex, consisting of the three species *Calanus finmarchicus*, *C. glacialis* and *C. hyperboreus* that to a smaller or larger degree co-occur in the study region, since the region is significantly influenced by water masses of both Atlantic and Arctic origin. *C. finmarchicus* is a key species in Atlantic boreal waters while the other two species can be considered true Arctic species having their center of distribution on the Arctic shelf (*C. glacialis*) and in the Arctic Ocean and Greenland Sea (*C. hyperboreus*).

The Macroplankton trawl was used to target the slightly larger and more motile macrozooplankton like krill, amphipods and mesopelagic shrimps. Due to the larger mouth area of the Macroplankton trawl, mesopelagic fish are also possible to quantify if present, although the limited data obtained so far, suggests that this component diminishes rapidly moving from the northern part of the Norwegian Sea through the Fram strait and into the Arctic Ocean. However, the few number of hauls conducted so far still leaves this an open issue. Sampling with a pelagic trawl in partly ice-covered areas is an additional challenge for obtaining quantitative information on the distribution and biomass of fish and macroplankton in the mesopelagic domain.

In all regions sampled, there were observed mixed mesozooplankton communities with all *Calanus* species present on many of the stations. Due to seemingly high variation in phytoplankton abundance, variable oceanographic conditions, and impact of water masses of both Arctic and Atlantic origin, the mesozooplankton community varied considerably from one station to another. Both in 2016 and 2017 depth stratified sampling was planned, but because of time and personnel constraints, not undertaken. By qualitatively assessing the mesozooplankton samples, high biomass could be traced on some stations while other stations had quite low biomass. During size fractionation of samples, it was noted quite high biomass both for the 180 µm and 1000 µm size fractions on a couple of occasions. Since most of the younger copepodite stages (CI-CIII) of *C. finmarchcius and C. glacialis* will be found on the 180 µm sieve, and not be retained on the coarser 1000 µm sieve, high biomass on the former suggests high activity and abundance in the surface layers since the younger stages are mostly located here. Other copepods found on the 180 µm fraction, were *Oithona* and *Oncea*, and to some extent *Pseudocalanus*. However, the size composition of *Calanus* sp. makes it difficult to determine which of the two species *Calanus finmarchicus* and *Calanus glacialis* these copepodites could be assigned to since there is strong evidence that their sizes for a given copepodite stage overlap considerably (cf. Parent et al., 2011). Species separation needs to be resolved by more detailed taxonomic analyses in the onshore laboratory and later by genetic analysis. The biomass retained on the 1000 µm fraction normally contains the majority the *Calanus* sp. CIV, CV and CVI's, but due to the sampling procedures, integrated sampling from bottom-0 m, it cannot be currently resolved if these were abundant in the surface region or had departed to deeper waters for overwintering. Only a few females were spotted during the brief, but admittedly incomplete examination of the raw samples.

Macroplankton like the krill *Thysanoessa inermis*, *Thysanoessa longicaudata*, *Meganyctiphanes norvegica*, the amphipods *Themisto abyssorum* and *Themisto libellula* were caught on numerous occasions and were sometimes highly abundant. On the shelf north of Spitsbergen different scattering layers were observed that could be assigned to krill, like *Thysanoessa inermis* or the two species of amphipods, the Atlantic *Themisto abyssorum* and the Arctic *Themisto libellula*, although a more detailed inspection of the acoustic data as well as the biological samples will be necessary to make any firmer conclusion whether these layers are monospecific or consist of a mixture of amphipods and krill. Some catches suggest that both scenarios are possible. On a couple of occasions targeted trawling for specific acoustic structures close to the surface, revealed that *Themisto libellula* was a dominant scatterer in the Arctic influenced cold-water region north-east of the Hinlopen. The Northern krill *Meganctiphanes norvegica* having its center of distribution much further south, was observed in many of the tows both on the northern Svalbard shelf, and over deeper waters north of the shelf break, although it was hardly observed in the shallow shelf area east of the Hinlopen Strait. As in 2016, specimens of the krill *Nematoscelis megalops***,** a temperate Atlantic species**,** was found in this region. This year one specimen was caught as far north as 81 degrees 28.0769'N and 21 degrees, 39.605'E. The occurrence of the latter two species indicates sustained advection of warm Atlantic water and transport of organisms from more southern regions. In some Macroplankton tows a substantial amount of chaetognaths and the sea angel *Clione limacina* (Gymnosomata) were observed, occasionally including numerous young of the year, due to their small size. Also in several deep-water tows off the shelf a substantial amount of the mesopelagic shrimp *Hymenodra* sp. was recorded along with moderate amounts of *Benthosema glaciale*, a mesopelagic myctophid, being more common and abundant further south in the Norwegian Sea, and possibly the only representative of this group in these northern waters. Another mesopelagic fish that was recorded on several occasions was *Arctozenus risso* (=liten laksetobis) (Paralepididae). Single individuals were caught in some of the Macroplankton trawl hauls in 2017, but was observed in larger quantities in the larger Åkratrawl and even in the Campelen bottom trawl catches on a couple of occasions.

Fish and zooplankton acoustics

Since the survey in 2017 forms part of the Arctic Ecosystem Survey, the acoustic data were allocated to the groups decided by the organizers of that survey, which, for instance, means that mesopelagic fish and mixture of krill and amphipods, used at previous SI_ARCTIC-surveys, were not applied this year. For this reason, the mesopelagic layer observed offshore along the west coast of Svalbard, is grouped among “plankton” and/or “other scatterers”.

The bulk of the scattering came from cod, 0-group and plankton. S_A-values up to about 3000 m^2/nmi^2 were recorded northwest of Svalbard. Polar cod, although present in several demersal trawl hauls (see below), did mostly not form concentrations that could be recognized in the water column. Capelin were also found in some trawl hauls, but no registrations of capelin could be seen on the echosounder and no s_A-values have been allocated to capelin.

The total scattering was highest along the northern west coast of Svalbard (Figure 14), and decreased further eastwards north of the archipelago. This pattern is mostly due to the backscattering from cod, which was high on the shelf north of Svalbard and partly along the west coast, while it was absent from the areas east of about 20°E (Figure 15). 0-group fish, being a mixture of many pelagic and demersal species, showed high backscattering along the west coast, but decreased eastwards north of Svalbard and were practically absent east of 25°E (Figure 16). The densest recordings of 0-group fish were found over the inner parts of the Yermak Plateau, where the values exceeded 3000 m^2/nmi^2. In that area, the catches from the trawls showed that the mixture of 0-group mostly consisted of redfish. The plankton which are recorded on the echo sounder mostly consist of large forms like krill and amphipods, and such recordings were found both in the upper parts of the water column and deeper down, often down to the sea floor. The highest recordings of plankton (Figure 17) were found in the southwestern part of the Yermak Plateau, but high concentrations were also recorded in the Hinlopen area and outside the northeastern corner of Nordaustlandet, at about 30°E.

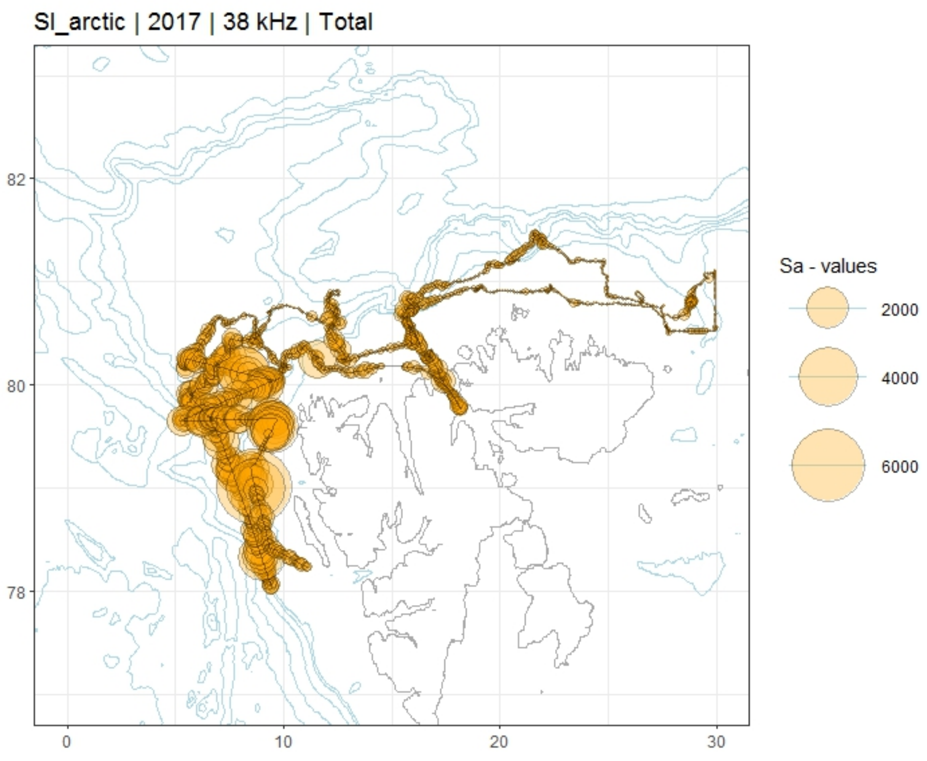

Figure 14. Total scattering from 38 kHz during the survey.

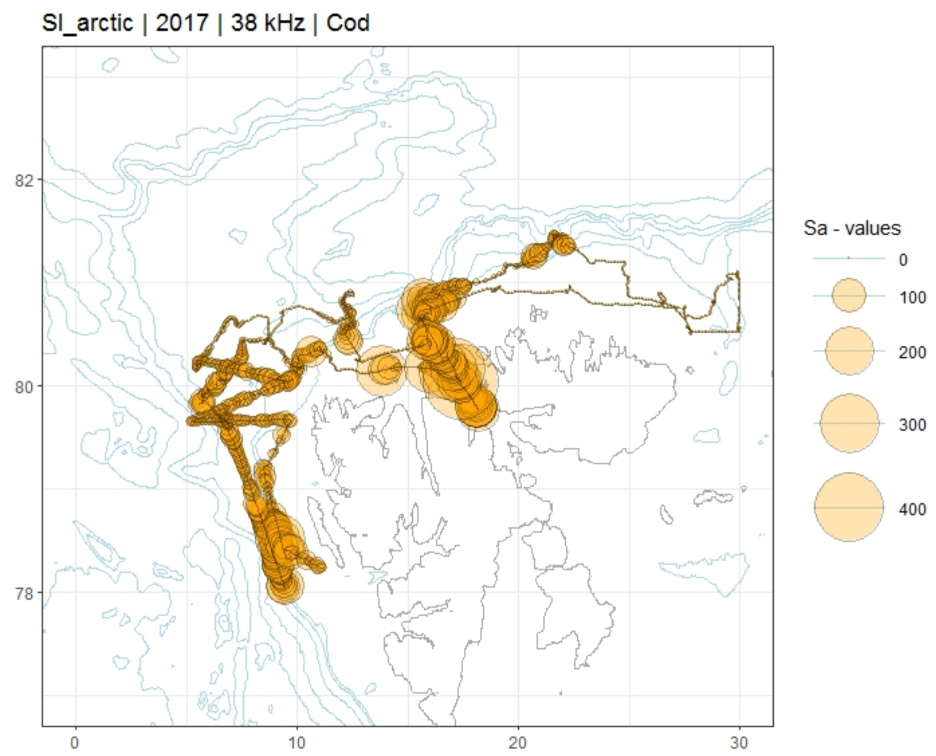

Figure 15. Scattering from cod.

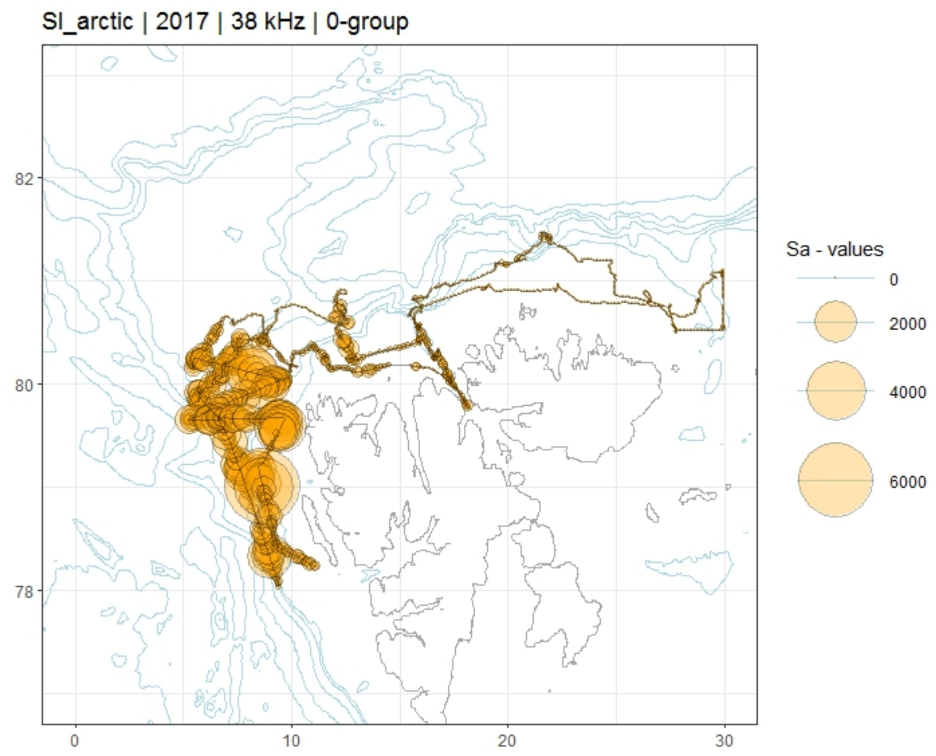

Figure 16. Scattering from 0-group.

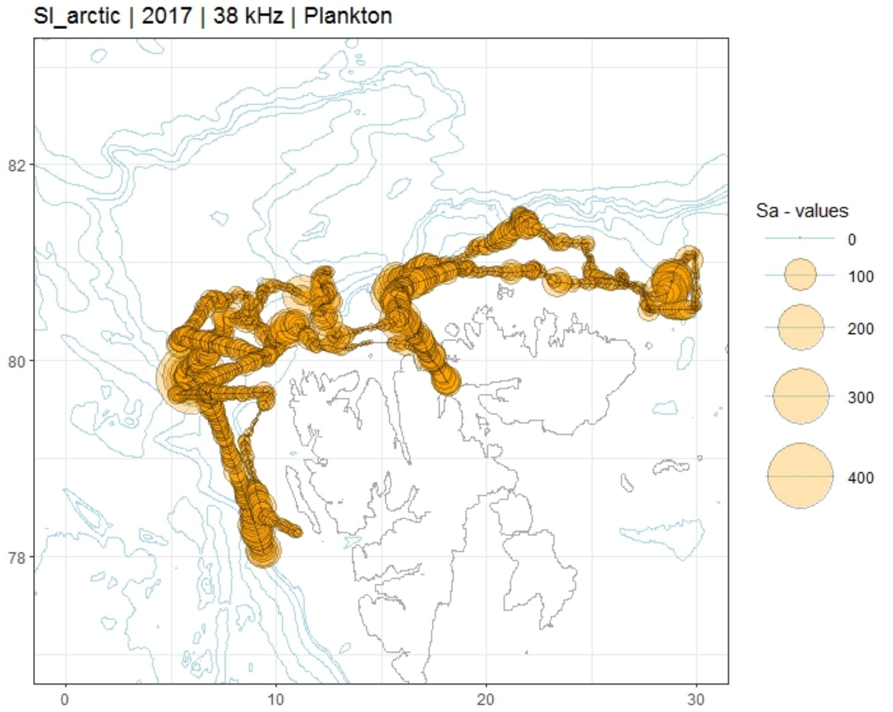

Figure 17. Scattering from plankton.

Fish sampled by trawls

Demersal trawl (Campelen with standard rigging – code 3271)

The standardized catches (kg/nmi) in demersal trawl hauls peaked in the continental slope in the northeasternmost parts of the survey area where one large catch of *Geodia* sp. sponges was taken (Figure 18), but large catches were also taken north of and west of Hinlopen, and in Isfjorden, where the catches was dominated by cod. Altogether, 44 species of fish were taken in the demersal trawl hauls. Apart from the large catch of *Geodia sp*. in trawl station no 170, cod dominated in the Campelen trawl. Cod was caught in 22 bottom trawl hauls, and in 5 hauls the catch exceeded 50 kg.

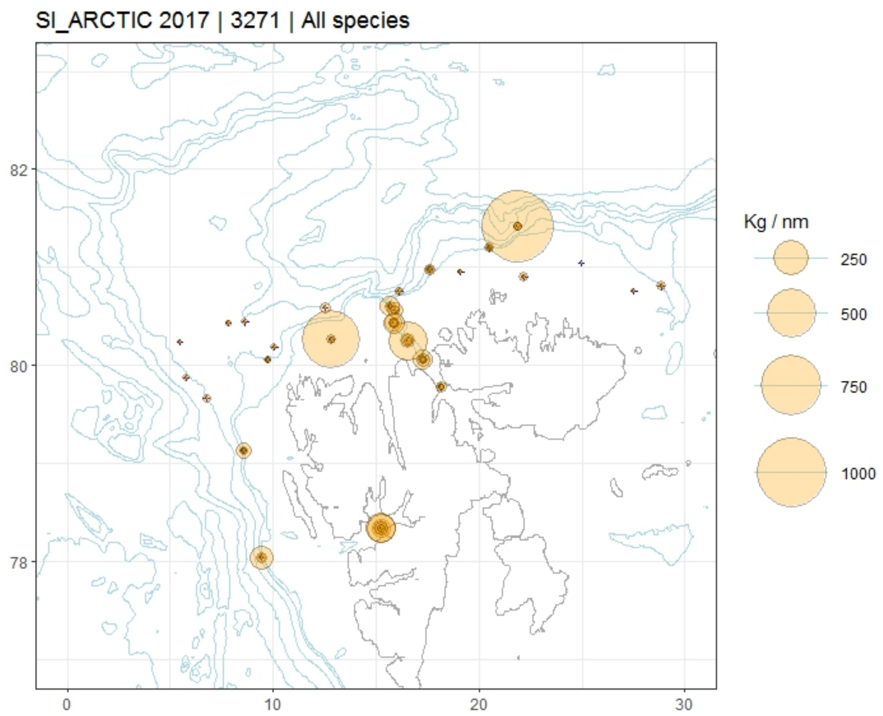

Figure 18. Total catch in demersal trawl of all species.

Åkra trawl (with multisampler – code 3541)

Twenty species of fish were caught in the Åkra trawl, and in addition eight taxons of plankton. Only larger zooplankton are caught in this trawl. The multisampler allowed for samples taken from three different depth layers. The composition in the three samples (usually two samples from the mesopelagic layer and one from about 50 m depth) differed, but a detailed analysis of the catch composition has not been undertaken.

Harstad trawl (rigged as 0-group trawl – code 3514)

Seventeen fish species and eight plankton taxons were recorded in the 0-group-hauls. Mainly large zooplankton are retained in the Harstad trawl cod end. Mostly 0-group fish were caught in these hauls, and main species were cod, haddock, redfish, and polar cod.

Harstad trawl (rigged without floats – code 3513)

Two hauls were taken with the Harstad trawl for identifying scatterers observed on the echo sounder, and 0-group cod and amphipods dominated in one, and krill dominated in the other.

Quantitative mapping of mega-benthos

Identification and measures of mega-benthos was made from 29 Campelen trawls (without extra floats for Tromsørigging) in 2017 (Table 1). More than 200 species were recorded. Station 2001, 2002 (Isfjorden), 2006, 2030, 2037 and 2046, had either highest species number, counts and biomass or a combination of these. Station 2072 had both low count and biomass, but relatively high species number.

Snow crab was recorded on st. 2078 (approximately at 450 m depth), and was the first record made west of Svalbard. A new, and relative large catch was made of the octocoral *Isidella lophotensis* at station 2046 (640 m depth) together with the largest catch of the sponge *Geodia* spp. The largest catch of octocoral *Umbellula encrinus* was made on station 2074 at approximately 900 m depth. The deep-sea shrimp *Pandalus borealis* made up the largest catch at station 2002, 2006 (Isfjorden and outside on C1) and 2037 (Hinlopen strait).

Table 1. Stations covered in 2017, with baseline data.

Year	Serial no	Depth	Records of taxa	Abu/100%catct	Biomass (kg/100%catch)
2017	2001	263	19	14610	59.41
2017	2002	263	11	10205	327.96
2017	2006	496	38	3224	118.50
2017	2014	1041	41	256	1.38
2017	2016	771	34	220	2.16
2017	2020	554	44	2343	13.22
2017	2025	424	15	4204	24.76
2017	2030	385	17	13268	78.82
2017	2034	338	22	1036	13.81
2017	2036	297	37	4176	152.66
2017	2039	438	28	183	1.42

2017	2043	319	21	118	5.64
2017	2046	645	54	7196	839.85
2017	2047	104	32	2895	9.14
2017	2050	118	54	3823	13.48
2017	2054	442	34	7941	49.75
2017	2059	124	39	5342	24.29
2017	2061	167	46	829	2.76
2017	2062	922	48	303	2.41
2017	2065	311	38	4598	20.88
2017	2067	394	19	351	50.77
2017	2070	164	32	189	1.47
2017	2072	1006	34	125	1.19
2017	2074	898	36	177	5.04
2017	2076	718	34	317	30.24
2017	2078	255	44	1409	10.36
2017	2081	1000	30	255	1.96
2017	2083	300	32	624	2.06

Marine mammals

A total of 18 blue whales, 8 fin whales, 9 common minke whales, 2 unidentified large whale, 5 killer whales, 126 white-beaked dolphins, 114 harp seals, 12 ringed seals, 70 bearded seals, 4 walruses and 1 unidentified seal were observed throughout the survey (Table 2). The spatial distributions of these sightings are shown in Figure 19.

Baleen whales, particularly blue whales, were most frequently observed in the eastern areas while white nosed dolphins were only seen in the west where they dominated. Some blue whales were observed foraging at the sea surface, and both fin, blue and common minke whales were observed to be present well into the open drift ice. Harp seals were distributed in larger and smaller numbers along the entire ice edge surveyed. The open drift ice along the ice edge were situated over shallow water both north of the Moffen island, and west, north and east of the Seven Islands – in both areas, considerable numbers of bearded seals were observed hauled out on the ice. In areas where the open drift ice was situated close to the edge of the continental shelf in the north, young hooded seals were quite abundant. As in 2016, humpback whales, frequently seen in both 2014 and 2015, were not observed at all in 2017. The high number of harp seals is of course a result of the priority to survey the ice edge which is their preferred habitat.

During all SI_ARCTIC surveys, “hot spots” with particularly large numbers of baleen whales were observed north of Svalbard along the transect proceeding from south to north from the Hinlopen Strait. The northernmost of these hot spots was located on the shelf break in 2014, 2015 and 2017. The other hot spot was located further to the south, at the mouth and within the Hinlopen Strait – in these areas no whales were observed in 2014 and 2016. The Hinlopen whales were primarily fin and blue whales. Both these and the harp seals observed scattered along the ice edge surveyed, are known to feed intensively on zooplankton, particularly krill and amphipods during summer and autumn.

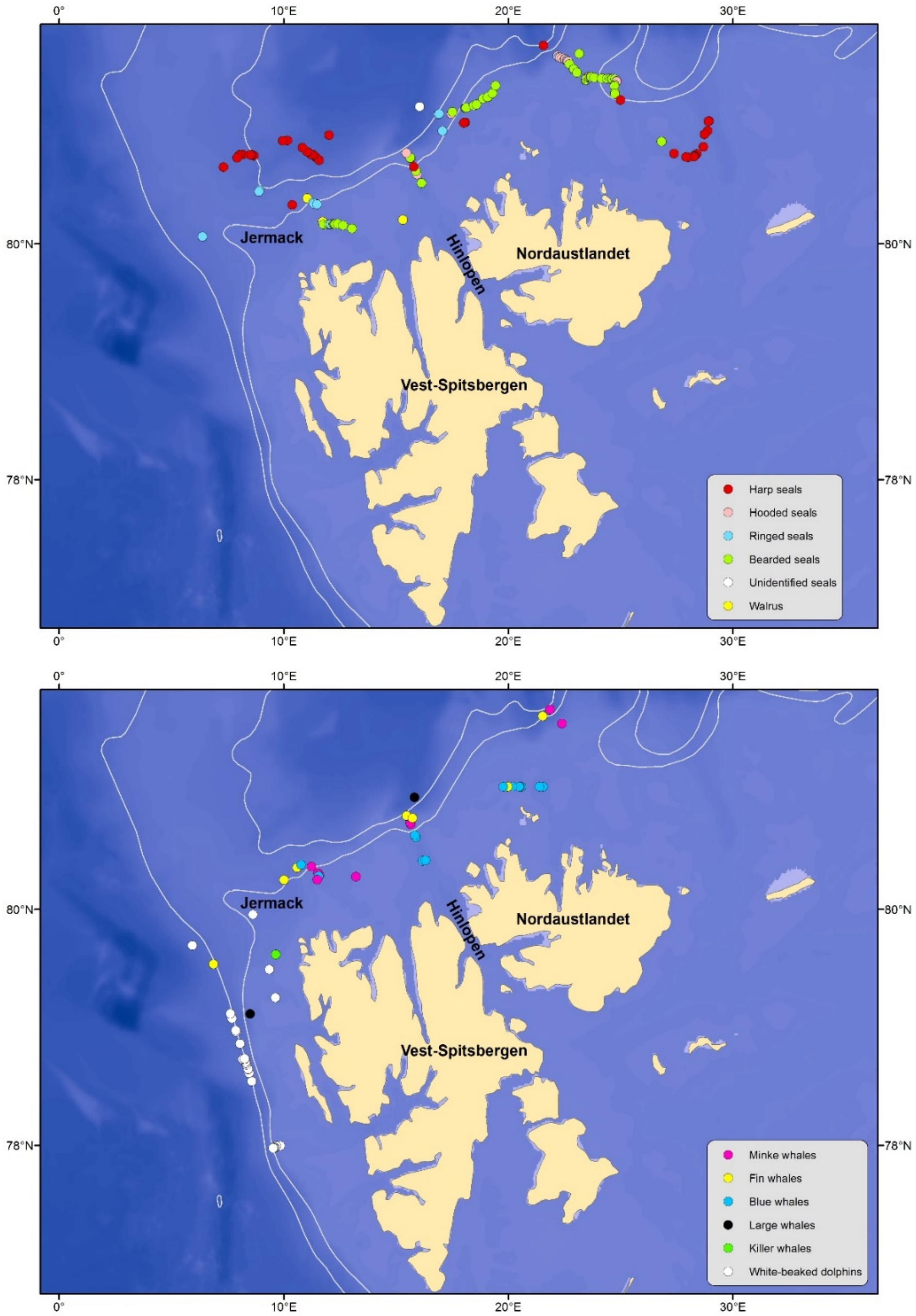

Figure 19. Locations where groups of seals (above) and whales (below) species were observed. Each location denotes one sighting. For some of the sightings several animals were part of the observation. The 500 m and 1000 m depth contrours are shown.

Unfortunately, harp seals were never observed to haul out on the ice during the survey. With difficult ice conditions and lots of swell, the planned sampling of harp seals became very difficult. Only one seal was shot and sampled. Sampling included parameters such as weight and length, blubber thickness, teeth taken for ageing, stomach/intestines for diet studies and muscle, blubber, liver and whiskers for studies of contaminants and stable isotopes. For comparison, also samples of relevant prey (amphipods and some fish species, all taken from trawl samples) were secured for the stable isotope analyses.

Table 2. Number of marine mammal individuals observed in 2017, sorted by two regions; Yermak and Hinlopen. All observations are given, including also those recorded when the vessel was stationary.

Species	**Yermak** (West of 10^{o}E)	**Hinlopen and further east** (East of 10^{o}E)	**Total**
	Animals (#)	Animals (#)	Animals (#)
Large whale	1	1[1]	2
Blue whale		18	18
Minke whale		9[1]	9
Fin whale	2	6	8
Killer whale	5		5
White-beaked dolphin	126		126
Seal		1	1
Harp seal	28	86	114
Bearded seal		70	70
Ringed seal	3	9	12
Walrus		4	4
Total	**165**	**204**	**369**

[1] One animal observed when the vessel was working on a station

Discussion

The fourth SI_ARCTIC survey was a combined SI_ARCTIC and Arctic Sea Ecosystem survey and was conducted with R/V *Helmer Hanssen* 21 August −7 September 2017. The survey covered open and partly ice-covered waters west and north of Svalbard. During the survey, most parts of the marine ecosystem was sampled including physical, chemical and biological oceanography (temperature, salinity, currents, fluorescence, oxygen, nutrients and chlorophyll). Phytoplankton and zooplankton (species abundance and biomass), fish (species abundance, biomass, age and stomach content), and benthic organisms (species abundance and biomass) were sampled using a multitude of different gear. Underway acoustic registration of fish and plankton (eco sounder) and ocean currents (ADCP), underway measurements of light (irradiance), sea surface temperature, meteorology and sea state, and visual observations of marine mammals and birds were also conducted. Unfortunately, we could catch only one harp seal (for diet investigations).

2017 was characterized with large amount of ice, much like the situation in 2014 and 2016. North of Svalbard the ice edge was located more or less along the shelf-break thereby limiting the access to the deeper Arctic Ocean. The region west of Svalbard had similar temperatures as in 2016, and higher than in 2014 and 2015. North of Svalbard, on the other hand, the temperatures were substantial lower than in 2016. This implies a significant cooling of the Atlantic Water when flowing from the western regions to the northern regions, which is likely to be linked to the sea ice cover.

Arctic conditions with temperatures below 0^{o}C in the whole water column dominated on the shallow shelf northeast of Nordaustlandet. The region was partly ice covered when the survey started, and were thus open for atmospheric input (solar heating and wind mixing) only just before the investigations were conducted. During the current investigations, phytoplankton blooms were traced nearly at every station in this area. The mesozooplankton biomass caught in the WP2 and Juday nets were variable in 2017 and seemingly of less magnitude then what was observed in 2014. Regular high abundances of phytoplankton made it difficult to separate these tiny algae from the zooplankton on many stations, and left a definite mark in the aluminum dishes used for mesozooplankton biomass determination, but mostly on dishes holding the >180 µm size fraction. The biomass in this size fraction should be considered mildly contaminated by phytoplankton and numbers should be treated with caution. Both the acoustic registrations and Makroplankton trawl hauls support the understanding that krill, particularly *Thysanoessa inermis* is an extremely important organism in the shallow shelf waters north-east of the Hinlopen Strait. Also, in this region the cold-water *Themisto libellula* is an important macrozooplankter and it is often seen in the acoustic record as “a curtain” hanging from the surface to about 50 m depth, although other thinner and similar acoustic structures may also be indicative of this species.

The conspicuous feature of this year’s observations was the frequently occurring algae blooms occurring over a wider area, from the Fram Strait region to Nordaustlandet in the east, and seemingly stronger in the north-eastern region. Associated registrations of *Themisto libellula* and *Thysanoessa inermis*, will most certainly benefit from these algal blooms, but the mesozooplankton biomass recorded seem to be somewhat reduced compared to what was observed the preceding years. This also means that the conditions for marine mammals which feed on macrozooplankton, particularly the baleen whales, should potentially be good during this period.

Baleen whales, and in particular blue whales, was observed in the eastern parts of the investigated area (about from Moffen and eastwards), while white-beaked dolphin dominated in the shelf regions in the west. The blue whales were observed foraging near surface, and both blue whales and minke whales were observed well into the open drifting ice. Harp seals were present along most of the ice edge, but unfortunately only in water. The ice conditions were difficult with waves and loose ice in small pieces. This made it difficult to hunt both from the main vessels and from the smaller boat, and only one animal was caught and sampled. The ice edge was far south – and the areas near Moffen and around Sjuøyene had open drift ice covering shallow banks where many bearded seals were observed on the ice. Further north, where the open drift ice was along the shelf-break, many individuals of young hooded seals were observed on the ice.

Acoustic registration of fish showed highest values along the west coast and on the northwestern corner of Svalbard, and decreased strongly when going eastwards on the shelf north of Svalbard. The dominating species were cod, 0-group fish and plankton. Capelin and polar cod were more or less absent with regard to the acoustic registrations. The epipelagic was dominated by 0-group fish and plankton, while the mesopelagic layer, which was observed over deep water in Fram Strait, contained small amounts of cod. Cod dominated close to the bottom, and the highest concentrations were found on the shelf on the northwestern corner of Svalbard. Plankton were observed both near the surface, in the mesopelagic layer, and near the bottom when shallower than 400-500 m. The acoustics showed high concentrations of plankton north of Svalbard, and increasing densities eastwards along the northern coast of Nordaustlandet.

Cod dominated in the demersal fish trawls, although the largest catch was *Geodia* north of Nordaustlandet. Some polar cod were observed in the demersal trawls. The 0-group hauls showed that juveniles of cod, haddock, redfish and polar cod were the most abundant. In the mesopelagic layers, we caught mesopelagic fish and macrozooplankton in the deepest net in the Åkra trawl.

More than 200 species of benthos were sampled with abundance and biomass. Snow crab were observed for the first time northwest of Svalbard (at about 500 m depth). Also, the coral species (*Isidella lophotensis*) were observed for the first time (near Nordaustlandet at 640 m depth), and were caught together with large amounts of *Geodia*. Largest catches of the sea pens *Umbellula encrinus* were taken on the Yermak Plateau northeast of Svalbard at about 900 m depth, while the larges catch of the shrimp *Pandalus borealis* was taken in Isfjorden, outside Isfjorden and in the Hinlopen strait.

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Appendix A - Tables

Table A1. Station list with all gear.

Table A2. Participant list for the SI_ARCTIC 2017 survey.

Table A3. Overview of light measurements conducted with TriOS.

Appendix B – Trawl reports (in Norwegian)

Contain trawl testing reports for Campelen and Harstad trawls.

Table A1. Stations with equipment used during the SI_ARCTIC 2017 survey. Position and bottom depth are based on CTD. Station number for the different equipment is given.

Location	Date when starting (CTD)	Latitude (CTD)	Longitude (CTD)	Bottom depth (CTD, m)	Ice	CTD/ LADCP/ WBAT	TRIOS light	Water samples (nutrient, phyto)	Water samp. (C_T/A_T)	Algae net (0-30m)	WP2/Juday (bottom-0) and WPII for Limicina (50m)	Krill trawl	Åkra trawl	Campelen trawl	Comment
Shake-down	22.08	78°19.95	15°13.93	264	0									139/2001	Trawl 1604 (06:37 UTC)
Shake-down	22.08	78°19.92	15°14.28	264	0									140/2002	Trawl 1042 (07:46UTC)
Case 1	22.08 (20:45)	78°00.24	09°28.01	505	0	94		94	94	94	94	143/2007 (460)	141/2003 (462m) 141/2004 (372m) 141/2005 (63m)	142/2006	Hight Åkra trawl all hauls: 38m in two lower levels, 50m in upper level.
FS north 1000m/B21/mooring	23.08 (13:53)	79°39.47	06°47.77	983	0	95	95	95	95	95	95		144/2008 (478m) 144/2009 (387m) 144/2010 (51m)		Two moorings deployed (station 5 and 6)
Yermak ice edge	23.08 (02:34)	79°49.73	05°45.68	1111	1	96		96	96	96	96	147/2015 (1044)	145/2011 (454m) 145/2012 (359m) 145/2013 (70m)	146/2014	
Yermak ice edge	24.08 (17:24)	80°26.33	07°29.77	709	1	97		97	97	97	97			148/2016	
Yermak ice edge	25.08 (04:46)	80°11.54	10°02.88	560	1	98	98	98	98	98	98	151/2021 (525m)	149/2017 (451m) 149/2018 (354m) 149/2019 (103m)	150/2020 (550)	
Hinlopen 1	26.08 (05:48)	79°46.51	18°08.40	418	0	99	99	99	99	99	99	154/2026 (356m)	152/2022 (350m) 152/2023 (250m) 152/2024 (104m)	153/2025	
Hinlopen 2	26.08 (15:11)	80°02.44	17°19.88	366	0	100	100	100	100	100	100	157/2031 (307)	155/2027 (300m) 155/2028 (150m) 155/2029 (50m)	156/2030 (380)	
Hinlopen 3	26.08 (23:31)	80°16.19	16°45.44	311	2	101*	101	101	101	101	101	160/2035 (316)	158/2032 (275m) 158/2033 (50m)**	159/2034 (338m)	*WBAT (1 m/s) **The uppermost from trench to shallower depths at the end of the haul. Only two nets due to ice.
Hinlopen 4	27.08 (07:27)	80°33.21	15°53.39	304	3	102*		102	102	102	102	162/2037 (270m)	No Åkra due to ice	161/2036 (295)	*WBAT (1/2 m/s) E21 taken later is between Hinlopen 3 and 4.
Hinlopen 5 (case 2)	27.08 (14:25)	80°41.03	15°27.44	523	4	103*		103	103	103	103	No trawl due to ice	No trawl due to ice (Harstad 187/2064 from E22)	Can use 188/2065 from E22	*WBAT (1/2 m/s) **No Campelen due to ice. St E22 close.
Hinlopen 6	27.08 (17:34)	80°43.49	15°30.81	1059	5	104*	104	104	104	104	104	163/2038 (821m)	No Åkra due to ice. (Harstad 186/2063 taken on 01.09)	Trawl 185/2062 taken 01.09	* WBAT (1/2 m/s) Campelen taken 01.09 (also listed later)
Hinlopen 7	28.08 (00:56)	80°49.33	15°36.61	1849	5	105		105	105	105	105	No trawl due to ice	No trawl due to ice	No trawl due to ice	
Greenland halibut (GB1)	28.08 (11:23)	80°58.80	17°41.23	411	2									164/2039 (410-438)	
Nordaustlandet 1	28.08 (21:19)	81°11.44	20°24.69	330	0	106	106	106	106	106	106	167/2044 (300m)	165/2040 (275m) 165/2041 (175m) 165/2042 (50m)	166/2043 (308)	
Nordaustlandet 2	29.08 (04:19)	81°27.95	21°33.63	1020	3	107*	107	107	107	107	107	168/2045 (714m)	No Åkra due to ice	169/2046 (650m)	* WBAT (1/2 m/s)
Nordaustlandet 3	29.08 (21:27)	81°02.19	24°55.69	83	5	108*	108	108	108	108	108	171/2048**	No Åkra due to depth	170/2047 (111m)	* WBAT (1/2 m/s) **(u-haul 60-0m)
Nordaustlandet 4	30.08 (04:30)	80°44.26	27°30.58	93	0	109*	109	109	109	109	109	172/2049 (70m)	No Åkra due to depth	173/2050 (105m)	* WBAT (1/2 m/s)

Location	Date when starting (CTD)	Latitude (CTD)	Longitude (CTD)	Bottom depth (CTD, m)	Ice	CTD/ LADCP /WBAT	TRIOS light	Water samples (nutrient, phyto)	Water samp. (C_T/A_T)	Algae net (0-30m)	WP2/Juday (bottom-0) and WPII for Limicina (50m)	Krill trawl	Harstad trawl	Campelen trawl	Comment
Testing Harstad trawl	30.08 (16:00)												x		Testing Harstad trawl near H21 before starting ecosystem stations. Trawl run with open net. Sensor data stored for later use.
H21	30.08 (17:33)	80°32.04	27°48.78	240	0	110*		110		110	110		174/2051 (0-60m)	Rocky bottom – no trawl	* WBAT (1/2 m/s)
I21	30.08 (22:16)	80°32.76	29°59.61	381	1	111*/ 112		111	111	111	111		175/2052 (0-60m)	Rocky bottom – no trawl	* WBAT (1/2 m/s) Position slightly shifted due to sea ice *CTD run with ½ m/s for better WBAT data CTD 112 extra only to 20 m depth
I22	31.08 (05:39)	81°05.31	29°53.65	144	1	113*		113	112	113	113		176/2053 (0-60m)	Rocky bottom – no trawl	Position slightly shifted due to sea ice * WBAT (1/2 m/s)
Kvitøya Trough	31.08 (10:11)	80°48.27	28°51.75	447	1	114*		114	114	114	114 (75m) only for Limicina	178/2055* (20 min in 195-215m)	179/2056 (20 min in 275m)	177/2054	Polar bear observed. Caught one Harp seal. *Krill trawl on registration (U-haul, 20 min in 195-215m depth). * WBAT (1/2 m/s)
H22	31.08 (20:19)	80°50.93	26°34.17	78	2	115*	115	115		115	115		180/2057 (0-60m)	Rocky bottom – no trawl	About 12 nm southeast of H22 due to sea ice. * WBAT (1/2 m/s)
G22	01.09 (03:19)	80°58.09	22°20.24	116	1	116*		116		116	116		181/2058 (0-60m)	182/2059	South of G22 due to sea ice. * WBAT (1/2 m/s)
F22	01.09 (12:59)	80°57.46	19°08.48	171	1	117*	117	117	117	117	117		183/2060 (0-60m)	184/2061	TRIOS * WBAT (1/2 m/s)
Hinlopen 6 trawls	01.09 (18:01)	80°45.65	16°17.43	872	1	-		-	-	-	-		186/2063 (0-60m)	185/2062	Campelen taken when reaching Hinlopen. Took also Harstad.
E22	02.09 (23:03)	80°36.65	15°41.26	307	0	118		118		118	118		187/2064 (0-60m)	188/2065	Between Hinlopen 5 and 6.
E21	02.09 (02:39)	80°23.36	15°58.00	367	0	119*		119		119	119*		189/2066 (0-60m)	190/2067	Between Hinlopen 3 and 4. Samples for Raphaelle * WBAT (1/2 m/s)
D21	02.09 (12:33)	80°14.67	12°43.36	155	0	120	120	120	120	120	120		191/2068 (0-60m) 192/2069 (20 min in 60m)	193/2070	Samples for Raphaelle
D22	02.09 (18:00)	80°33.95	12°14.04	985	1	121*	121	121	121	121	121		194/2071 (0-60m)	195/2072	Somewhat southeast of D22 due to sea ice. * WBAT (1 m/s)
Sofiadjupet	03.09 (00:50)	80°52.52	12°25.24	1764	3	122*			122						CTD and WBAT taken while waiting for conditions for finding seals * WBAT (1/2 m/s)
C22	03.09 (14:04)	80°24.44	08°34.41	816	0	123*		123	123	123	123		196/2073 (0-60m)	197/2074	* WBAT (1/2 m/s)
B22	04.09 (03:09)	80°11.20	05°26.41	792	0	124*		124	124	124	124		198/2075 (0-60m)	199/2076	* WBAT (1/2 m/s)
C21	04.09 (11:54)	80°01.64	09°21.03	448	0	125*		125	125	125	125		200/2077 (0-60m)	201/2078	* WBAT (1/2 m/s). Samples for Raphaelle.
B21	05.09 (04:21)	79°39.13	06°43.81	1017	0	126*	126	126	126	126	126 (only for Raphaelle)	203/2080 (921)	202/2079 (0-60m)	204/2081	Recover moorings. Samples for Raphaelle. Snow crab. * WBAT (1/2 m/s)
B20	05.09 (19:54)	79°09.19	08°30.67	318	0	127*	127	127		127	127		205/2082 (0-60m)	206/2083	* WBAT (1 m/s)
B19	06.09 (03:55)	78°24.14	09°21.57	749	0	128*	128	128		128	128		207/2084 (0-60m)		Harstad trawl twisted when deployed. Fished but with reduced hight. * WBAT (1 m/s)

Table A2. Participant list for the SI_ARCTIC 2017 survey.

Participant	**Main field**	**Institution**
Helene Lødemel	Chem oceanography	IMR
Ella Weissenberg	Plankton	UNIS
Ine Elise Moksness	Fish	IMR
Malin Lie Guldbrandsen	Fish	IMR
Sebastian Menze	Chem/phys oceanog	IMR
Lars-Johan Naustvoll	Plankton	IMR
Håvard Eggen	Sea birds	NINA
Robert Andre Johansen	Benthos	IMR
Harald Gjøsæter	Fish acoustics	IMR
Tor Knutsen	Plankton	IMR
Lis L. Jørgensen	Benthos	IMR
Tore Haug	Marine mammals	IMR
Atle Børje Rolland	Marine mammals	IMR
Nils Erik Skavberg	Marine mammals	IMR
John-Terje Eilertsen	Instrument chief	UIT
Ronald Pedersen	Instrument	IMR
Thomas Wenneck	Fish	IMR
Gunnar Langhelle	Fish	UIB
Randi Ingvaldsen	Cruise leader	IMR

Table A3. Overview of light measurements conducted at CTD stations. Surface light was collected with a TriOS Ramses hyperspectral irradiance sensor (SAM_82C5) every 1 minute. Vertical profiles of irradiance were collected with a TriOS Ramses hyperspectral irradiance underwater sensor (SAMIP-5057), set up to integrate data over 5 second intervals, hence output the spectrum every 5 seconds. Data from RV Helmer Hanssen, 21 August - 7 September 2017.

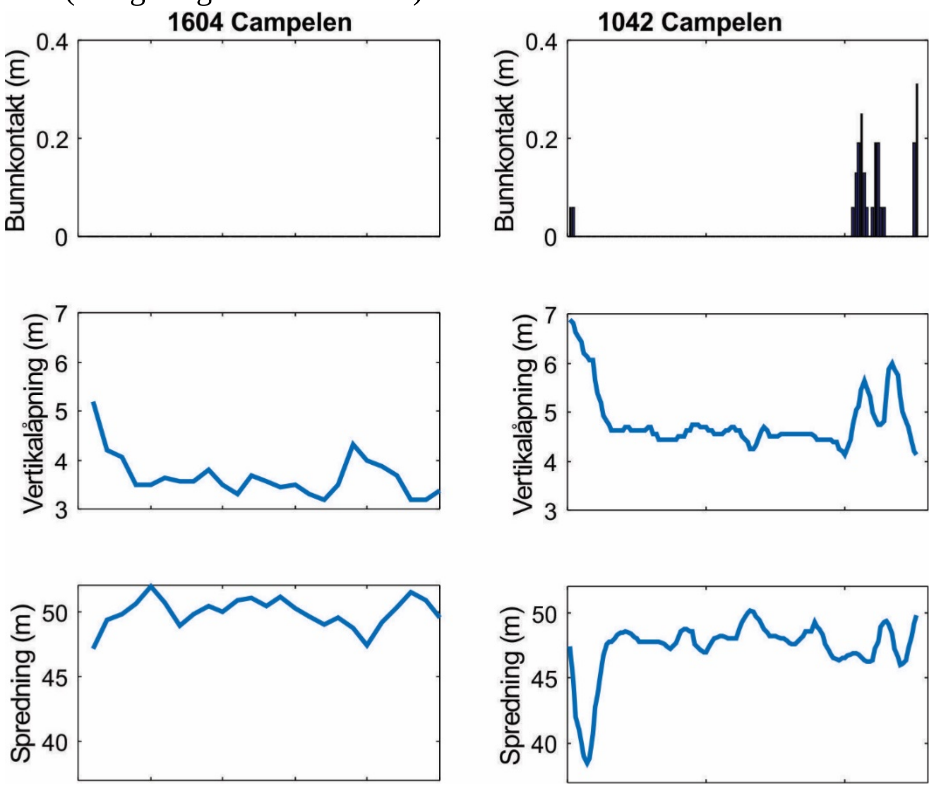
Station (ctd)	Date	TimeUTC		Maxdepth (m)	Comment
		Start	Stop		
95	23.08.2017	14:51:53	15:18:33	132,01	SAMIP_5057_Spectrum_Calibrated_2017-08-23_16-51-53_926_SAM_82DD_330c_2017-08-23_16-51-53_926_142.dat
98	25.08.2017	06:39:09	06:55:54	132,78	
99	26.08.2017	06:19:03	06:33:48	105,84	
100	26.08.2017	15:41:29	15:59:04	103,67	
101	27.08.2017	00:08:31	00:26:51	100,49	Took some time before the software was stopped ….
102	27.08.2017	08:12:15	08:36:43	184,86	
104	27.08.2017	18:58:36	19:13:21	132,45	
106	28.08.2017	21:49:13	21:59:58	114,28	Stops logging on the way up around 11 meter depth
107	29.08.2017	07:13:56	08:35:51	163,45	Took a long time before we remembered to stop logging, most probably st107
108	29.08.2017	21:47:47	21:59:47	68,20	
109	30.08.2017	04:56:01	05:01:41	52,73	
115	31.08.2017	20:59:20	21:08:50	77,17	
117	01.09.2017	13:26:24	13:38:59	100,95	
120	02.09.2017	13:44:36	13:59:21	126,92	
121	02.09.2017	18:45:39	18:59:44	103,11	
126	05.09.2017	07:08:37	07:22:42	125,90	
127	05.09.2017	21:10:06	21:19:21	59,90	
128	06.09.2017	04:36:53	04:45:28	88,23	

Appendix B - trawls

Shake-down av Campelen tråler, HH 22 aug, 2017, for Arktisk Økosystemtokt/SI_ARCTIC tokt.

Shake-down av Campelen ble gjennomført i Karlskronadjupet. Shake-down av Campelen trål 1604, st. 139, viste at trålen gikk veldig stabilt og fint. Bunnkontakt og spredning innenfor kriterier, men høyde litt for lav for kriteriet (se figur og tabell nedenfor).

Shake-down av Campelen trål 1042, st. 140 (med dyphavskuler) viste at trålen gikk relativt stabilt og fint, men med noe mer tid på å stabilisere seg sammenlignet med 1604. Trålen hadde god bunnkontakt under halet, med unntak av helt siste del. Trolig pga steiner på bunn. Spredningen litt for liten, og høyden litt for stor (se figur og tabell nedenfor).



Figur. Bunnkontakt, vertikalåpning og spredning for Campelen 1604 og Campelen 1042. Sensordata er gitt i filene 2017856-SCANMAR-DATA_sta139 og 2017856-SCANMAR-DATA_sta140. Gjennomsnittsverdier er gitt i tabellen nedenfor.

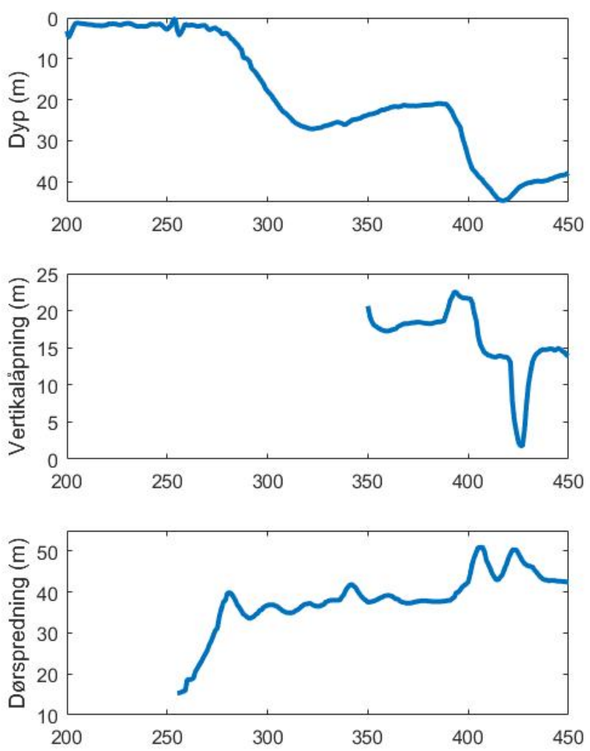
Trål	Gjennomsnittelig vert. åpning	Gjen. spredning	Gjen. bunnkontakt	Innenfor kriteriene 90% av tiden
1604 Campelen	3.7 m	49.6 m	0 m	Nei
1042 Campelen	4.8 m	47.4 m	0 m	Nei

Konklusjon: Ingen av trålene var innenfor kriteriene gitt i sjøtestingsinstruksen. Trål 1042 (med dyphavskuler) ble brukt videre i toktet.

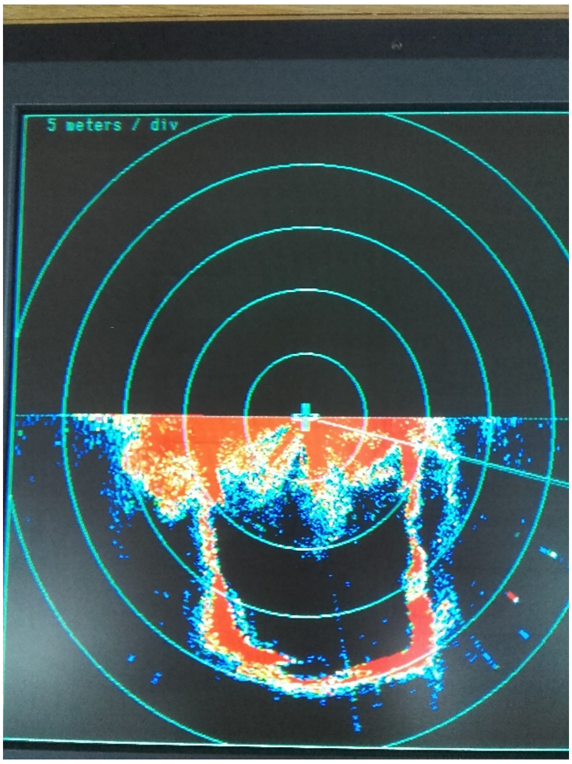
Sjøtesting Harstadtrål 1603 for Arktisk Økosystemtokt/SI_ARCTIC tokt, HH 30 aug, 2017.

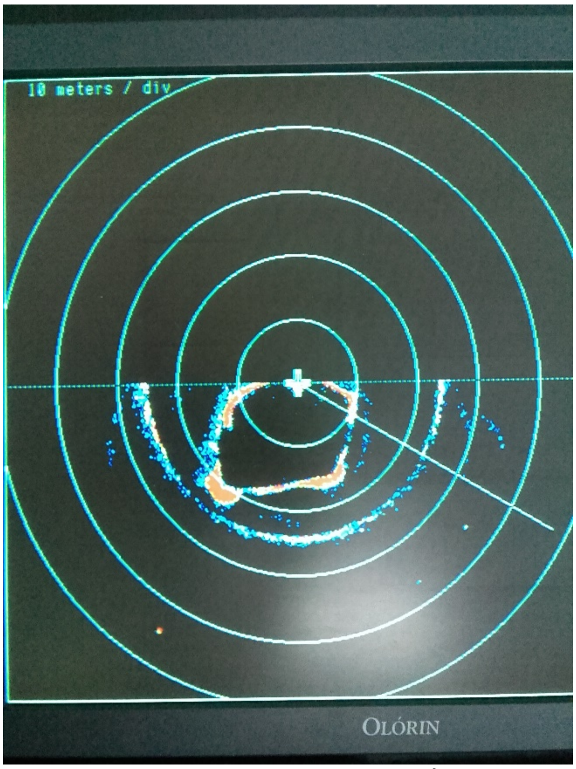
Sjøtesting av Harstadtrål 1603 ble gjennomført da den ble påsatt midt i toktet nord av Svalbard 30 aug. Det var gode forhold for testing med lite vind og lite sjø. Trålen var rigget i henhold til ny rigging og prosedyre for bruk av Harstad trål i forbindelse med 0-gruppe tråling. Testen ble gjennomført med kuletelne i 0, 20 og 40 m dyp. Trålen var påmontert dybdesensor, tråløye og dørsensor (se figur nedenfor). I tillegg brukte vi Mesotech sensor med trålkabel for å få et grundigere bilde av trålens geometri under halet. Dessverre gav ikke tråløyet fornuftige data mens trålen var i 0m, og den måtte også oppholde seg noe tid i 20 m før tråløyet gav rimelige data (se figur nedenfor).

Mesotech gav et godt bilde av trålens geometri ved de ulike dyp (se bilder av skjermen på neste side). Trålen hadde vertikalåpning ~20 m ved kuletelne i overflaten, men ble mer rektangulær når trålen ble senket ned (vertikalåpning ~18 m med kuletelne i 20 m, og vertikalåpning ~12 m med kuletelne i 40 m).

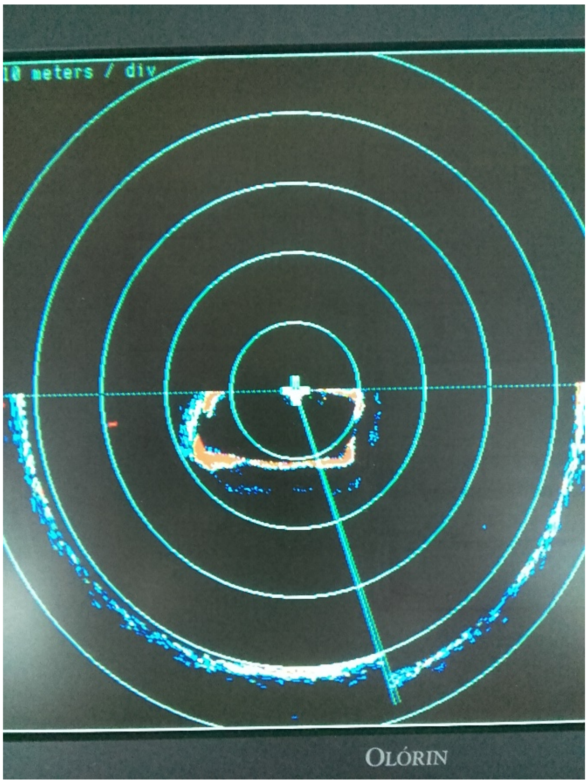


Figur. Dyp av kuletelne, vertikalåpning og dørspreding ved test av Harstadtrål 1603. Data fra sensorene er gitt i filen 2017856-TRÅLSTASJON-TEST-HARSTADTRÅL.txt





Bilder over. Bildet til venstre viser Mesotech skjerm ved kuletelne i 0m. Vertikalåpning er ~20 m. Bildet til høyre viser Mesotech skjerm ved kuletelne i 20 m. Vertikalåpning er ~18 m.



Bildet til siden viser Mesotech skjern ved kuletelne i 40 m. Vertikalåpning ~12 m.