Cruise Report

Polar Night Cruise 2016

Edited by Malin Daase

1. Introduction and Background

From 8-24 January 2016 the 5th consecutive Polar Night cruise with RV Helmer Hanssen took place. The Arctic climate is experiencing fundamental changes at the moment which will affect ecosystem structure and productivity higher in the food web. Arctic marine ecosystem structure and productivity within the next decades are anticipated to be substantially different from what we observe last century. Our ability to understand the Arctic as a single, linked system as well as our ability to predict the effects resulting from forecasts of change in the global climate is still hindered by fundamental gaps in knowledge, such as the understanding of processes occurring during the polar night. To eventually fill this knowledge gaps, UiT and ARCTOS scientist started the Polar Night cruises in January 2012. For the last five winters biological processes have been studied within the framework of several research projects (CIRCA, Marine Night, Cleopatra II, Arctic ABC, see www.mare-incognitum.no), and in conjunction with UiT and UNIS courses (BIO-8510 ARCTOS - Marine ecological research cruise to Svalbard, AB-334 Underwater Robotics in the Arctic Polar Night). Through the observations made during these cruises the prevailing view of the polar night as devoid of biological activity has been refuted (e.g. (Last et al. ; Berge et al. 2015; Cohen et al. 2015)). The discoveries made under the extreme conditions of the Arctic winter reflect the historically low levels of scientific investigations during polar night, and challenge our understanding of Arctic marine organisms and ecosystems.

This years' Polar Night cruise was mainly a contribution to two mare incognitum projects: *Arctic ABC* and *Marine Night*, as well the UiT master course *BIO-8510 ARCTOS - Marine ecological research cruise to Svalbard*. The scientific program included sampling zooplankton, benthic and fish communities using traditional methods (nets, trawls, grabs and box corer) as well as applying modern technologies such as the Acoustical fish and zooplankton profiler (AZFP) as well as a number of optical methods (Video Plankton Recorder, Laser Optical Plankton Counter, under water bottom camera, ROVs and Hyperspectral imaging systems). In addition to biological program, marine archaeological research was conducted using automated under water vehicles (AUV) and ROVs equipped with imaging systems.

Marine Night: The primary objective of *Marine Night* is to achieve a basic understanding of Arctic biodiversity and food web structure during the polar night, and how ecological processes from reproduction and growth to trophic interactions and life-history processes during this nearly unstudied time contribute to functioning of Arctic ecosystems.

Arctic ABC: Virtually nothing is known about the overwintering strategies of key species in the Arctic Ocean, and their dependence on sea ice during the polar night and winter period, and predictions of their future under a decreasing ice-cover are frequently contradictory. *Arctic ABC* will fill these knowledge gaps by developing a new autonomous observational platform that is to be deployed in the Arctic drift ice. This will for the first time allow real-time monitoring of the succession of ice-associated communities in the Arctic Ocean during the polar night and winter-spring transition. By combining this novel approach with the well documented drift patterns of the Arctic pack ice and ocean circulation within the Arctic Ocean, we will utilize state-of-the-art modelling tools to provide much needed projections as to how climate-induced changes at the base of the food chain are likely to propagate through the Arctic ecosystem.

***COPPY* (Fate ofCOPePod secondarY production in a chancing Arctic):** COPPY targets the differences between two key Arctic and sub-Arctic secondary producers, *Calanus glacialis*, endemic to the Arctic, and *C. finmarchicus*, endemic to the North-Atlantic. In this project, Norwegian and Russian scientists and students work closely together, combining historical data with new field data and experimental work to gain more knowledge on Arctic zooplankton reproduction to predict the fate of secondary production in a warmer and less ice rich Arctic. Two main studies will be focused upon 1) the differences in the reproductive strategies (particularly timing) of *C. glacialis* and *C. finmarchicus* and 2) the potential for hybridization between these closely related species.

IMOS: Isfjorden Monitoring Observatory Svalbard: IMOS aims for long-term synergistic cooperation between Russian and Norwegian scientists working in Svalbard by establishing a joint marine plankton observatory in Isfjorden, where both nations have marine research bases. Isfjorden Marine Observatory Svalbard (IMOS) aims to monitor the long-term dynamics in plankton in relation to sea ice, hydrography and nutrients in Isfjorden to study the **impacts of climate change** at the base of the Arctic marine food web. A number of standard stations have been identified in Isfjorden which should be sampled according to standard sampling procedures whenever there is an opportunity (available ship time).

The BIO-8510 ARCTOS - Marine ecological research cruise to Svalbard course runs each second year and is based upon cruises with RV Helmer Hanssen to the waters around Svalbard and the Barents Sea. Research questions relevant to activities within the ARCTOS network are addressed. The course also opens up for individual students to obtain necessary samples for their PhD work.

2. Study area

The archipelago of Svalbard is located in a border-area between Atlantic and Arctic climatic and biogeographic zones (Stroemberg 1989)(Stroemberg 1989). The main pathway of Atlantic water into the Arctic Ocean (the West Spitsbergen Current, WSC) runs along the western coast of Svalbard. There is a high inter-annual variability in the strength of the WSC and the inflow of Atlantic water to the Arctic (Saloranta and Haugan 2001). In addition, Svalbard waters are often modified by local oceanographic processes (e.g. freshwater runoff, wind driven circulation, and cooling).
At the northwestern corner of Svalbard the WSC splits into two branches. The Svalbard branch turns eastwards and enters the Arctic Ocean following the continental slope (Rudels et al. 1999). This branch defines the largest input of Atlantic water in the Arctic Ocean (Manley 1995) and the inflow of warm Atlantic water keeps this area largely ice free also during winter.

Isfjorden
Isfjorden is the largest fjord on the western coast of Svalbard. While the inner fjords of the Isfjorden system are influenced by glacial and fluvial inputs, the central part of Isfjorden is strongly affected by inflowing Atlantic water and annual variations in the inflow/distribution of water masses have been observed (Nilsen et al. 2008). The central part of Isfjorden has largely been ice free since 2006.

Billefjorden
Billefjorden is located in the inner part of Isfjorden. It is a sill fjord with a threshold at 50. The inner basin (180 m depth) is largely unaffected by inflowing Atlantic water and temperatures remain below -1 C year round, providing a refuge for arctic zooplankton species. Ice usually form in December- January and last until June. At the time of this cruise ice had not formed.

Smeerenburgfjorden
Smeerenburgfjorden is located at the north-western corner of Spitsbergen with a max. depth of ca 220 m. The fjord is influenced by Atlantic water. The area is of historical interested being the center of the whaling activities in the 16th century.

Rijpfjorden
Rijpfjorden is located on the northern coast of Nordaustlandet. It is a north-facing fjord (max 240 m deep) with a wide opening towards the broad shallow shelf (100–200 m deep), which extends to the shelf-break of the Polar Basin at approx. 81 N. Rijpfjorden is dominated by cold Arctic water masses and the inflow of Atlantic water is much less pronounced here compared to fjords along the western coast of Spitsbergen, thus Rijpfjorden represents a ‘true’ Arctic fjord. Ice forms in October and lasts until July (Ambrose et al. 2006; Søreide et al. 2010; Wallace et al. 2010). Interannual variations in timing of freeze-up and ice break up as well as ice thickness are observed (Leu et al. 2011).

Kongsfjorden
Kongsfjorden is located on the north-west side of Spitsbergen sharing a common entrance with Krossfjorden. It is an open fjord without any pronounced sill allowing a relatively free connection to adjacent shelf, 20 km long with a width ranging from 4-10 km and a maximum depth of 400m.

The fjord is largely influenced by advection of both Atlantic water from the West Spitsbergen Current (WSC) and Arctic water from the coastal current. It also receives a discharge of fresh water and sediments from adjacent glaciers, peaking during the summer melting. Kongsfjorden has been ice free since winter 2005-06.

3. Cruise Diary

The cruise started in Tromsø Friday, 8 January 2016. R/V Helmer Hanssen steamed northwards and reached Longyearbyen at 1:00 am Sunday morning, 10 January 2016. Equipment stored in Longyearbyen was loaded on board, additional cruise participants came on board and Helmer Hanssen departed Longyear harbor in the early morning. Zooplankton work started shortly after departure at Karlskronadjupet (IsK). Due to malfunctioning equipment the plan to work with the ROV in Trygghamna in the afternoon was abandon and Helmer Hanssen steamed instead into Billefjorden where trawling and zooplankton sampling was conducted.
On its way back, Helmer Hanssen stopped briefly in Longyearbyen to retrieve an ROV cable and embarked to Trygghamna where the ROV was deployed during the night. Afterwards the boat steamed northwards to Smeerenburgfjorden. Strong winds prevented the scheduled deployment of the AUV the next morning, but zooplankton sampling was successfully conducted at this location. The boat steamed north-east towards Rjpfjorden, stopping briefly at Moffen to dredge for clams.
Helmer Hanssen arrived in Rijpfjorden at 2 am Thursday 14 January. A mooring was deployed in Vindbukta. Zooplankton sampling, trawling and benthic sampling was conducted in Rijpfjorden over the next 14 hours. The mooring was retrieved before leaving Rijpfjordenin the evening.
Along a transect crossing the shelf break north-west of Rijpfjorden several stations were taken with the LOPC, Multinet and fish trawling. In the morning of Friday, 15 January, station “Rolf” was established at roughly 81 N. Only very loose drift ice was observed in this region. Zooplankton work was conducted before Helmer Hanssen steamed south-west towards Smeerenburgfjorden on Friday evening. Along the way another transect crossing the shelf break was run, deploying LOPC, Multinet and fish trawls. On Saturday, 16 January, marine archeological work was conducted in Smeerenburgfjorden using the AUV. In the evening, benthic work was conducted in Magdalenefjorden. Helmer Hanssen reached Trygghamna Sunday morning, 17 January. Here the jetyak was deployed and marine archeological work was conducted with the ROV. At this point the cruise leader discovered that there was still a whole day left before Helmer Hanssen had to return to Longyearbyen, which was somehow not accounted for. The additional time was filled with zooplankton work at IsK, water sampling at IsA (Isfjorden-Adventfjorden), trawling in Dicksonfjorden and by deploying a mooring outside Longyearbyen before Helmer Hanssen called at port in Longyearbyen at 19:00 on Monday, 18 January. This was the end of leg 1. In Longyearbyen the crew of Helmer Hanssen was exchanged, with the new crew arriving Tuesday 19 January. 9 cruise participants disembarked in Longyearbyen, and 3 new arrived.
Leg 2 started Tuesday evening, 19 January. The mooring in Isfjorden was retrieved before Helmer Hanssen departed to Kongsfjorden. Here zooplankton work started Wednesday morning, 20 January, at KB3. In the afternoon a mooring was deployed in Kongsfjorden. During the night benthic work took place in the inner part of Kongsfjorden, in the morning the ROV was deployed here. Between 11-13 on Thursday, 21 January, the jetyak (an automated kayak deployed with light and acoustical sensors) was deployed. Helmer Hanssen steamed towards the outer part of Kongsfjorden to Kvadehuken, where a permanent photostation was visited using the ROV. In the

evening zooplankton and trawling was conducted at station KB1, before the boat steamed back to the inner part of Kongsfjorden were benthic work was conducted. On midday Friday, 22 January, the jetyak was deployed again. Helmer Hanssen called at the port of Ny-Ålesund on Friday afternoon. Here diving was conducted. Trawling and benthic sampling continued during the night in the inner part of Kongsfjorden, the jetyak was deployed for the third time at midday on Saturday. Helmer Hanssen steamed southwards towards Longyearbyen on Saturday evening, on the way V12, a station outside Kongsfjorden, was sampled. Helmer Hanssen arrived in Longyearbyen on Sunday morning, 24 January, and all cruise participants disembarked here.

Overall, the cruise was very successful with all planned sampling running smoothly and the weather being cooperative. The jetyak proofed to be very a promising tool: equipped with optical and acoustical sensors the jetyak could conduct measurements of light and vertical migrations of zooplankton further away from the vessel in areas undisturbed by light emitted from the boat. Two interesting biological discoveries were made: a large wood log trawled up from the depth of Rijpfjorden contained the northernmost reported observation of the ship worm (*Teredo navilis* (?)). And north of Svalbard the deep water fish *Argyropeleceus hemigymnus* (Half-naked hatchedfish) made an appearance in a pelagic trawl taken over 400 m both depth, marking the northern most record of this bathypelagic species.

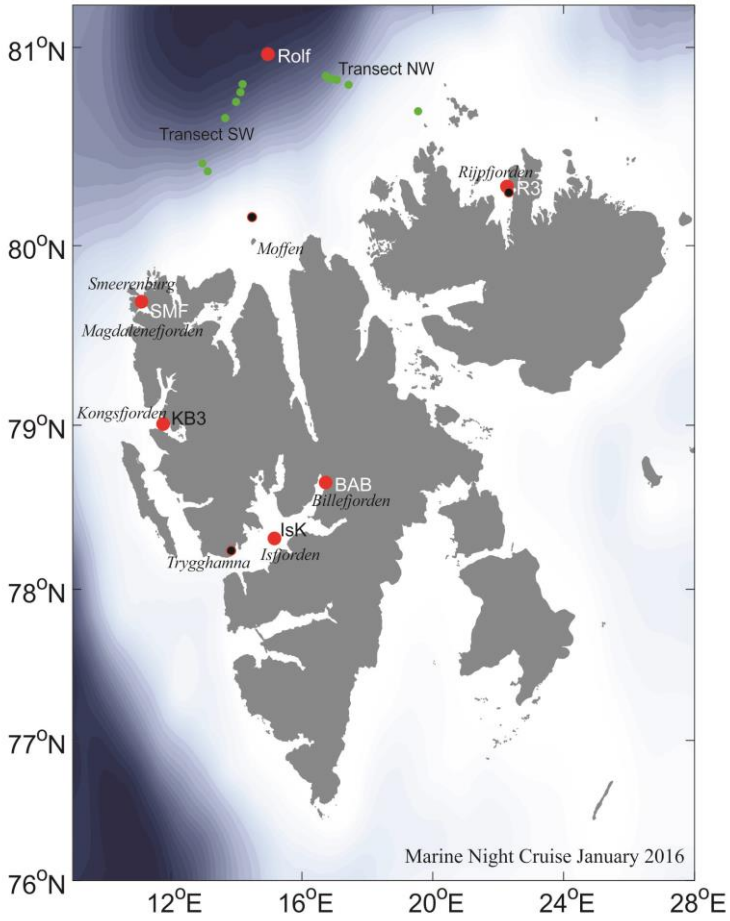


Figure 1. Stations and locations sampled during the Polar Night cruise 2016

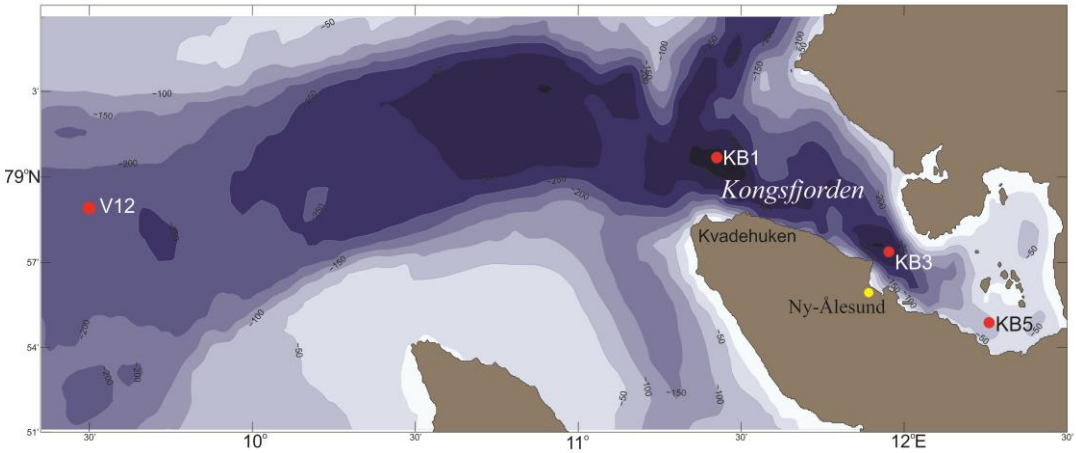


Figure 2: Stations in Kongsfjorden visited during leg 2 of the Polar Night cruise 2016

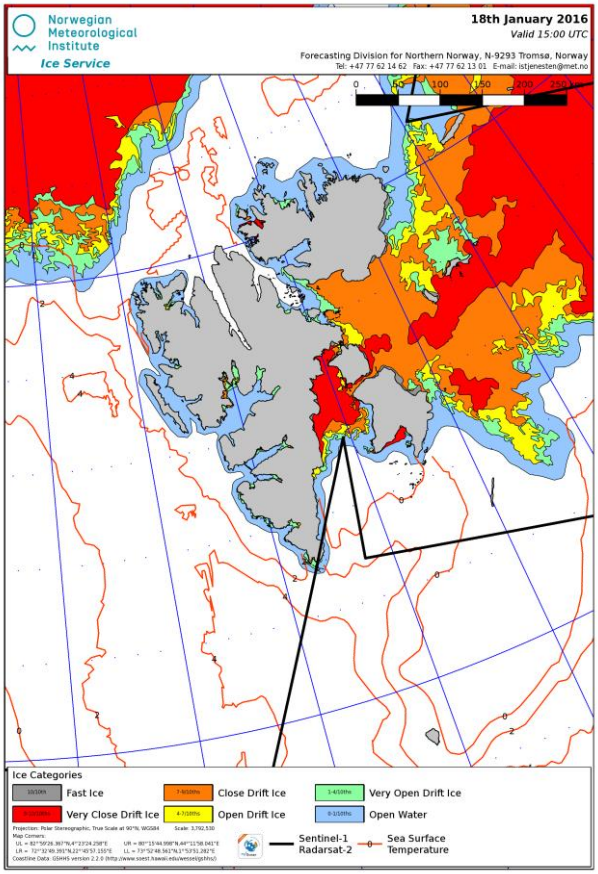


Figure 3: Ice conditions around Svalbard during Marine Night Cruise 2016 (18. January 2016, http://polarview.met.no/)

4. Participants

Name	Leg 1	Leg 2	Function	e-mail
Jørgen Berge	1	1	Cruise leader	Jorgen.berge@uit.no
Daniel Vogedes	1	1	Research technician	Daniel.vogedes@uit.no
John-Terje Eilertsen	1	1	Technician	john-terje.eilertsen@uit.no
Eli Kintisch	1		Media	elikint@gmail.com
Marine Cusa	1	1	Lead Fish group	marine.cusa@mail.utoronto.ca
Carl Ballantine	1	1		carl.ballantine@akvaplan.niva.no
Sam Newby		1		sameglundnewby@aol.com
Geir Johnsen	1	1	Lead light group	geir.johnsen@bio.ntnu.no
Jon Cohen	1	1		jhcohen@udel.edu
Corie Charpentier	1	1		
Kim Last	1			Kim.Last@sams.ac.uk
Rolf Gradinger	1	1		Rolf.gradinger@uit.no
Aksel Mogstad	1			akselam@stud.ntnu.no
Finlo Cottier	1		Lead oceanography group	Finlo.Cottier@sams.ac.uk
Maxime Geoffroy	1	1		maxime.geoffroy.1@ulaval.ca
Martin Ludvigsen	1	1	Lead robotics group	martin.ludvigsen@ntnu.no
Sturla Haltbakk	1	1		sturla.haltbakk@ntnu.no
Frode Volden	1	1		frode.volden@ntnu.no
Ines Dumke	1	1		ines.dumke@ntnu.no
Øyvind Øydegard	1			oyvind.odegard@ntnu.no
Stein Nornes	1	1		stein.nornes@ntnu.no
Nicole Aberle-Malzahn		1		nicole.aberle-malzahn@ntnu.no
Choquet, Marvin	1	1	Student Bio8510	marvin.choquet@uin.no
Deja, Kajetan	1	1	Student Bio8510	kajetandeja@iopan.gda.pl
Hatlebakk, Maja	1		Student Bio8510	MajaKaroline.Hatlebakk@unis.no
Kniazeva, Olga	1	1	Student Bio8510	knyazeva.sp@gmail.com
Malin Daase	1	1	Lead zooplankton group	malin.daase@uit.no
Sunnje Basedow	1			sunnje.basedow@uin.no
Pierre Priou	1			pierrepriou@gmail.com
Ingrid Wiedmann		1		ingrid.wiedmann@uit.no
Janne Søreide	1			jannes@uit.no
Frode Gerhardsen		1	Dive leader	frode.gerhardsen@uit.no
Randall Hymann		1	Media	

5. Scientific program

5.1. Hydrography and environmental background data

At each station a CTD (Seabird) was taken to measure temperature and salinity throughout the water column (Figure 4). Along the two transects north of Svalbard the CTD attached to the LOPC was used, and no additional shipboard CTD was taken (Figure 5 and 6).

At the main stations water samples were taken from specific depth (Table 1) to be analysed for chlorophyll a, nutrients, POC/N concentration and phytoplankton community. The samples are stored at UNIS and analysis will be coordinated by Janne Søreide.

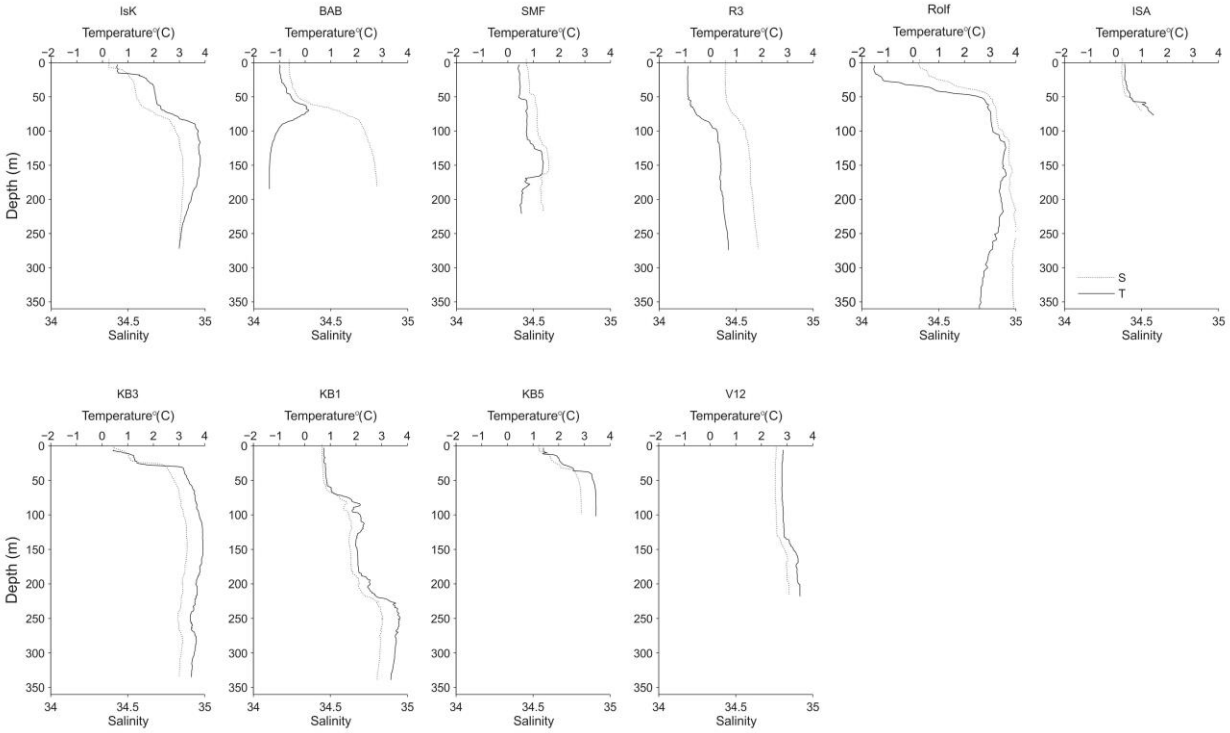


Figure 4: Temperature and Salinity profiles at stations sampled during the Polar Night Cruise 2016

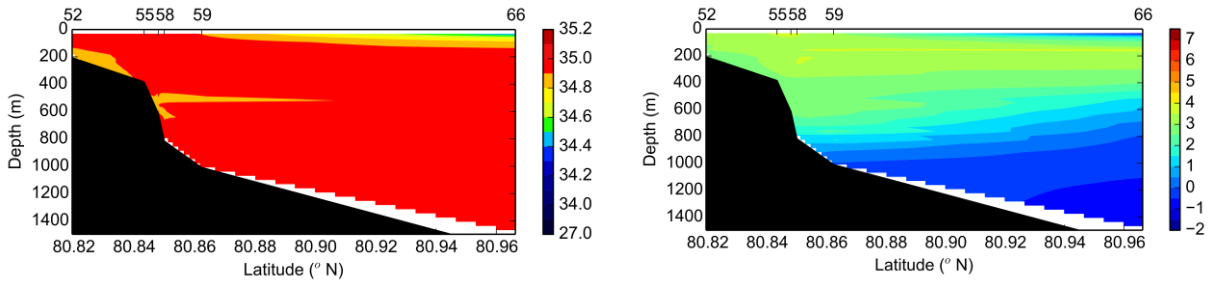


Figure 5: Salinity and Temperature along NW transect

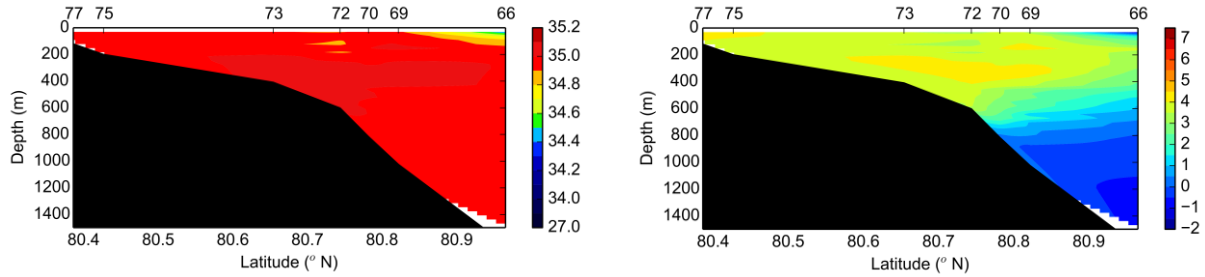


Figure 6: Salinity and Temperature along SW Transect

Table 1: Overview of water samples

HH station number	Station	Sample depth (m)	Chl a	>10 µ Chl a	POC/N	Nutrients	Community
4	IsK/KKD	5	x				
		15	x	x	x	x	x
		35	x				
		75	x				
		275	x	x	x	x	x
14	BAB	5	x			x	x
		15	x	x	x	x	x
		183	x	x		x	x
26	SMF	5	x	x		x	x
		15	x	x	x	x	x
		225	x		x	x	x
38	R3	5	x			x	x
		15	x	x	x	x	x
		280	x	x	x	x	x
62	Rolf	5	x	x	x	x	x
		15	x	x	x	x	x
		35	x				x
		400	x		x	x	x
117	KB3	10	x	x	x		
		25	x	x	x	x	?
		50	x	x	x	x	?
		100	x	x	x	x	?

At KB3 water was also filtered for DNA

5.2. Zooplankton in the Polar Night

Malin Daase (UiT), Sünnje Basedow (UiN), Janne Søreide (UNIS), Maja Hatlebakk (UNIS), Pierre Pirou (UiT)

Aim

Our aim during the Marine Night cruise in January 2016 was to study the abundance, size structure, spatial distribution and life history adaptations of zooplankton during the polar night. Special focus was on *Calanus* populations, in particular the abundance and distribution of males, which are often underrepresented in the population during the rest of the year and of whose life history adaptations very little is known. Another focus was the estimation of in situ mortality and the advection of overwintering zooplankton biomass with the Atlantic water along the shelf break into the Arctic Ocean. By combining traditional net sampling with Video Plankton Recorder (VPR) and Laser Optical Plankton Counter (LOPC) we tried to achieve a high spatial resolution than by net sampling alone.

Sampling was conducted at standard stations at different locations around Svalbard. Stations that are regularly sampled over the year and have been sampled for many years exist in Isfjorden (Karlskronadjupet (Isk), since 2014), Billefjorden (Adolfbukta (BAB), since 2001), Rijpfjorden (R3, since 2003) and Kongsfjorden (KB stations, since 1996). We also have a number of previous samples from Smeerenburgfjorden. Stations IsK and BAB are part of the IMOS program.

Sampling

Zooplankton distribution, abundance, lipid and biochemistry

At IsK, BAB, R3 and Smeerenburg as well as the off-shelf station "Rolf" a full set of zooplankton sampling was conducted, including Multinet hauls, VPR, LOPC and CTD profiles. Water samples were taken to estimate chlorophyll *a*, nutrient and phytoplankton concentrations. During Leg 2 the VPR and LOPC were not available and Multinet sampling was conducted on 4 stations along the MOSJ transect in Kongsfjorden (KB5, KB3, KB1 and V12).

Sampling of mesozooplankton with the Multinet was conducted using the Hydrobios Multinet (0.25 m^2) with mesh size 180 µm and 64 µm (at R3, KB3 only). Samples were taken from 5 depth strata (Table 2) and were stained with Neutral Red Stain to determine the amount of dead individuals, before being preserved in 4% formalin-seawater solution. Samples will be analysed by Malin Daase at UiT in spring 2016.

An additional multinet sample (180µm) was taken to investigate the state of the lipid content of the *Calanus* population at different depths (Table 2). Subsamples containing approximately 100 *Calanus* were taken from the deepest depth strata and from the surface. Digital images were taken of all *Calanus* individuals in the subsamples. Image analysis of the lipid sac area will provide a measure of lipid content and wax ester concentration (Vogedes et al. 2010).

Females and males were counted and sorted out from all five depth strata to estimate sex ratios. Images were taken of males to measure length and lipid content of males, some of these individuals were fixed in ethanol for genetically species determination, or frozen for lipid class analysis.

Additional individuals of *Calanus* (especially *C. finmarchicus*) were sorted and frozen for analysis of lipid content, digestive and metabolic enzymes and dry weights. Samples are stored at -80 at UNIS and analysis will be coordinated by Janne Søreide and Maja Hatlebakk (UNIS).

In addition to the Multinet the vertical distribution of plankton was determined using the VPR and the LOPC. VPR data will be processed by Pierre Pirou, LOPC data by Sünnje Basedow.

Table 2. Overview of stations where Multinet samples were taken

Station	HH station number	bottom depth (m)	date	time (UTC)	sampling depth (m)	Live/ lipids	VPR	LOPC
Multinet 180 µm								
IsK/KKD	10	277	11.01.2016	06:36:22	258-200-100-50-20-0	x	x	
BAB	16	192	11.01.2016	15:42:35	180-150-100-50-20-0	x	x	x
SMF	24	215	12.01.2016	22:18:28	200-150-100-50-20-0	x	x	x
R3	41	283	14.01.2016	06:33:24	265-200-100-50-20-0	x	x	x
Vindbukta	49	211	14.01.2016	14:26:49	100-80-60-40-20-0			
Transect NW 4	57	608	15.01.2016	02:42:51	585-200-100-50-20-0			x
Rolf	60	1628	15.01.2016	08:13:37	1600-1000-600-200-50-0	x	x	x
Transect SW 3	71	591	16.01.2016	00:38:56	550-200-100-50-20-0			x
Tryghamna	83	130	17.01.2016	15:29:53	100-80-60-40-20-0			
IsK/KKD	95	277	18.01.2016	12:16:29	260-200-100-50-20-0		x	
KB3	106	341	20.01.2016	10:10:02	320-200-100-50-20-0	x		
KB5	132	81	21.01.2016	14:11:03	60-50-20-0			
KB1	137	377	21.01.2016	22:18:37	340-200-100-50-20-0			
V12	162	232	23.01.2016	18:00:49	200-100-50-20-0			
Multinet 64 µm								
R3	43	274	14.01.2016	08:16:31	265-100-50-20-0			
KB3	108	341	20.01.2016	11:54:54	320-200-100-50-20-0			

Advection of zooplankton biomass

To estimate the inflow of zooplankton into the Arctic Ocean we collected data on zooplankton distribution and current velocities along two cross-shelf transects north of Svalbard using the LOPC. Along each transect 6 LOPC and one Multinet station was taken. The LOPC is an optical instrument designed to count and measure particles in the water column (Herman et al. 2004). The instrument is towed through the water, whereby zooplankton and other particles pass through a channel and their number, size and transparency are registered on a matrix of photo diodes. Based on size and transparency a number of different particles can be distinguished (Checkley et al.

2008). Older stages of *Calanus* spp. have a characteristic size signature that enables us to study their abundance and distribution based on data from the LOPC (Gaardsted et al. 2010; Basedow et al. 2013). Data on current velocities were obtained along the transects by a ship-mounted broad-band Acoustic Doppler Current Profiler (ADCP).

Table 3. Overview of stations where LOPC was taken

Station	HH Station number	Lat (N)	Lat (min)	Long (E)	Long (min)	bottom depth (m)	date	time
BAB	15	78	39.7	16	43.9	192	11.01.2016	14:41:26
SMF	23	79	41.9	11	6.1	219	12.01.2016	21:38:13
R3	40	80	18.5	22	16.3	281	14.01.2016	05:37:26
Transect NW 1	51	80	41.4	19	33.1	119	14.01.2016	20:23:17
Transect NW 2	52	80	49.2	17	25.8	208	14.01.2016	22:38:15
Transect NW 3	55	80	50.6	17	4.5	386	15.01.2016	01:29:38
Transect NW 4	56	80	50.9	16	56.4	609	15.01.2016	02:06:41
Transect NW 5	58	80	51.0	16	50.9	817	15.01.2016	03:40:00
Transect NW 6	59	80	51.8	16	44.0	1010	15.01.2016	04:35:00
Rolf	66	80	58.0	14	53.7	1625	15.01.2016	17:30:28
Transect SW 1	69	80	49.4	14	11.4	1025	15.01.2016	22:00:03
Transect SW 2	70	80	47.0	14	7.4	818	15.01.2016	23:17:35
Transect SW 3	72	80	44.7	14	3.3	603	16.01.2016	01:42:52
Transect SW 4	73	80	39.3	13	39.5	409	16.01.2016	03:03:11
Transect SW 5	75	80	25.7	12	57.7	201	16.01.2016	06:27:20
Transect SW 6	77	80	23.2	13	7.2	122	16.01.2016	08:14:13

Feeding experiment: does krill feed on copepod nauplii?

Investigation during previous Polar Night Cruises have shown that krill (*Thysanoessa* spp.) is an active migrator during the polar night. A recent study concludes that lipid stores of *T. inermis* are not sufficient to survive the entire winter without food uptake (Huenerlage et al. 2015). In the absence of phytoplankton an additional food source need to be available. Data from the polar night cruises in 2014 and 2015 have shown that nauplii of cycloid copepods dominate the zooplankton community in terms of numbers during winter. To assess whether these nauplii are a potential food source for *Thysanoessa* a feeding experiment was conducted in Kongsfjorden. Krill was taken with a MIK net at KB3 and transferred to 2 l bottle with filtered sea water. 4 WP2 net with 64µm mesh size were takebn from100-0 m. The zooplankton was screened several times through a 1000µm sieve to remove larger zooplankton (*Calanus, Metridia*, chaetognath). An equal amount of the zooplankton mix was added to the krill bottles. In addition 6 bottle were only filled with the zooplankton mix, without a krill. The bottles were kept in a plankton wheel filled with sea water. After 24h, 5 krill bottles and 3 control bottles were removed, the krill was removed and measured, and the content of the bottle was fixed in formalin. After 48h the other 5 krill bottles and 3 controls were fixed. Samples will be analysed by Malin Daase.

Observations and preliminary results

Calanus abundance was highest in Billefjorden. Here, and to some degree at IsK, copepodite stage IV of *C. glacialis* dominated. At all other locations *C. finmarchicus* CV dominated. At SMF, Rolf and KB3 a large part of the population caught in the deep layers was dead.

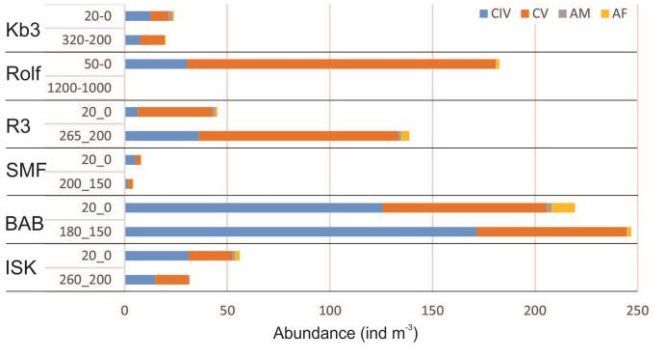


Figure 7: Abundance of *Calanus* spp. in the deepest and upper depth strata sampled at the 6 main stations. Estimates are based on counts from subsamples taken for lipid pictures**.**

As in previous winters, we observed a relative high contribution of *Calanus* males, mostly concentrated in the upper 100 m. Sex ratios were estimated at all locations.

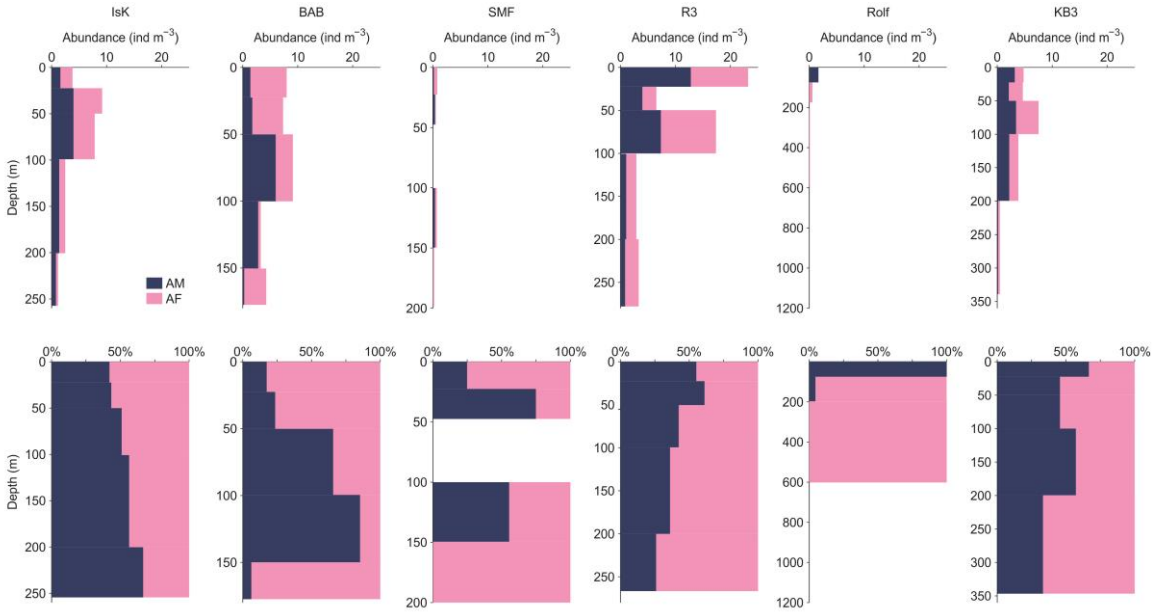


Figure 8: Vertical distribution and abundance of *Calanus* males and females at different stations in January 2016

5.3. Pico and Nanoplankton Investigations

Rolf Gradinger, UiT

The objective of the study was to identify the composition and activity of heterotrophic pico- and nanoplankton during the polar night. Water samples from the CTD (Table 5) were filtered onto 0.2 µm filters, and stained with DAPI. Bacteria, cyanobacteria, photo- and heterotrophic flagellates and diatoms were counted using an epifluorescence microscope within 48 hours after fixation. Filters were stored frozen at -18 deg C

Growth and grazing rates of bacteria and cyanobacteria were estimated with serial dilution experiments at three stations (Table 4). Samples from 15m depth were incubated in three dilution steps (100%, 50% and 10%, triplicates each) in a cold room for ca. four days. At the beginning and end of the experiment sub-samples were taken and counted using epifluorescence microscopy (see above). Preliminary data indicate measurable growth and grazing rates (h-1) for bacteria and cyanobacteria in all three experiments. These rates will provide estimates of the food web dynamics in the microbial loop.

New ice (pancake) was only collected at station from a zodiac. Ice samples were melted in filtered water and counted as outlined for the water samples.

Table 4: Water sampling for pico- and nanoplankton investigations including cell counts and serial dilution experiments.

Date	CTD Station	Lat	Long	Depths for cell counts (m)	Experiment	Location
11.1.16	4	78 19.3N	15 09.9E	5, 15, 35, 75, bottom	-	KKDypet
11.1.16	14	78 39.6N	16 43.8E	5, 15, 35, 75, 183	-	Adolfbukta
13.1.16	26	79 41.8N	11 05.8E	5, 17, 37, 77, 218	x	Smeerenbfj.
14.1.16	38	80 18.5N	22 16.3E	5, 15, 35, 75, 150, 270	x	Rijpfjorden
15.1.16	62	80 58.0N	14 56.4E	5, 15, 35, 75, 150, 400	x	
20.1.16	103	78 57.2N	11 57.1E	10, 25, 50, 100, 300	-	KB3, Kongsfjorden
21.1.16	127	78 55.0N	12 15.6E	10, 25, 50	-	KB5, Kongsfjorden
21.1.16	136	79 01.0N	11 26.6E	10, 25, 50	-	KB1, Kongsfjorden

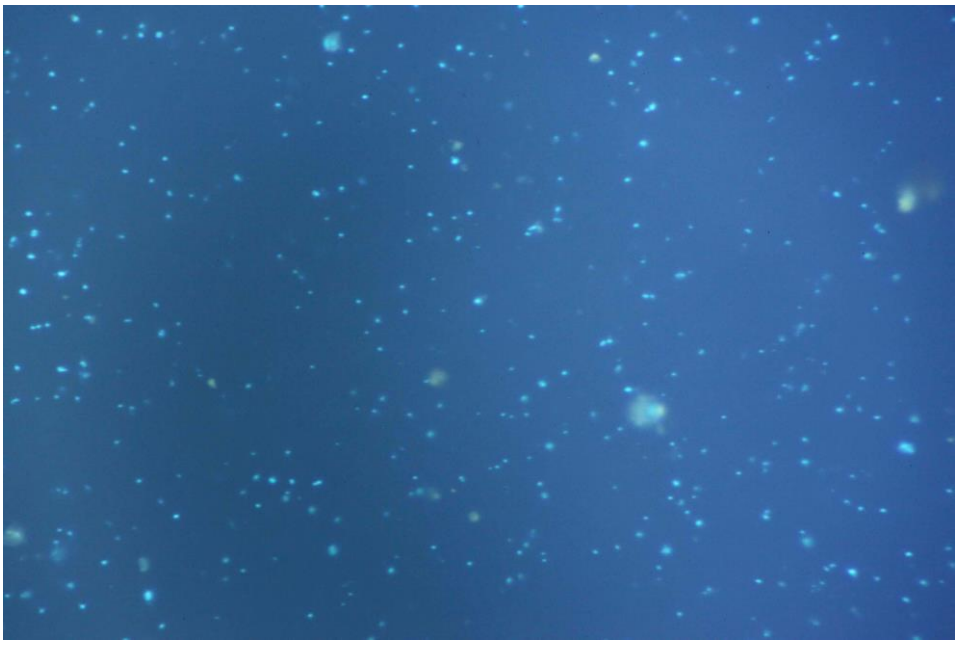


Figure 9: Example of an epifluorescence sample showing bacteria from CTD station 4.

5.4. Protozooplankton

Nicole Aberle-Malzahn, NTNU

During the second leg of the Polar Night Cruise 2016, additional samples for taxonomic enumeration and biomass estimates of protozooplankton (PZP) were taken. PZP is part of the microzooplankton, a size fraction of zooplankton ranging between 20-200 µm. The focus of the present analysis was on heterotrophic protists (mainly ciliates, heterotrophic dinoflagellates, radiolarians) which are considered as an important link between microbial and traditional food webs. Especially at times, when phytoplankton production is low, heterotrophic protists are likely to play a pivotal role in channeling matter and energy from the microbial food web to higher trophic levels. Data on PZP estimates from the polar night period is rare and the role of PZP as a trophic link within the winter zooplankton community remains underinvestigated so far.
The aim of the present analysis was, to get an estimate on the relevance of PZP during the polar night period relative to mesozooplankton and to relate PZP abundances, species composition, diversity and biomass distribution within the water column to mesozooplankton abundances (Malin Daase, Janne Søreide & co-workers). In order to get a closer idea on trophic relations within the microbial food web, it was aimed to directly link PZP data to the composition and activity of heterotrophic pico- and nanoplankton fractions (e.g. bacteria, heterotrophic nanoflagellates, cyanobacteria) obtained from the same stations and depth intervals during Leg. 2 of the Polar Night Cruise 2016 (Rolf Gradinger).

Protozooplankton sampling:

Seawater samples from the CTD were obtained from several station ranging from just off the entrance of Kongsfjorden (Station V12) to the inner part of Kongsfjorden close to the Kongsbreen glacier. A detailed list of the stations sampled for PZP enumeration are given in Table 1. Right after sampling, the seawater was transferred to 250 ml brown glass bottles and fixed with 1% acidic Lugol's iodine solution. For detailed analysis on PZP abundance and composition, water samples need to be analyzed using the Utermoehl technique where samples are transferred to sedimentation chambers and counted using an inverted microscope. Since an even distribution of particles within the sedimentation chambers cannot be guaranteed onboard a ship, PZP samples will be analyzed in the laboratory on return.

In addition to the regular PZP sampling, GFF-filters containing the residue from filtered seawater where obtained at several station in order to gain DNA-material of the protist community. The filters where dried and stored in the dark at ambient temperature. On return, the DNA will be extracted and PZP diversity analyzed using next-generation sequencing.

In close cooperation with the robotics group (Martin Ludvigsen, Geir Johnsen & co-workers), additional PZP samples were obtained at several occasions during JetYak deployments. The aim was to relate PZP depth distribution patterns to mesozooplankton and fish distribution patterns obtained from the AZFP (Acoustic Zooplankton- and Fish-Profiler) in cooperation with Maxime Geoffroy.

Table 5: Water samples taken for protozooplankton and DNA studies

Date	*Station no.*	*Station*	*Position*	*Protozoo-plankton*	*Phyto-plankton*	*DNA*
20.01.2016	# 103/104	KB3	78°57'N 11°57'E	X	X	X
21.01.2016	# 127 (JetYak)	Kongsbreen	78°55'N 12°15'E	X	X	
21.01.2016	# 129 (JetYak)	Kongsbreen	78°54'N 12°15'E	X	X	
21.01.2016	# 131	KB5	78°53'N 12°26'E	X	X	X
21.01.2016	# 136	KB1	79°00'N 11°26'E	X	X	
22.01.2016	# 146(JetYak)	Kongsbreen	78°54'N 12°11'E	X	X	
23.01.2016	# 158 (JetYak)	Kongsbreen	78°54'N 12°12'E	X	X	X
23.01.2016	# 161	V12	78°58'N 09°30'E	X	X	

5.5. Pelagic water sampling (KB3) and sediment traps on the mooring

Ingrid Wiedmann, UiT

Water from the niskin rosette at KB3 (10, 25, 50, 100 m) was collected for nutrient analysis (unsure about the quality, due to some sampling problems). In addition, water was filtered for Chlorophyll *a* tot (Chl *a* > 0.7 µm), Chl *a* > 5 µm, particulate organic carbon and nitrogen (POC/ PON) and DNA (0.45-10 µm; > 10 µm) (Table 6).

In proximity to KB3, short-term sediment traps were deployed on the mooring at 17, 27, 47, and 77 m (Figure 6) and subsamples from the traps were filtered for Chl *a* > 0.7 µm, Chl *a* > 5 µm, POC/ PON and DNA (0.45 µm – 10 µm; > 10 µm). One sediment trap cylinder per depth was modified with a gels jar to determine the particle size spectrum of sinking particles (> 50 µm, Table 6).

The data collected during the Polar Night Cruise will be part of a larger data set. I aim to compare the suspended parameters (Chl *a*, POC/ PON and DNA) with the downward flux of these parameters and the sinking particles at (1) KB3 in the ice-free Kongsfjorden (in conjunction with the PROECO project, Clara Hoppe, AWI, Germany) and (2) the seasonally ice-covered van Mijenfjorden (in conjunction with the UNIS course in April 2016 and the FAABulous project, Eva Leu, Akvaplan Niva) during different seasons.

Table 6: Overview over the suspended and sedimented parameters taken at KB3 and in proximity to it during the mooring deployment.

Date	Time (local)	Long	Lat	Susp./ Sed.	Equipment	Depth	Parameters
20.1.2016	22:15	78° 57.34N	11° 57.16E	susp.	Niskin bottle	10, 25, 50, 100 m	(nutrients*) Chl a Chl a > 5 µm POC DNA (0.45-10 µm; > 10 µm)
20.1.2016	21:53	78° 56.73N	12° 01.81E	sed.	sediment trap (19 h deployment; out: 20.1.2016; local time: 21:53, in: 21.1.2016; local time: 16:40)	17, 27, 47, 77 m	Chl a Chl a > 5 µm POC DNA (0.45-10 µm; > 10 µm)
					gel trap (deployed together with sediment traps)	17, 27, 47, 77 m	sinking particles (> 50 µm) from image analysis in lab

*problems during sampling!

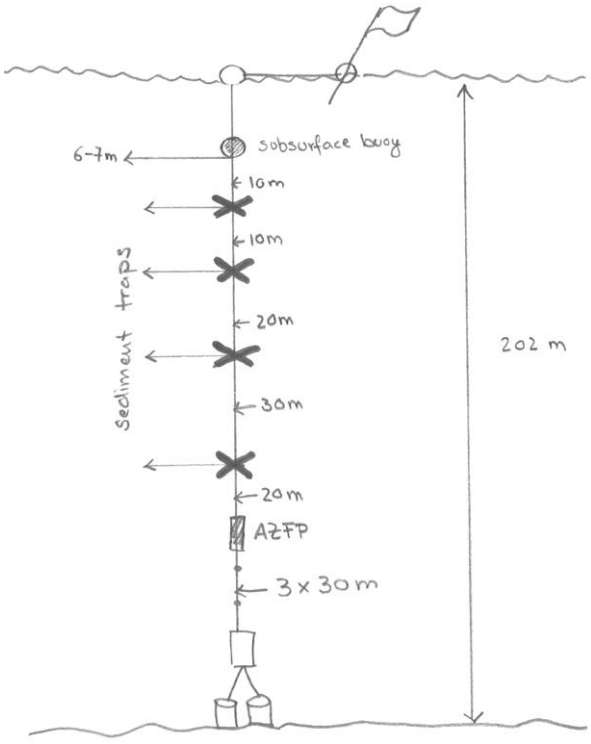


Figure 10: Drawing of the setup of the mooring. A depth meter was deployed right under the subsurface buoy, and indicated a depth of 6-7 m (low/ high tide).

5.6. Genetically variability in *Calanus* populations

Marvin Chorquit, UiN

Calanus finmarchicus and *Calanus glacialis* are key components of the marine food web in the Northern Oceans, and very little is known about the genetic diversity of their populations. A better understanding of the dynamics of *Calanus* populations would bring insights about the potential ability of the species to face important environmental changes, as global warming.

This is basically what my PhD is about, aiming at figuring out either populations of *Calanus* are differentiated, and understand the potential structuration of these populations. I also want to go further and to assess the temporal stability of this structuration with a sampling over the time.

Another project in my phD is to study the microbiome (bacterial community living together with a host species) of *Calanus glacialis* and *Calanus finmarchicus*, and to compare it between species, and also at different latitudes.

I am using the new technologies of Next-Generation Sequencing, and the genotyping of Single Nucleotide Polymorphisms markers (SNPs) in these different purposes.

The Polar Night Cruise was for me the opportunity to gather more samples from locations where *Calanus finmarchicus* and *Calanus glacialis* are present, in order to complete my collection of sampling.

So, thanks to this cruise, I now have a temporal sampling from the whole distributional range of both species *Calanus finmarchicus* and *Calanus glacialis*. I will use these samples for the different parts of my phD.

Table 7: Sampling stations, with WP2 180 µm

date	Time (local)	Station	Lat (N)	Long (E)	Sample depth
08/01/2016	23:05	St.2 (Tromsø)	*70 34.442*	*019 14.5969*	300–0
11/01/2016	05:30	St.5 KKD (Isfjord)	*78 19.2918*	*015 09.8672*	190–0
11/01/2016	19:30	St.21 (Billefjord)	*78 39.7348*	*016 43.6853*	180–0
13/01/2016	03:00	St.28 (Smeer.)	*79 42.0186*	*011 05.5166*	210–0
14/01/2016	08:30	St.44 (Rijpforden)	*80 18.601*	*022 16.468*	260–0
15/01/2016	21:00	St.67 (North ice)	*80 58.080*	*014 41.693*	200–0
20/01/2016	14:30	St. 109 (Kongsfjorden)	78 59.290	011 58.051	200-0

Main jobs:
For each station I picked 10 individuals from *Calanus finmarchicus* and *Calanus glacialis*, rinsed them twice in sterile seawater, and froze them directly at -80 degrees for later analysis of microbial communities associated to its gut.
I fixed the rest of the sample in ethanol 96% for later population structure analyses.
Also, I sampled 1 liter of surface seawater for each sampling station, and I filtered it with 5 µm filter, and then with 0,22 µm filter. I froze the filters at –80 degrees. It will be a control in my microbiome analyses.

Other jobs
Also, for collaboration, I have been asked to look for an individual of the large chaetognathe *Sagitta maxima*, living in deep Arctic waters, and to extract DNA freshly from it. This project aims to sequence the whole genome of the species. I have been successful in finding it, and could then extract DNA from it.

5.7. Benthic photographic survey

Kajetan Deja, Institute of Oceanology, Polish Academy of Science

I took part in research cruise on Helmer Hansen ship. My task was photographing organisms living on the seabed near the glaciers fronts using Lander. I was able to gather interesting research material at 10 stations located in the Isfjorden, Kongsfjorden, Magdalenfjorden, Smeerenburgfjorden and in Rijpfjorden (Fig. 11). In Rijpfjorden I took only one station but sea bottom here is very interesting. There was here a lot of brittle stars mainly *Ophiura sarsi, Ophiopholic acuelata*, and a single big red starfish *Urasterias lincki* and predatory *Diplopteraster multipes* (Fig.12, Fig. 13). In Kongsfjorden and Billefjorden I also collected interesting material (Fig. 14, Fig.15). The film material filmed on the bottom, was recorded for further analysis.
In addition to the tasks associated with the collection of material needed to complete my dissertation, I helped the other participants of the cruise. In Trygghamna archaeologists made an inspection of the wreck Figaro. Scientists launched and tested Jetyak - a special remote controlled kayak that can be used for measurements in the immediate vicinity of the glacier. During the cruise I observed how to operate the vehicle ROV and sampling plankton.
Every evening there were also interesting lectures, among others about underwater archaeology and robotics, during which I learned a lot of interesting things.

My participation in the research cruise on the vessel Helmer Hanssen significantly increased exceedingly my knowledge and experience, and the possibility of working with excellent experts from different countries was a great honor.

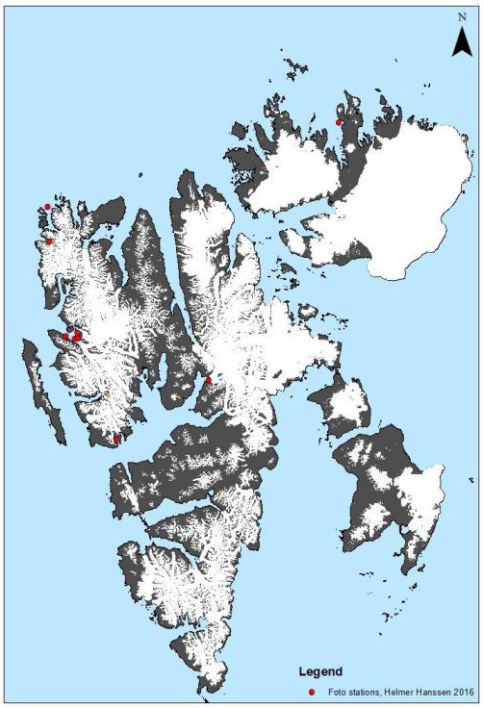


Figure 11: Locations of photo stations taken during the cruise

Figure 12: Sea bottom in Rijpfjorden.

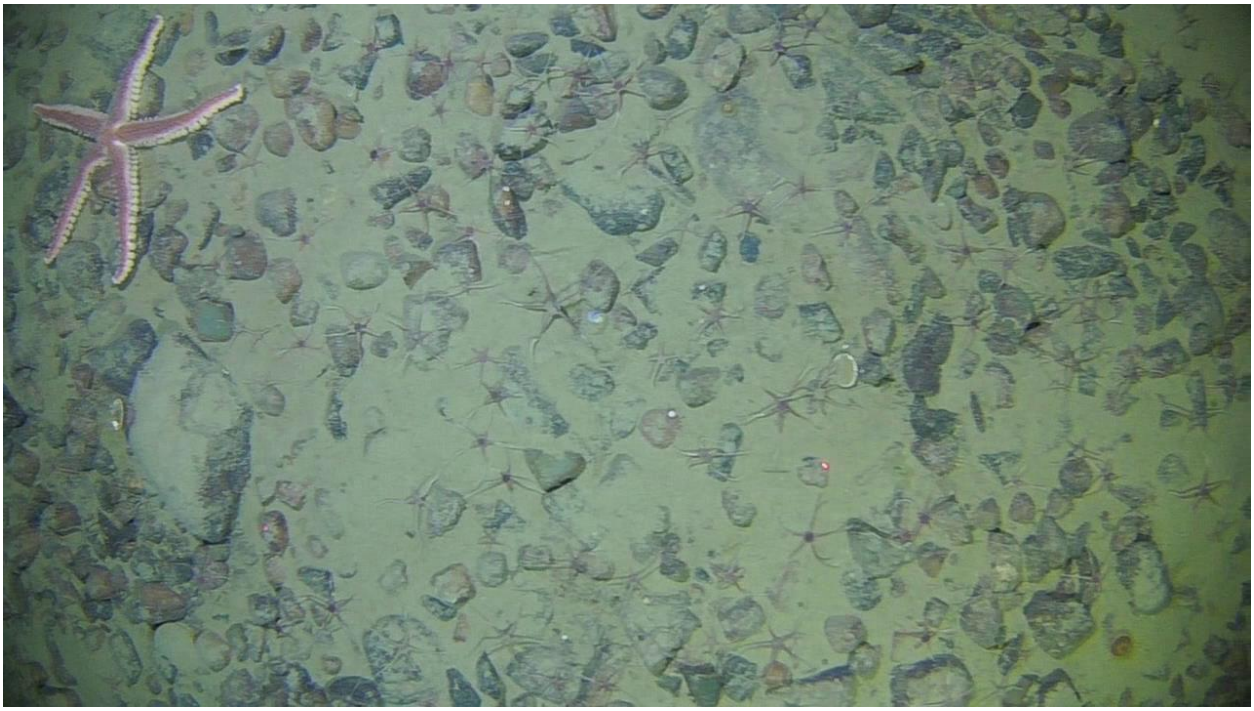


Figure 13: Sea bottom in Rijpfjorden.

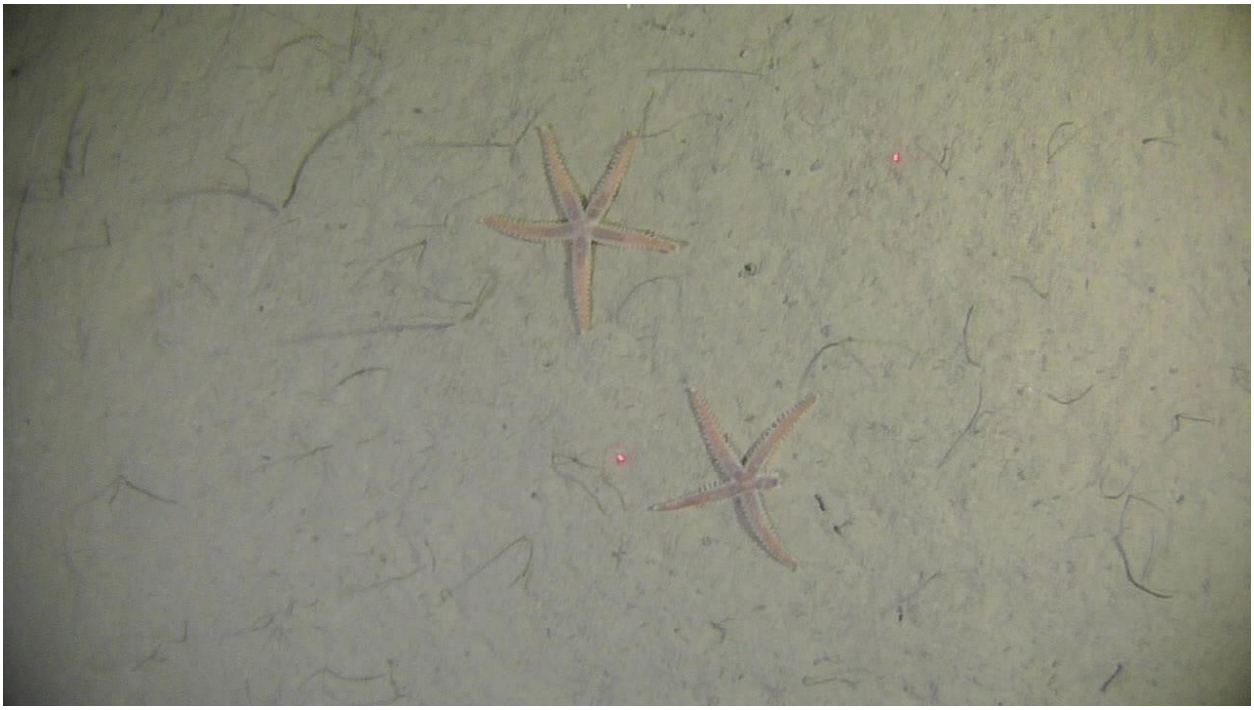


Figure 14: Sea bottom in Kongsfjorden

Figure 15: Sea bottom in Billefjorden.

5.8. Light and Ecophysiology

Jon Cohen and Corie Charpentier – UDel; Kim Last – SAMS; Geir Johnsen – NTNU

1) Endogenous rhythm in krill visual sensitivity (**Figure 16**)

We investigated whether diel changes in visual sensitivity of *Thysanoessa inermis* were present and under endogenous control. Krill were collected by MIK (primarily) and WP3 nets from Isfjorden, Rijpfjorden, and Kongsfjorden, then sorted (under red light) and held in the small environmental room at ~3 °C in darkness without food. Visual sensitivity was assessed after ~24h in darkness with extracellular electroretinograms (ERGs), which use a metal microelectrode to record the mass retinal response from photoreceptors in the eye when flashed with 488nm light. We made ERG recordings in *T. inermis* to generate response-intensity (*V* – log *I*) curves, where response magnitude (peak-to-peak height) increases with light intensity until reaching a maximum response. The irradiance at half-saturation (log K) can be used as a quantitative measure of visual sensitivity. *V* – log *I* curves were generated for individual krill during day (9:00 – 15:00; n = 8) and night (21:00 – 3:00; n = 8). We also conducted a sensitivity time series experiment where an individual *T. inermis* (n = 3) was given a 50 ms light (488 nm) stimulus of constant intensity at 15 min intervals over 24-48 hours. In addition to electrophysiology, krill were sampled for histology (fixed in 4% borax-buffered formaldehyde; day [n = 5], night [n = 5]). Finally, we sampled *T. inermis* (n = 15, from Isfjorden MIK sample) every 4 hours over 48 hours while held in darkness. Samples were flash frozen with liquid nitrogen and stored at -80 °C.

2) Spectral and intensity sensitivity in amphipods

Using ERG recordings, we determined spectral and intensity sensitivity in three amphipod species: *Themisto libellula* (n = 1), *Themisto abyssorum* (n = 5), and *Apherusa glacialis* (n = 1). We assessed spectral sensitivity by determining what irradiance is needed to generate a criterion ERG response magnitude across a spectral range, and intensity sensitivity with *V* – log *I* curves.

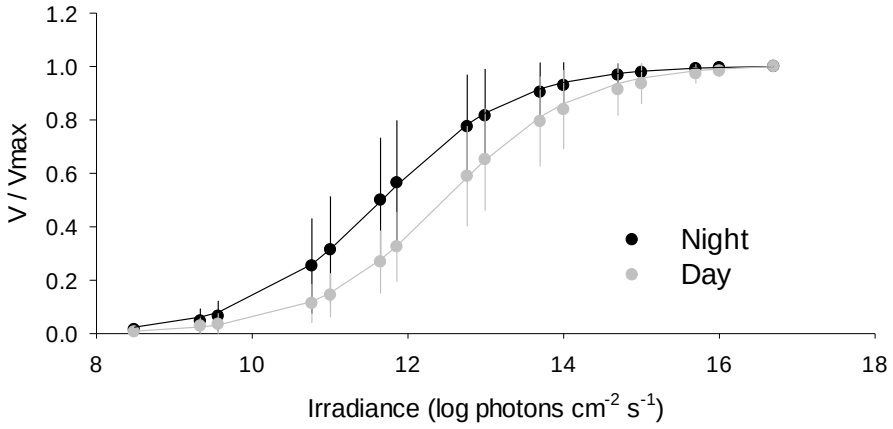


Figure 16. Composite visual sensitivity (V-logI) curves for *Thysanoessa inermis* tested during the day and night. Data are means ± 1 SD, n=8.

3) Irradiance measurement (hyperspectral and PAR) and all-sky imagery (**Table 8**, **Figure 17**)

All light measurements were made on atmospheric light. We made hyperspectral irradiance measurements with a QE-PRO spectroradiometer (200 µm slits) calibrated on 9JAN16 (1000 µm fiber, 2m) and on 20JAN16 (1000 µm waterproof fiber, 2m). For all measurements, the optical

fiber was positioned at 45° and ~2 cm from a reflectance plate (USRT-99-050) facing the sky zenith. In most cases, 10 replicate spectra were captured sequentially with a 10 second integration time for each. An IMO PAR sensor was deployed periodically, but results were inconsistent and questionable. Light measurements were made near the crow's nest on the roof of the bridge starboard (~15 m above sea level), and from the communications pole aboard the jetyak (~0.5 m above sea level). All-sky images were made with a Canon EOS 5D Mark III with full size CMOS sensor and 8 mm fish eye lens, set to a constant ISO of 12800, aperture of 4.5, "daylight" white balance, and variable shutter speed.

Table 8. Light measurements and all-sky imagery completed during the cruise. Abbreviations indicate measurement corresponding to approximate maximum elevation of sun (sol) and moon (lun), and presence of aurora (aurora). Instruments are: spectroradiometer with reflectance plate (QE-PRO), all-sky camera (Camera), and cosine-corrected IMO PAR sensor (IMO).

Date	Time (GMT)	Location	Instrument	Platform
10-Jan-16	11:34 (sol)	76 30.9 N, 14 24.8 E	QE-PRO, Camera, IMO	Roof
11-Jan-16	11:17 (sol)	78 29.8 N, 16 05.7 E	QE-PRO, Camera	Roof
12-Jan-16	11:11 (sol)	78 10.4 N, 11 44.1 E	QE-PRO, Camera	Roof
	11:33 (aurora)			
13-Jan-16	11:16 (sol x2)	79 59.3 N, 12 33.3 E	QE-PRO, Camera	Roof
	14:30 (lun)	80 12.7 N, 14 39.6 E		
14-Jan-16	Start 6:06 -	80 18.5 N, 22 16.3 E	QE-PRO, Camera	Roof
15-Jan-16	- 15:40 (lun) End	80 57.2 N, 14 52.2 E		
17-Jan-16	11:14 (sol)	78 09.2 N, 13 08.8 E	QE-PRO, Camera, IMO	Roof
20-Jan-16	23:30 (post-lun)	78 57.2 N, 11 57.7 E	QE-PRO, Camera	Roof
21-Jan-16	9:44 - 12:16	78 53.9 N, 12 20.1 E	QE-PRO, IMO	Jetyak
22-Jan-16	8:45 - 13:33	78 55.1 N, 12 14.3 E	QE-PRO	Jetyak
23-Jan-16	8:40 - 13:20	78 54.9 N, 12 13.5 E	QE-PRO	Jetyak

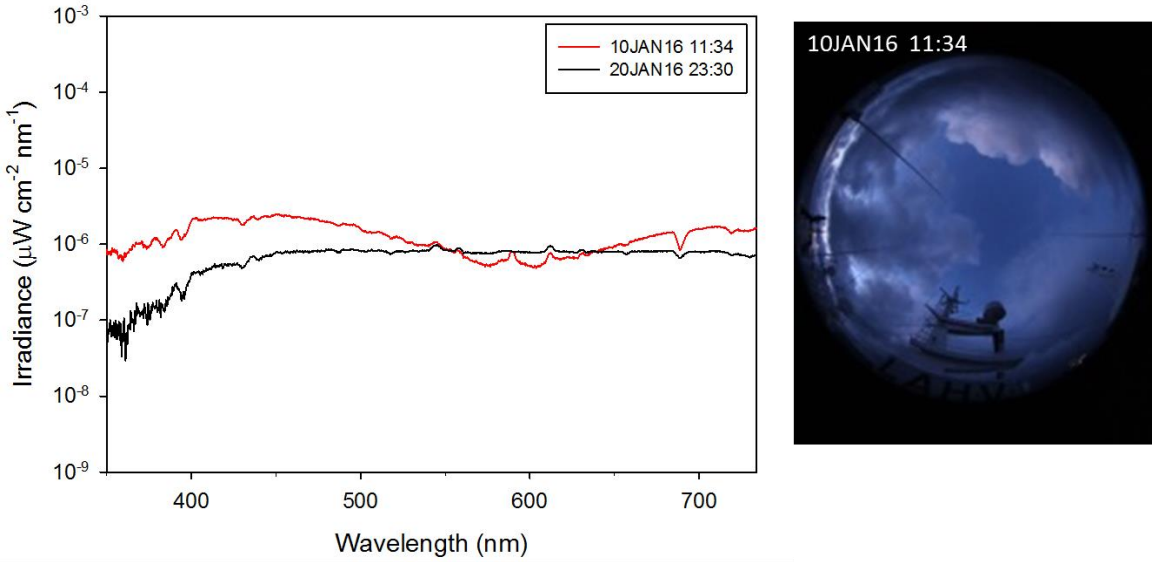


Figure 17. Representative spectral irradiance data for skylight dominated by sun and moon. An all-sky image for approximately solar noon on 10JAN16 is sown at right.

5.9. Acoustic programme

Finlo Cottier, Scottish Association for Marine Science; Maxime Geoffroy, UiT

Objectives:

The main objectives of the acoustic programme were:

1) To collect acoustic recordings of the pelagic ecosystem along the ship's track and to validate the echoes using pelagic trawls and multi-net samplers.

2) To test different sampling phases with the Acoustic Zooplankton and Fish Profiler (AZFP), as part of the Arctic ABC project.

3) To test the use of an AZFP on board an autonomous platform, as part of the Arctic ABC project.

Materials and Methods:

The multifrequency (38, 120, and 200 kHz) Simrad EK60 echosounder hull-mounted on the Helmer Hanssen was calibrated prior to departure and continuously recorded acoustic data from January 8 to 24. Throughout the cruise, 9 pelagic trawls were deployed by the fish and benthos team (leader Marine Cusa, UiT) and 23 multi-net deployments were conducted by the zooplankton team (leader Malin Daase, UiT). Comparing trawl and net samples with acoustic data will allow estimating the pelagic biomass of fish and zooplankton along the ship's track.

A first AZFP was moored on three occasions, for a total of 56.5 hours (Table 9). Each deployment was divided in 4 different sampling phases to test the accuracy of longer ping-averaging periods. Analysis of the acoustic data collected during different sampling phases will allow determining the optimal configuration for the deployment of the AZFP on a long-term autonomous platform during the Arctic ABC project.

Table 9: Details of moored AZFP deployments

Date (UTC)	Location	Lat	Long	Time in (UTC)	Time out (UTC)	Sampling depth	Bottom depth
14-01-2016[1]	Ripjfjorden	80°16.79N	22°19.51E	01:00	15:00	75 m	190 m
18-01-2016	Isfjorden	78°19.41N	15°33.45E	18:30	18:30 +1	102 m	200 m
20-01-2016	Kongsfjorden	78°56.72N	12°01.23E	21:00	15:30 +1	96 m	220 m

[1]Only the first 6 metres above the instrument were surveyed during that deployment.

In collaboration with the robotic team (leader Martin Ludvigsen, NTNU), a second AZFP was mounted on an autonomous Jetyak. Jetyak-based acoustic transects were conducted on four occasions, for a total of 10.75 hours (Table 10). During the last three deployments (Kongsfjorden), high-resolution sampling phases (0.5 Hz) were programmed to allow accurate comparisons between acoustic and light data (collected by John Cohen, University of Delaware).

Table 10: Details of Jetyak-mounted AZFP deployments

Date (UTC)	Location	Time in (UTC)	Time out (UTC)
17-01-2016	Trygghamna	15:00	16:00
21-01-2016	Kongsfjorden	10:30	12:00
22-01-2016	Kongsfjorden	09:15	13:15
23-01-2016	Kongsfjorden	09:00	13:15

The 22 CTD casts conducted throughout the cruise will allow calculating the sound-speed and sound-absorption profiles required for acoustic calculations.

Preliminary results:

Data from the EK60 echosounder suggest that pelagic biomass was higher in fjords and over the northern shelf break than over the shelf.

Successful deployments on board the Jetyak suggest that during the polar night (1) zooplankton react to changes in sun irradiance (Figure 18); (2) collecting data from an autonomous surface platform allows detecting small-scale vertical migration of zooplankton in the top 15 m of the water column, which corresponds to the blind zone of the ship's EK60 echosounder; and (3) close to the ship, zooplankton in the surface layer react to artificial light and are distributed >10 m deeper than elsewhere.

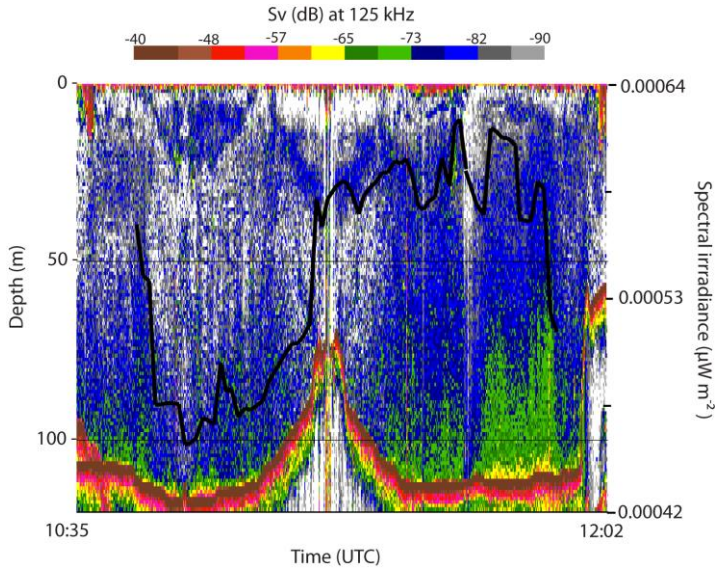


Figure 18. Backscatter data at 125 kHz from the Jetyak deployment in Kongsfjorden on January 21. The black line indicates changes in spectral irradiance.

5.10. Fish community and polar cod diet

Jørgen Berge, Marine Cusa, Carl Ballantine, Maxime Geoffroy, Sam Newby; UiT

Master's project (Marine Cusa): Seasonal variation in polar cod's diet
Post-doc project (Maxime Geoffroy): AZFP
Ongoing project: Fish community structure during the polar night

1. Fish and invertebrates were caught using a Campelen 1800 bottom trawl with a 22 mm cod end mesh size and a Harstad pelagic trawl with an 8 mm mesh size. We trawled 17 times during the cruise at different depths (see Table 11). Trawls lasted on average 15 minutes.

2. Once in the boat's fish lab, species were sorted in groups and total weight plus number of individuals per species was recorded for each trawl (fish and invertebrates).

3. We then measured individual fish length and weight for a minimum of 30 specimen (random subsample) for a number of fish species in benthic trawls and for all fish species in pelagic trawls. We dissected the fish and recorded the weight of liver, gonads, and stomachs of 30 Atlantic cod. Furthermore, we estimated stomach fullness and determined sex based on gonads when possible. Saithe and haddock were processed in the same way. The same information was recorded for a minimum of 40 polar cod whenever present. Stomachs were dissected from all the fish for which these information were recorded.

4. The trawl information and the types of sampling are summarized in the tables below:

5. The dissected stomachs were kept in ethanol or frozen and some of them were analysed on board. Stomach content preys were analysed down to the lowest taxonomic level possible, weighed, and counted. Stomach fullness was estimated again from a scale of 1-5 after opening the

stomach. Empty stomach weight was recorded. Stomachs that were not analysed are conserved in 70% ethanol and will be analysed at the University in Tromsø. Each stomach was given an ID number which corresponds to the fish for which all gut measurements were taken.

Table 11. Trawling and cruise information for each of the 7 trawl.

Trawl #	Trawl ID	Trawl type	Station #	Location	Start	Stop	Lat	Long	Bottom Depth
1	**BF**	Bottom	13	Billefjorden	12:27	12:47	78 35.95N	016 30.53E	158
2	**SB**	Bottom	30	Smeerenburg	6:43	7:00	79 45.40N	011 05.16N	189
3	**SC**	Pelagic	31	Smeerenburg	7:59	8:19	79 44.28N	011 05.94E	213
4	**RG**	Bottom	37	Rijpfjorden	2:17	2:33	80 22.84N	022 03.66E	260
5	**RH**	Pelagic	48	Rijpfjorden	12:48	13:15	80 20.32N	022 03.73E	287
6	**RI**	Bottom	50	Rijpfjorden	16:13	16:35	80 22.87N	022 05.20E	251
7	**NA**	Pelagic	53	Transect	23:20		80 50.69N	017 26.45E	206
8	**NA**	Bottom	54	Transect	0:40	0:53	80 51.35N	017 27.58E	215
9	**NA**	Pelagic	81	Transect	12:53	13:25	78 14.38N	013 49.23E	132
10	**NA**	Bottom	92	Isfjorden	9:23	9:44	78 25.11N	015 05.54E	219
11	**NA**	Pelagic	93	Isfjorden	10:45	11:09	78 19.46N	015 04.43E	271
12	**KL**	Bottom	101	Kongsfjorden	6:44		79 03.22N	011 21.82E	353
13	**KM**	Bottom	113	Kongsfjorden	17:04	17:24	78 58.13N	011 57.02E	287
14	**KN**	Pelagic	114	Kongsfjorden	17:56	18:21	78 58.08N	011 56.03E	303
15	**KP**	Pelagic	138	Kongsfjorden	23:44	0:04	79 00.95N	011 24.43E	337
16	**KQ**	Bottom	152	Kongsfjorden	19:32	19:52	78 54.33N	012 12.49E	88
17	**KR**	Pelagic	153	Kongsfjorden	20:27	20:48	78 54.58N	012 11.93E	115

Table 12. Types of sampling performed for each trawl (x = yes, empty cell = not performed for this trawl).

Trawl ID	Total # of individuals per species	Total weight (biomass) per species (g)	Weight and size of individuals within fish species	Gut content measurements	Stomach dissection
BF	X	X	X	X	X
SB	X	X	X	X	
SC	X	X	X	X	
RG	X	X	X	X	
RH	X	X	X		
RI	X	X	X	X	X
NA	X	X	X		
NA	X	X	X		
NA	X	X	X		
NA	X	X	X		
NA	X	X	X		
KL	X	X	X	X	
KM	X	X	X	X	
KN	X	X	X	X	
KP	X	X	X		
KQ	X	X	X	X	
KR	X	X	X	X	

5.11. Robotics

Martin Ludvigsen, Ines Dunke, Stein Melvær Nornes, Øyvind Ødegard, Aksel Alstad Mogstad, Geir Johnsen, Sturla Haltbakk, Frode Volden; NTNU

1. Remotely Operated Vehicle (ROV)

1.1 Equipment

1.1.1 ROV Minerva

Minerva is a SUB-fighter 7500 ROV made by Sperre AS in 2003 for NTNU. It is a medium sized ROV (144x82x81 cm, 485 kg) and is powered from and communicates with the surface vessel through a 600 m umbilical. The standard sensor suite includes an HD-camera, 5 SD-cameras, depth gauge, Inertial Measurement Unit (IMU) and Doppler Velocity Logger (DVL). The global positioning was done using the USBL system HPR300 mounted on the side of Helmer Hanssen.

1.1.2 Stereocameras

For this survey, the ROV was also equipped with a stereo camera rig. This features two Allied Vision GC1380C cameras mounted in parallel on a horizontal bar, 31.5 cm apart at a 45° forward-facing angle. The cameras have a resolution of 1360x1024 pixels and are capable of recording at 20 frames per second. Their high light sensitivity and signal to noise ratio makes them suitable for underwater operations.

1.1.3 Underwater hyperspectral imager (UHI)

The Ecotone Scientific UHI is a hyperspectral line scanner mounted on the port side of the ROV. It points at 90° towards the seafloor and records light from two Halogen lamps (250 W each) – mounted on either side of the UHI – that is reflected back from the seafloor. The width of the scanned line is the same as the ROV altitude, which is kept at 1-2 m. To produce a recognizable picture, the scanner needs to be moved forward at a steady speed, and the lines are then combined into a larger image in post-processing. Unlike a regular camera, which records rectangular images with three colour bands (RGB), the UHI images are lines of up to 1600 pixels with up to 980 colour bands spanning the entire visible spectrum (378-848 nm). With the spectral information stored in each image pixel, different bottom substrates and objects on the seafloor can be identified based on their individual spectral signatures.

1.2 Surveys

1.2.1 Trygghamna – survey 1

The first ROV survey was conducted on 12 January 2016 at the Figaro wreck site in Trygghamna. Figaro was a floating whalery that caught fire and sank in Trygghamna in 1908. It measures 50 m long and about 12 m wide, and protrudes maximum 4 m above the seabed. The wreck site is an underwater cultural heritage site protected by law, and our archaeological investigations of the site had to be done using only non-intrusive methods. The wreck seemed to be very well preserved and to a large degree structurally intact. Photogrammetry and underwater hyperspectral imaging (UHI) are expected to be very appropriate technologies for archaeological surveys of this site.

The aim of the ROV survey was to collect video data and photogrammetry data from the wreck site, as well as UHI data from both inside and outside the wreck. Deployment of the ROV started at about 02:00 (local time) and the ROV was recovered at 09:30. Underwater visibility was initially poor, probably caused by the Helmer Hanssen's anchor chain, but improved during the survey. The survey yielded approximately 6 h of video data and more than 20,000 images for

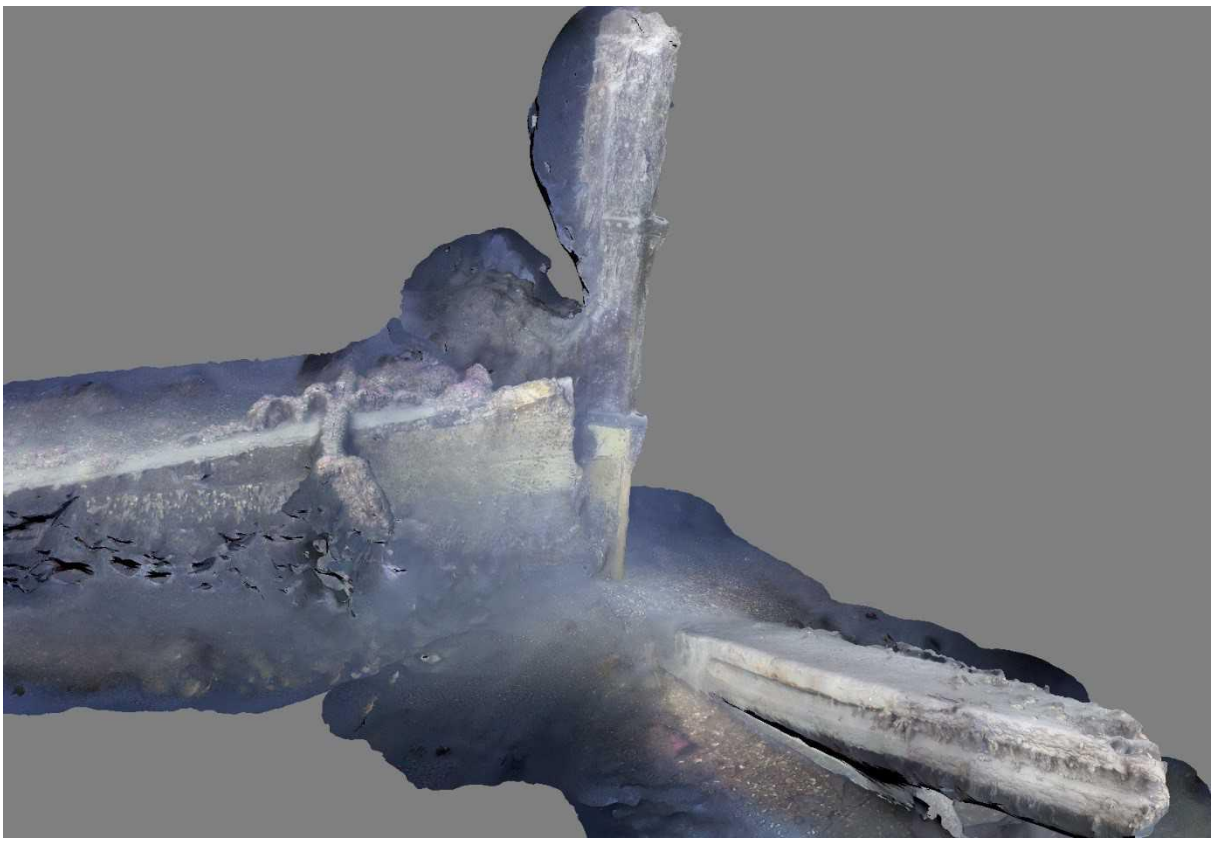
photogrammetry. UHI data could not be acquired due to communication problems between the ROV and the UHI.

1.2.2 Trygghamna – survey 2

The Figaro wreck site was revisited with the ROV on 17 January 2016 to fill gaps in the video and photogrammetry coverage and acquire UHI data. This time, communication between the ROV and UHI could be established. The ROV was deployed at 19:00 and recovered at 23:00. Although the main focus of the survey was on the wreck site, three UHI transects were also conducted outside the wreck to map the surrounding seafloor. In addition to the UHI data, additional video data and more than 10,000 additional images for photogrammetry were acquired during the survey.

Preliminary results

Initial 3D photomosaics are shown below (1: mosaic of deck, 2+3: sternpost and rudder seen from the side).



The image below is an example from the raw UHI data (here in pseudo-RGB) acquired inside the wreck, showing wooden and metal structures, barnacles (*Balanus balanus*) covered by red calcareous algae, and brownish patches of rust at different concentrations. Barnacles, red calcareous algae and various hydrozoans were by far the most abundant organisms associated with the wreck. In addition, sea anemones and crabs from the genus *Hyas* were frequently observed. The degree of biofouling appeared to vary between wreck substrates. Wood, rope and steel were for instance covered by organisms to a large degree, whereas copper and brass were virtually untouched. Based on the UHI raw data, the species composition associated with the wreck itself appeared to differ from the composition of the surrounding area. The UHI data will be further processed and interpreted in terms of archaeology, biology and geology at the wreck site.

1.2.3 Kongsfjorden (Kongsvegen)

The ROV survey at Kongsvegen in Kongsfjord was conducted on 21 January 2016 with the aim of acquiring seabed video data for biological interpretations. After some delay due to an iceberg in the vicinity of the ship, the ROV was deployed at 09:00 and surveyed an area close to the glacier (approx. 1 km). Acquisition of photomosaic images was not possible because the ROV altitude necessary to obtain good HD-video was too low for the mosaic camera to focus. The ROV was recovered again at 10:20 to avoid delaying the JetYak operations.

1.2.4 Kongsfjorden (Kvadehuken)

The last ROV survey was conducted at the Kvadehuken photo station in outer Kongsfjorden on 21 January 2016. It lasted from 18:00 to 22:00. Both video and UHI data were acquired and are to be interpreted in terms of geology and biology.

The example below shows the raw UHI data (in RGB). Reddish bedrock, red sea anemones (Hormathia sp.), and dark sea urchins can be identified.

2. Autonomous Underwater Vehicle (AUV)

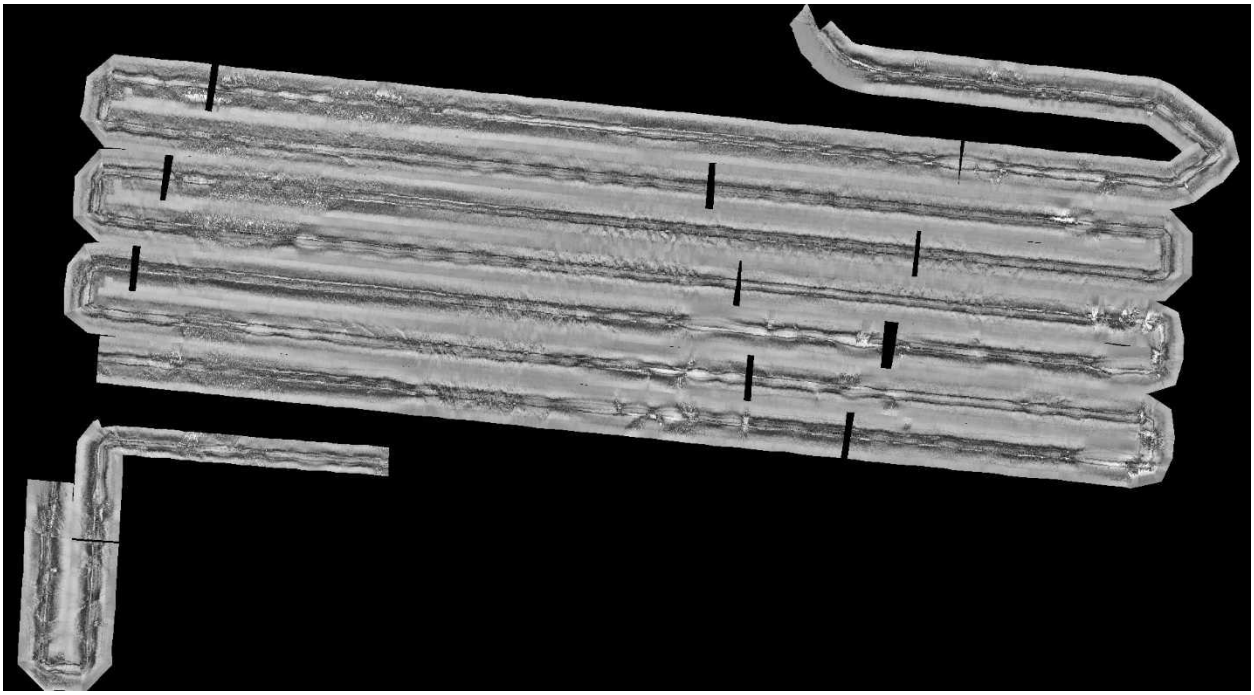
2.1. REMUS 100

The REMUS 100 is a small AUV with a maximum depth rating of 100 meters. It is equipped with a Marine Sonics 900 kHz Sidescan Sonar, CT, Depth sensor, RDI 1200 kHz ADCP/DVL, Long Base Line (LBL) Navigation, and flux gate magnetic compass.

2.2 Danskegattet (Smeerenburg)

The AUV survey took place in Danskegattet near Smeerenburg on 16 January 2016. The aim of the survey was to acquire sidescan sonar data to search for potential 17th century shipwrecks on the seabed. Deployment and recovery of the AUV were done from the Polarcirkel and the survey lasted from 15:50 to 20:10. In addition to the acquired sidescan sonar data, CTD and oxygen optode measurements were also conducted by the AUV.

The image below shows the sidescan sonar mosaic after initial post-processing (removal of the water column and automatic gain control). The data are at present inconclusive as to the presence of potential wreck sites, but will be analysed in more detail.



3. JetYak

3.1 Equipment

3.1.1 JetYak

The JetYak is an autonomous kayak developed by Woods Hole Oceanographic Institution. The core of the JetYak is a commercially sold gas-powered kayak built in upstate New York and marketed mostly to fishermen and hunters. It has a roto-molded polyethylene hull and an air-cooled

7-horsepower four-stroke engine. It is propelled and steered by means of a water-drive. The vehicle navigates using GPS and compass, and can be reprogrammed from the mission command computer on the bridge of Helmer Hanssen via radio-link. It can also be controlled manually using a small remote control.

3.1.2 Acoustic Zooplankton- and Fish-Profiler

(Maxime Geoffroy, see 6.9.)

3.1.3 Light Measurement

(Jon Cohen, see 6.8.)

3.2 Surveys

3.2.1 Trygghamna

The first JetYak survey was conducted in Trygghamna close to the glacier edge on 17 January 2016. This was the first time the JetYak was used in Svalbard environments. An acoustic zooplankton fish profiler (AZFP) and a light measurer were mounted on the JetYak to acquire data away from the light influence of the Helmer Hanssen. The JetYak was launched from the ship at 15:30 and the mission was started at 15:50, using manual control. The mission was stopped at 16:45 due to empty batteries of the JetYak remote control, requiring the vehicle to be towed back to the Helmer Hanssen. AZFP and light measurement data were successfully acquired during the survey.

3.2.2 Kongsfjorden

Another JetYak operation consisted of repeated surveys over three consecutive days (21-23 January 2016) in the Kongsvegen area of Kongsfjorden. All three surveys were conducted at the same time of day between 10:00 to 14:00. The system showed fantastic progress over the course of the days as the crew became more familiar with it. Initially, the PolarCirkel had to follow the JetYak relatively close the whole time and the JetYak was mainly steered manually with the remote control. On the third day, the JetYak completed the full mission autonomously, with the PolarCirkel only being on the water for launch and recovery. AZFP and light measurement data were acquired during all surveys.

The jetyak team and the jetyak in action (Photos: Kajetan Deja)

7. Outreach

Radio
NRK2: «Månesyk plankton», Ekko hovedsending 08.02.2016
https://radio.nrk.no/serie/ekko-hovedsending/MDSP25002616/08-02-2016#t=1h8m7s

Svalbardposten
Svalbardposten nr 4/ 2016 29.01.2016: Fant dypvannsfisk på grunna
Svalbardposten nr 4/ 2016 29.01.2016: Kronikk: Mørkest fyrster med påskrudd lys (Berge, Johnsen)
http://svalbardposten.no/index.php?page=vis_nyhet&NyhetID=6824
Svalbardposten nr 5/ 2016 5.02.2016: Kronikk: Design for latskap- men med store muligheter (Berge, Johnsen, Ludvigsen, Cohen)
http://svalbardposten.no/index.php?page=vis_nyhet&NyhetID=6850
Svalbardposten nr 6/ 2016 11.02.2016: Kronikk: Kinderegg i polarnatten (Berge, Johnsen, Ødegård)
http://svalbardposten.no/index.php?page=vis_nyhet&NyhetID=6870

Fram Centre website
Mørkest fyrster med påskrudd lys. 29.01.2016
http://www.framsenteret.no/moerkets-fyrster-med-paaskrudd-lys.5839096-146437.html#.VrjBL8c0slY

Forskning.no
Undervannsrobot som oppfyller tre ønsker. 16.02.2016
http://forskning.no/havforskning-biologi-skipsfart/2016/02/undervannsrobot-som-oppfyller-tre-onsker
Månesyke for plankton i Arktis. 01.09.2016
http://forskning.no/havforskning-sjodyr-arktis/2016/01/manesyke-plankton-i-arktis

UiT website
Design for latskap- men med store muligheter (Bergen, Geoffroy, Johnsen, Ludvigsen, Cohen). 05.02.2016
https://uit.no/om/enhet/aktuelt/nyhet?p_document_id=451861&p_dimension_id=88165

Presentations given during cruise:
Kim Last: Moonlight mass migration of zooplankton
Jonathan Cohen: Light ecophysiology
Geir Johnsen: Everything you need to know about light
Rolf Gradinger: Microbial activities in the Arctic
Martin Ludvigsen: Underwater robotics
Øyvind Øydegard: Marine Archaeology in Svalbard
Nicole Aberele-Mahlzahn: Protists and protozooplankton
Malin Daase: Arctic zooplankton in the polar night
Jørgen Berge: Unexpected level of activities during the polar night
Daniel Vogedes: Impressions from working as a volunteer in refugee camps on Lesvos/Greece

References

Ambrose WG, Carroll ML, Greenacre M, Thorrold SR, McMahon KW (2006) Variation in *Serripes groenlandicus* (Bivalvia) growth in a Norwegian high-Arctic fjord: evidence for local- and large-scale climatic forcing. Glob Change Biol 12:1595-1607. doi:10.1111/j.1365-2486.2006.01181.x

Basedow SL, Tande KS, Norrbin MF, Kristiansen SA (2013) Capturing quantitative zooplankton information in the sea: Performance test of laser optical plankton counter and video plankton recorder in a Calanus finmarchicus dominated summer situation. Prog Oceanogr 108:72-80. doi:10.1016/j.pocean.2012.10.005

Berge J, Daase M, Renaud Paul E, Ambrose William G, Jr., Darnis G, Last Kim S, Leu E, Cohen Jonathan H, Johnsen G, Moline Mark A, Cottier F, Varpe Ø, Shunatova N, Bałazy P, Morata N, Massabuau J-C, Falk-Petersen S, Kosobokova K, Hoppe Clara JM, Węsławski Jan M, Kukliński P, Legeżyńska J, Nikishina D, Cusa M, Kędra M, Włodarska-Kowalczuk M, Vogedes D, Camus L, Tran D, Michaud E, Gabrielsen Tove M, Granovitch A, Gonchar A, Krapp R, Callesen Trine A (2015) Unexpected Levels of Biological Activity during the Polar Night Offer New Perspectives on a Warming Arctic. Current Biology. doi:10.1016/j.cub.2015.08.024

Checkley DM, Davis RE, Herman AW, Jackson GA, Beanlands B, Regier LA (2008) Assessing plankton and other particles in situ with the SOLOPC. Limnol Oceanogr 53:2123-2136. doi:10.4319/lo.2008.53.5_part_2.2123

Cohen JH, Berge J, Moline MA, Sørensen AJ, Last K, Falk-Petersen S, Renaud P, Leu E, Grenvald J, Cottier F, Cronin H, Menze S, Norgren P, Varpe Ø, Daase M, Darnis G, Johnsen G (2015) Is ambient light during the high Arctic polar night sufficient to act as a visual cue for zooplankton? . Plos One. doi:10.1371/journal.pone.0126247

Gaardsted F, Tande KS, Basedow SL (2010) Measuring copepod abundance in deep-water winter habitats in the NE Norwegian Sea: intercomparison of results from laser optical plankton counter and multinet. Fish Oceanogr 19:480-492. doi:10.1111/j.1365-2419.2010.00558.x

Herman AW, Beanlands B, Phillips EF (2004) The next generation of Optical Plankton Counter: the Laser-OPC. J Plankt Res 26:1135-1145. doi:10.1093/plankt/fbh095

Huenerlage K, Graeve M, Buchholz C, Buchholz F (2015) The other krill: overwintering physiology of adult *Thysanoessa inermis* (Euphausiacea) from the hig-Arctic Kongsfjord. Aquatic Biology 23:225-235. doi:10.3354/ab00622

Last Kim S, Hobbs L, Berge J, Brierley Andrew S, Cottier F Moonlight Drives Ocean-Scale Mass Vertical Migration of Zooplankton during the Arctic Winter. Current Biology. doi:10.1016/j.cub.2015.11.038

Leu E, Søreide JE, Hessen DO, Falk-Petersen S, Berge J (2011) Consequences of changing sea-ice cover for primary and secondary producers in the European Arctic shelf seas: Timing, quantity, and quality. Prog Oceanogr 90:18-32

Manley TO (1995) Branching of Atlantic water within the Greenland-Spitsbergen passage - an estimate of recirculation. J Geophys Res- Oceans 100:20627-20634

Nilsen F, Cottier F, Skogseth R, Mattson S (2008) Fjord– shelf exchanges controlled by ice and brine production: The interannual variation of Atlantic Water in Isfjorden, Svalbard. Cont Shelf Res 28:1838-1853

Rudels B, Friedrich HJ, Quadfasel D (1999) The Arctic circumpolar boundary current. Deep-Sea Res Part II 46:1023-1062

Saloranta TM, Haugan PM (2001) Interannual variability in the hydrography of Atlantic water northwest of Svalbard. J Geophys Res- Oceans 106:13931-13943

Søreide JE, Leu E, Berge J, Graeve M, Falk-Petersen S (2010) Timining in blooms, algal food quality and *Calanus glacialis* reproduction and growth in a changing Arctic. Glob Change Biol 16:3154-3163. doi:10.1111/j.1365-2486.2010.02175

Stroemberg J-O Northern Svalbard Waters. In: Rey L, Alexander V (eds) Proceedings 6th Conference of the Comité Arctique International 13-15 May 1985., 1989. pp 402-426

Vogedes D, Varpe Ø, Søreide JE, Graeve M, Berge J, Falk-Petersen S (2010) Lipid sac area as a proxy for individual lipid content of arctic calanoid copepods. J Plankt Res 32:1471-1477. doi:10.1093/plankt/fbq068

Wallace MI, Cottier FR, Berge J, Tarling GA, Griffiths C, Brierley AS (2010) Comparison of zooplankton vertical migration in an ice-free and a seasonally ice-covered Arctic fjord: An insight into the influence of sea ice cover on zooplankton behavior. Limnol Oceanogr 55:831-845

Appendix I: Overview of stations where CTD profiles were taken (ship-boarded Seabird CTD or CTD attached to LOPC (Seabird)). For data contact John Terje Eilertsen or Malin Daase (Helmer Hanssen CTD) or Sünnje Basedow (LOPC CTD).

Station #	Station	Latitude (N)		Longitude (E)		Bottom depth (m)	Date	Time (UTC)	Gear	Water Temp (°C)
4	IsK/KKD	78	19.17	15	9.79	277	11.01.2016	03:48:23	CTD	0.5
14	BAB	78	39.61	16	43.80	192	11.01.2016	13:56:32	CTD	-0.8
26	SMF	79	41.78	11	5.82	227	12.01.2016	23:41:55	CTD	0.6
38	R3	80	18.55	22	16.11	280	14.01.2016	03:45:30	CTD	-0.8
62	Rolf	80	58.30	14	58.15	1643	15.01.2016	14:23:38	CTD	-1.4
82	Trygghamna	78	14.50	13	48.70	132	17.01.2016	15:09:31	CTD	0.5
90	IsA	78	15.64	15	32.02	85	18.01.2016	06:34:14	CTD	0.6
94	IsK/KKD	78	18.92	15	8.70	277	18.01.2016	11:41:05	CTD	0.1
103	KB3	78	57.32	11	57.65	341	20.01.2016	08:42:50	CTD	1.1
104	KB3	78	57.29	11	57.63	341	20.01.2016	09:26:49	CTD	0.8
127	KB5	78	55.01	12	16.11	106	21.01.2016	10:05:04	CTD	1
129	KB5	78	54.99	12	15.64	107	21.01.2016	12:22:04	CTD	1
131	KB5	78	53.82	12	26.14	71	21.01.2016	13:46:40	CTD	0.6
143	inner KF	78	57.56	12	23.23	66	22.01.2016	04:12:21	CTD	-0.3
145	inner KF	78	54.87	12	11.84	71	22.01.2016	10:57:27	CTD	1
146	inner KF	78	54.89	12	11.44	82	22.01.2016	11:07:47	CTD	1.1
158	inner KF	78	54.98	12	12.30	68	23.01.2016	11:04:59	CTD	1.2
159	inner KF	78	55.12	12	14.87	113	23.01.2016	13:58:53	CTD	1.1
160	inner KF	78	54.42	12	13.73	80	23.01.2016	14:18:28	CTD	1.1
161	V12	78	58.81	9	30.57	224	23.01.2016	17:36:42	CTD	2.9
117	KB3	78	57.34	11	57.16	342	20.01.2016	21:15:17	CTD	1.7
136	KB1	79	0.60	11	25.99	348	21.01.2016	21:41:33	CTD	0.9
15	BAB	78	39.65	16	43.88	192	11.01.2016	14:41:26	LOPC	-0.7
23	SMF	79	41.87	11	6.11	219	12.01.2016	21:38:13	LOPC	0.5
40	R3	80	18.46	22	16.27	281	14.01.2016	05:37:26	LOPC	-0.7
51	Transect NW 1	80	41.35	19	33.10	119	14.01.2016	20:23:17	LOPC	-0.1
52	Transect NW 2	80	49.18	17	25.76	208	14.01.2016	22:38:15	LOPC	2.9
55	Transect NW 3	80	50.61	17	4.50	386	15.01.2016	01:29:38	LOPC	3.7
56	Transect NW 4	80	50.89	16	56.39	609	15.01.2016	02:06:41	LOPC	3.7
58	Transect NW 5	80	51.01	16	50.87	817	15.01.2016	03:40:00	LOPC	3.6
59	Transect NW 6	80	51.76	16	43.95	1010	15.01.2016	04:35:00	LOPC	3.6
66	Rolf	80	57.98	14	53.67	1625	15.01.2016	17:30:28	LOPC	-1.4
69	Transect SW 1	80	49.36	14	11.44	1025	15.01.2016	22:00:03	LOPC	-1.1
70	Transect SW 2	80	46.98	14	7.39	818	15.01.2016	23:17:35	LOPC	3.8
72	Transect SW 3	80	44.69	14	3.26	603	16.01.2016	01:42:52	LOPC	3.5
73	Transect SW 4	80	39.31	13	39.46	409	16.01.2016	03:03:11	LOPC	3.4
75	Transect SW 5	80	25.66	12	57.69	201	16.01.2016	06:27:20	LOPC	4.5
77	Transect SW 6	80	23.24	13	7.25	122	16.01.2016	08:14:13	LOPC	4.3