Photo: Rudi Caeyers

Cruise report:

Norwegian Cruise to Kong Håkon VII Hav 28th February -10 April 2019

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Contents

Summary

Norwegian Polar Institute led a cruise to the Kong Håkon VII Hav 28th February -10 April 2019. Our focus area was the ocean south of 65°S east of 0° meridian and 13.5° E (Fig 1) with a focus on Astrid ridge. Our focus was to map and describe the whole ecosystem. During transit, we registered birds, seals and whales systematically and registered krill and fish abundances using echo sounder. At different depths, we ran ROV transects filming and retrieving samples for later species identification. The ROV transects made up the basis of our intensive study areas. Each intensive study area contained in addition to the ROV transect, benthic sampling with appropriate gear, fish and krill trawling, long line and 3-4 CDT station with extensive water sampling for primary production and water chemistry. We rad oceanographic sections across and along the Astrid ridge and at 6,2° E. Due to heavy ice we did get to 69.5° S and depths of about 1100m.

Crossing the deep ocean along 86.1°S we encountered an extensive algae bloom in the deep trench separating Astrid ridge and Maud rise. Associated with the algae bloom we had large concentrations of krill, humpback whales and birds. We found some large concentrations of krill in the pack ice over Astrid ridge with few whales around. Far south on Astrid ridge we encountered some flocks Emperor penguins and Antarctic petrel and Snow petrels were abundant. Of the seals, mainly Crabeater seals was seen and no Weddell seals was spotted.

On Astrid ridge the ROV and bottom trawls found that Echinoderms and shrimps were dominating the transect. Holothuroids were especially abundant and included at least five different species. We set three longlines and got only four tootfish, all at Maud rise. The results from the CTD samples are still being analyzed and no conclusions are made.

Most of the samples are still being processes so any results must be used with caution.

INTRODUCTION

The aim of the cruise is to improve the knowledgebase for the management of the Kong Håkon VII Hav north of the coast of the Dronning Maud Land. Specifically, cruise focused on a part of planning Domain 4 (CCAMLR - Commission for the Conservation of Antarctic Marine Living Resources) extending from the 0 meridian to the Astrid ridge at approximately 13.5 E (Fig. 1, 2). We divided the work into 7 work packages: WP1 Bird and marine mammal observations, WP2 Fish community, WP3 Benthic mapping, WP4 Zooplankton, WP5 Primary production, WP6 Oceanography, WP7 Ocean Carbon chemistry and ocean acidification. Besides the work to gather data for the MPA planning process, we had two Norwegian Research Council projects on the cruise too: iMelt Ocean-ice shelf Interaction and channelized Melting in Dronning Maud Land" and SOPHY-CO2 (Southern Ocean phytoplankton community characteristics, primary production, CO2 flux and the effects of climate change). In this report, we report on themes rather than the work packages.

We wanted to study and sample the benthic fauna and the associated pelagic ecosystem and defined extensive study areas. An extensive study area contained: three CDT stations with extensive water sampling(WP4, 5, 6, 7); a 6-12h ROV transect with continuously video recording and grab samples (WP3); Krill and fish trawl (WP2, 4); Mulitnet tow (WP4); bottom sampling gear (RP sled, beam trawl, bottom trawl, WP2, 3, 4) ; and a longline (WP2) to gather data to assess the toothfish stocks in the area. Unfortunately we only got toothfish from Maud rise so our data is limited. Our plan was to conduct 5 extensive study areas but due to ice and weather conditions we did manage 4, but not in the intended locations. The four extensive areas are denoted with yellow dots on figure 1.

Whenever the ship was moving, the manned the lookout and all observations of birds and marine mammals recorded (WP1). We also ran continuously multibeam echo sounder for bottom profiles, appropriate echo sounder for krill and mesopelagic layer (WP2,4), pCO2 (WP7 and waster for incubation experiments) and ADCP for currents throughout the water column (WP6). At occasions, when the echo sounder indicated a krill swarm we trawled and sampled for species and size distribution (WP2, 4).

We deployed two gliders in the deep basin west of Astrid ridge. The gliders sample the water masses by moving vertically and horizontally in the water using changes in buoyancy. It sample different physical properties and would expand our spatiotemporal footprint. Unfortunately, they did not work properly and we had to return from station 3 (fig1) to pick up one and the other cause a detour on our way to Maud Rise

Our original focus was on the Astrid ridge and the shallow areas along the shelf. Our original cruise track was organized around sections going across the Astrid ridge and running north – south along the top of the ridge. Along the oceanographic sections, we did CTD casts (WP5) at stations (Fig 2), and on every other station, we took water samples for phytoplankton and ocean chemistry (WP5, 6, 7, fig 2).

We departed Punta Arenas (Chile) 0100h 28th February after some delay due to late arrival of essential pumps for the engine. Once at sea we steamed towards the 0 meridian. We arrived at the study area 11:30 11th March 2019 after 12 days transit (fig1). We crossed over the deep ocean and met the ice 14th March on the western side of the Astrid Ridge. The ice conditions was heavier than normal and we met heavy ice from the top of Astrid ridge and eastwards. In general, the ice seem to cover the areas spanned by the 1500-2000m depth contour that limited our ability to trawl and set a longline. The ice got heavier and the floes bigger as we moved south and it pushed us westwards in search for easier ice. The ice drifted with about 0,2-0,8 kn from east to west. After installing an ocean observatory at the base of Astrid ridge (fig 2) we tried to push further south but gave up and headed north for more open water (fig 1). We attempted to get in to the shallow areas close to the shelf at 6,2 E and ran a CTD section south after sampling the marginal ices zone for krill and the mesopelagic layer. Again, heavy ice stopped us at -68,9 S 6 E and we had to turn north. We installed another ocean observatory at about 2200m depth. The 27th March we decided that we could not reach the shelf and steamed along the marginal ice zone trawling for krill and fish and picked up a glider. Once the glider was on board we steamed for Maud Rise at -65,8 S 2,3 E to extensively study the pelagic community and benthic fauna.

Maud Rise is a volcanic plateau at about 2200m depth with a ridge running N-S at approximately the center and a ridge protruding to the east. We planned to have two extensive study areas on Maud Rise one at each of the ridges. Unfortunately, a heavy storm hit when we were to start the second extensive study area and we had to abandon it. The sampling stopped the 31 march and the ship steamed north to avoid a strong low-pressure system with predictions up to hurricane winds. We took a detour on our way home and picked up another glider deployed by our South African partners in a joint project.

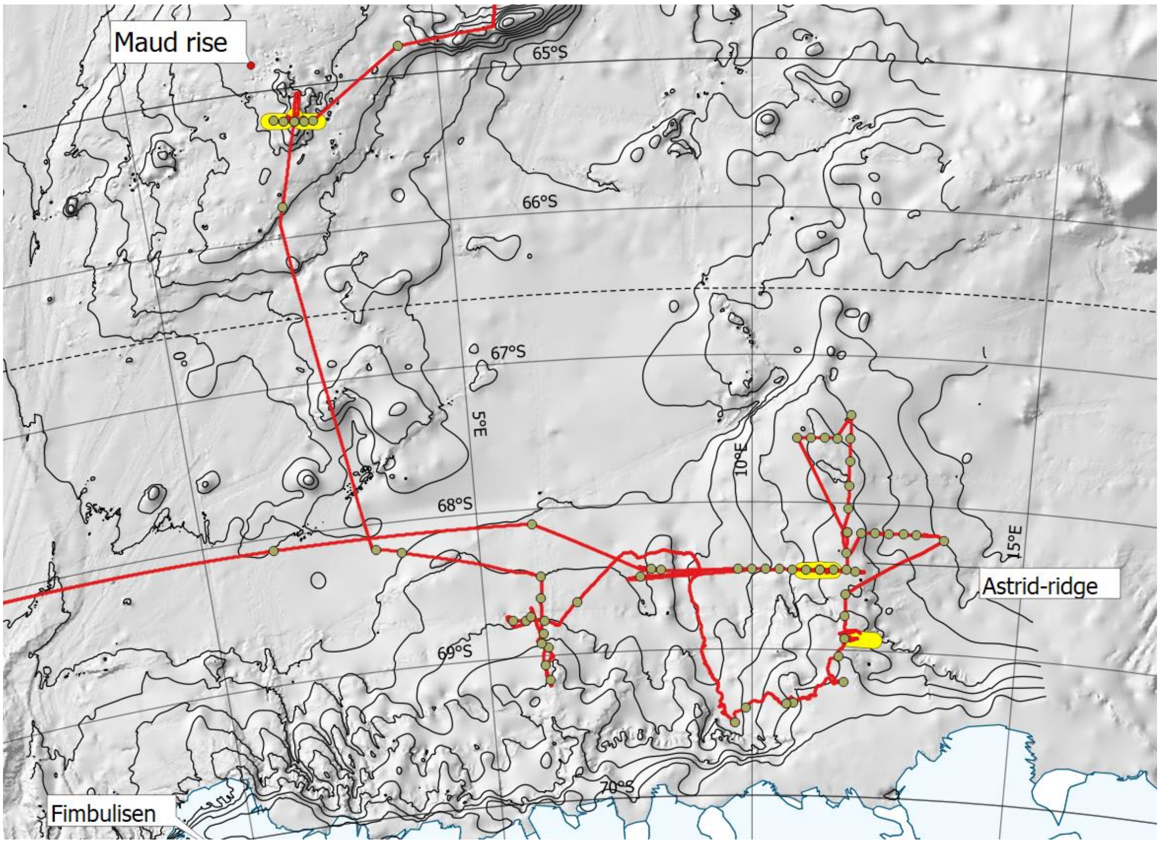


Figure 1. Overview over the part of the Kong Håkon VII Hav that was our study area. Tthe cruise track and samplings stations, yellow dots indicate where we ran benthic video and sampling transects. The size of the transect is exaggerated for visiability

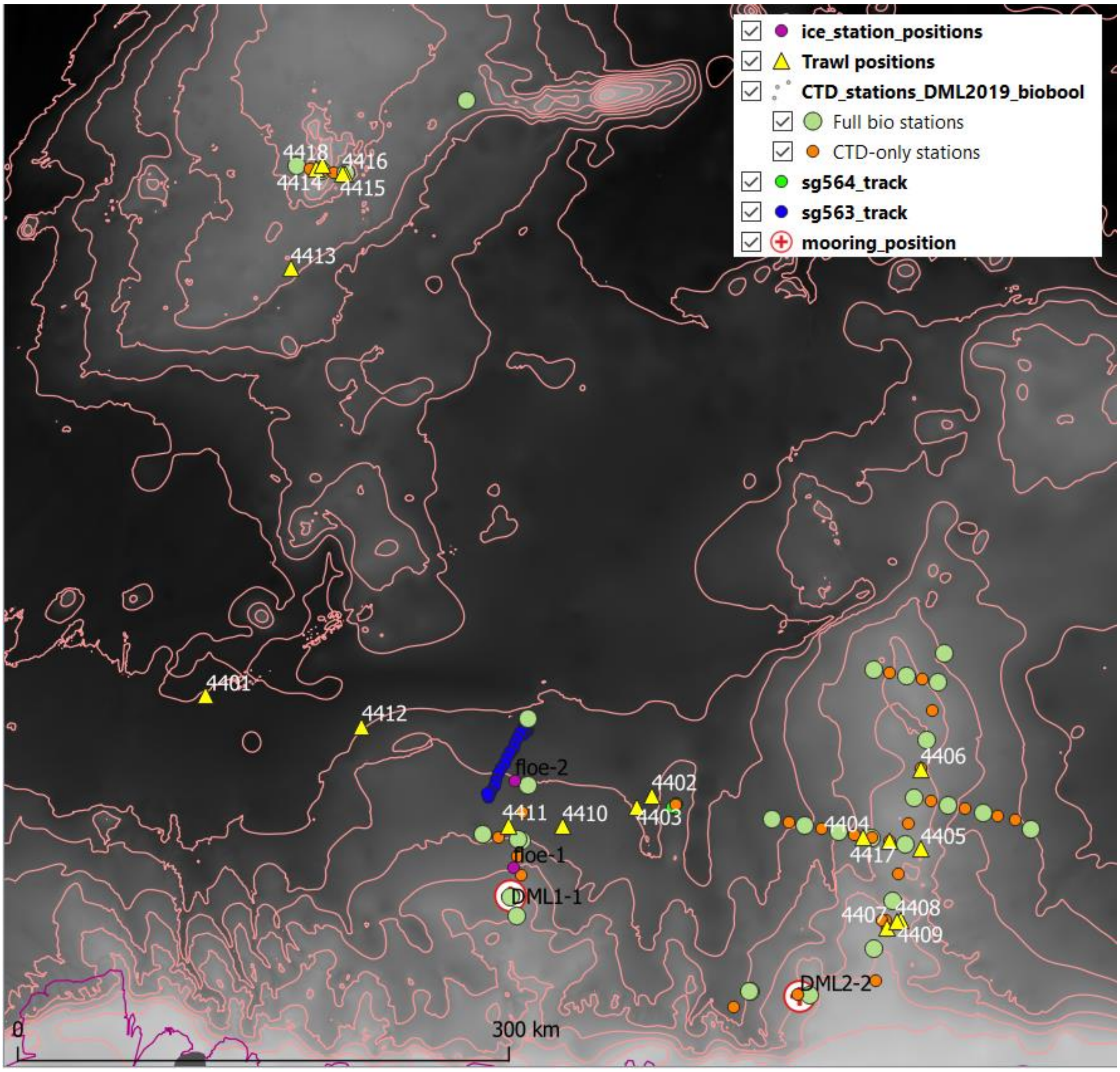


Figure 2: Map showing the study region showing the stations: CTDs (green & orange dots, numbered), glider dives (blue circles), and DML moorings (white circles with red rim).

Summary cruise dates:

Date	
26/2/2019	Cruise participants go on board – loading
28/2/2019 01:00	Leave Punta Arenas (Chile)
11/3/2019 11:30	Crossed 0 meridian – entered the study area
14/3/2019	Meet the ice at Astrid ridge
27/3/2019	We give up getting to the shelf
28/3/2019	Arrive at Maud rise
31/3/2019	A storm stops the work and we stop sampling.
1/4/2019	Kronprins Haakon start to sail towards Cape Town
10/4/2019	We arrive in Cape Town

MARINE MAMMAL AND BIRD OBSERVATIONS

Participants: Eirik Grønningsæter (Independent), André van Tonder (UP), Nico Lübcker (UP)

Effort: From port to port Punta Arenas to Cape Town there was in total of 15657 minutes (261 hours) surveyed for birds. This include 5080 minutes (84,6 hours) within the intensive study areas Princess Astrid ridge area and 809 minutes (13,5 hours) in the Maud Rise study area. For marine mammals the effort adds up to 230 hours and 43 minutes in total.

Bird survey

Method: Due to different behaviour of species involved and their numbers the method used is a modified version of the standardised bird survey at open sea methodology used in the North Atlantic and Barent's Sea. In Southern Ocean we ended up not dividing between Ship followers and Non-ship followers. Due to the sometimes high amount of birds we do accumulative counts and record all birds within last 10 minutes that has passed within 300 meters from the ship in a sector 0-90 degrees (0 degrees being the bow of the ship). It is of course sometimes hard to judge if it is the same bird circling the ship, and double count might have happened occasionally. However, the chance of under scoring a species is a greater risk with this method as the changeover in birds is probably higher than we think. When abundance of birds were high, we ended up using peak numbers counted within the sector each 10 minutes period.

Each half an hour we did a point count where we count all birds following in the wake of the ship. This count is not restricted to 300 meters.

We only count birds when ship is transiting between sampling stations as trawling and other ship activities tend to affect bird activity a lot. Sometimes, if the ship is going very slow (less than 3 knots), for instance in ice, the birds are only recorded in 30 minutes periods instead of 10 minutes.

Taxonomy: Seabird taxonomy is under a lot of discussion and the amount of species involved varies with which author and nomenclature is used. For this survey we have chosen to follow the taxonomy used in D.Onley and P.Scofield; Albatrosses, Petrels and Shearwaters of the World. Christopher Helm Publishers 2007. For other taxa we follow Hadoram Shirihai; A complete guide to Antarctic wildlife. A&C Black Publishers 2007.

Prions: It is hardly any group of birds which presents a bigger challenge when it comes to identifying than the prions. There is also substantial discussion about the taxonomy of this group and most birds are simply impossible to identify at sea (and even in hand). Although probably 99% of our prion observations most likely belong to the species Antarctic prion, at least south of 50 degrees south, we have chosen to record all prions as Prion sp.. We are quite confident that at least a handful of birds belong to the species Slender-billed prion during the crossing of the Drake Passage (during south transit), and at least one bird was identified as Fairy prion when crossing over the South Indian Ridge just east of Bouvet Island during our northward transit. Also on 7th April we came across flocks of 200+ birds (total 804 individuals logged within trasect but even more outside our 300 meters sector) that from field observations and photos most likely were Salvin's prions. All assumed Slender billed prion – and Fairy prion observations were done in subantarctic waters while it was 12,6 Celsius water temperature on the Salvin's day and we crossed the Subtropical Convergence that same evening.

Wandering albatrosses: The Wandering albatross group was in the late 1990s split into 5 different species. Also here is it still some ongoing discussions taxonomy wise. Most plumages and birds are impossible to identify down to species level outside their breeding colonies. We have therefore chosen to report all birds in this group simply as Wandering albatross.

Antarctic tern vs Arctic tern: There was initially some confusion around these two similar species. Birds with a solid black cap + black bill (but with similar tail length as Antarctic) and a defined dark line on the outer primary tips are reported as Arctic tern in our survey. This plumage is not shown in any available literature, but was in fact the most common plumage in the terns we saw. Our impression is that the lack of white forehead and long tail is a result of late austral autumn/early boreal spring season where the Arctic tern is moulting into its breeding plumage. A very few birds showed longer tail streamers resembling the length that Arctic tern attain in breeding plumage and this made us confident that the birds we saw with this so far undescribed? plumage is in fact Arctic terns in transition plumage.

Results:

Number of species total during survey was 51 seabirds and this include 20 bird species recorded within Intensive study areas around the Astrid Ridge and Maud Rise in the Study area (0 – 13 degrees East and 69°30 – 63 degrees South).

It is important to note that this survey is not a study to estimate population sizes. That is much better done in the breeding colonies. This study is more to understand the ecological dynamics and to look for potential hotspots in biodiversity when the results are compared with other parameters sampled during the survey. As very few ships visit the area we have been surveyed it must also be seen as an Atlas mapping of distribution of the different species involved as literature is pretty vague for at least some of these species.

Summary of observations:

Transit Southeast 28th February – 10th of March: Out of Magellan strait along the South East American coast we had very few birds. We observed Great grebes sitting on the water several times and quite a few Magellanic Diving Petrels as well as Magellan penguins and the only Rockhopper penguins for the trip. Greater Shearwater was common. These species disappeared as we arrived deeper water in Drake Passage. The obvious lack of birds in Drake passage was probably at least partially due to the very calm weather during the crossing. We crossed the Antarctic Convergence 2nd of March as the sea temperature dropped from 5,8 Celsius at 11:30am to 2,8 Celsius 13:30pm. This also ment that seabird species composition changed as we got more of the cold water species like Light-mantled albatross and Kerguelen petrels as well as Blue petrels started to show up.

Astrid Ridge area 11th -27th of March. The most important results of this bird survey are that the drift ice at Astrid ridge is used as feeding ground by Emperor penguins. In total 9 observations were made – all of them south of 68° in fairly heavy multiyear ice and ice coverage above 70%. Emperor penguin is listed as Near Threatened on the IUCN Red List and population trends are unknown. To identify the foraging areas for this species are therefore of potentially significant importance for the management of the species.

Adélie penguin were also common in the area already from the marginal ice zone. As soon as ice floes started to show, we also encountered a lot of Adélie penguins and interestingly many of the groups sitting on the ice had birds in heavy moult. We also found several juvenile fledged Adélie penguin groups sitting on ice floes in the area.

Along the marginal ice zone in our main study area near Astrid Ridge it was also recorded a relative high number of Arctic terns. In more open water groups of 1-300 Sooty shearwaters were seen and highest densities were found near groups of Humpback whale. Both Antarctic- and Snow petrel were present here but became increasingly abundant as we got closer to the ice edge. Inside the denser ice covered areas the density of birds dropped with Snow petrel and Antarctic petrels occasionally seen. Groups of Arctic terns often found in patches with more open water within the sea ice covered area. In general, few bird species in the area with Arctic tern, Snow petrel, Antarctic petrel and Adélie penguin being the dominant species near ice and Kerguelen petrel and Sooty shearwater were added to this list in more open water.

Maud Rise 28th March – 1st April: We got unfortunately very little survey time in this area as most of the time were spent doing sampling work from the ship, one day lost to bad weather and strong winds and the fact we had to abandon the area earlier than planned due to a predicted heavy storm. There was nothing very unexpected seen here apart from the very low number of birds. A Wandering albatross of the Snowy type plumage that started follow the ship 28th March and stayed with us until morning 30th March. This one started following our ship at S65°13 already.

Summary of bird observations is listed in table 3

Marine Mammals

Only 3 days with more than 50 whales observed. Total of 9 whale species seen. Crabeater seals relatively common in break up zone in sea ice. Very few open water observations of seals. Total of 4-5 seal species observed.

Methods:

Due to the design of the ship, we had to modify our methodology a little from the standard, and only one side of the ship (port side) was surveyed properly. All observations on the starboard side (0-90 degrees) must be seen as random observations when handling the data. Whenever weather permitted – we had one dedicated person to do marine mammal observations from the observation deck. We recorded everything from 270 – 0 degrees (0 degrees being the bow of the ship). We did not use binoculars to search for whales or seals. These were only used to aid in identification once a whale or seal had been spotted with naked eye. This because of the risk to miss many observations when narrowing the view through binoculars. This means that we realistically don't have much chance of discovering whales without visible blows further than about 1000 meters from the ship. Large whale blows normally easily visible until about 5000 meters from the ship – under ideal conditions with back lit and little wind up to about 15 kilometers. The observation deck is placed 21 meters above sea level on RV Kronprins Haakon.

Observations were done in three different "modes". T-mode means that sea and visibility is good enough to see all types of whales – also the smaller ones that normally don't give a visible blow (minke whale, some beaked whales, dolphins etc). This mode was used up to sea state Beaufort 4. Above sea state Beaufort 5 we went into F-mode. This mode is for large whales which normally give a visible blow. P state was used when we did survey during trawling or ROV-operations. Normally we only surveyed when the ship sailed between sampling stations. Above sea state Beaufort 8 and/or when visibility was limited to less than 1000 meters we stopped dedicated marine mammal observations (random observations were still recorded as well as seals on ice).

For whales, we used a record system so that we could read in our observation with a microphone and positions were logged for each observation. This to reduce the time of looking down to write notes, which meant reduced chance of missing whales. This was especially important in areas with high density of whales. Each observation was recorded with Species (when possible), number, angle from the ship in relation to the ship's bow, distance and swimming direction of the whale (whenever possible). Any interesting behaviour was also recorded.

Seals on ice were recorded manually with species, position, group size, ice floe density and thickness.

Fur seals: Due to the extreme difficulty identifying fur seals, we have chosen to note any observation of these simply as fur seal. Within the transect area, South American-, Antarctic- and Cape fur seal are believed to occur.

Whale observations

206 dolphins and 341 whales recorded. Only 4 larger congregations of 50+ were found. One that mostly consisted of Fin whales when crossing Bransfield strait on the 3rd of March (between S59°13 W54°28 and S60°37 W52°03). We had 70 observations of at least 127 whales, most of the ones that were close enough to confirm identification were Fin whales but in the afternoon also a few Humpback whales were seen. One Sperm whale was seen here too. Some blows were most likely Blue whales, but too far to confirm 100%. This whale aggregation was going on from early morning to late afternoon. It is linked to big aggregation of Krill according to echosounder data.

An aggregation of 62 Humpback whales on the 12th of March was when entering a known plankton bloom close to the ice edge. This was within our intensive study area (around S68° and 05° East). The 27th we again visited the same area, but slightly further west (S68°09 E03°04) and had again good numbers of humpbacks with a total of 78 individuals during the day.

Apart from this no larger concentrations of whales were found. We had smaller numbers (5-20) of humpback whales most days from 4th of March onwards until we started the north transit on the 1st April. Many of the observations were done along the ice edge in very open drift ice, but also some smaller numbers seen in open ocean.

During our north transit from Maud Rise to Cape Town, very few whale observations were done – most of them too far to identify safely. One Fin whale and 8 Humpback whales on the 4th of April was the only small aggregation of whales during the crossing.

Sei whales were encountered in total 6 individuals before we left the continental shelf of South America on 1st of March. Here was also our only Commerson's dolphins for the trip with two groups observed 1st of March. Next to a fishing vessel at the continental shelf edge we recorded one of very few Sperm whales observed during the survey. One group of 6 Peal's dolphins was observed in the evening 1st of March when we had entered Drake Passage.

Despite very good whale observation conditions during the crossing of the Drake Passage, the only whales recorded was a group of 7-15 Hourglass dolphins.

Blue whales were recorded 3 times: one individual in front of our ship on the evening of 6th March at S66°34 W32°40. Two whales travelling together, where only one of them confirmed to be Blue whale were recorded on the 7th of March at about S66°54 W26°39. And the last observation was of two Blue whales close to the ship on the evening of 7th of March at S67°00 W24°37. All Blue whale observations were in open water far from any drift ice.

Antarctic minke whales are known to be able to enter deep into the drift ice zone in relatively dense drift ice. We found no minke whales in open water, but all were in 20% - 100% ice cover. No big groups observed but only singles or 2-3 together in the same area. At the time of our survey the ocean had started to freeze and several of the observations were in 100% ice cover where the whales had to break through a thin layer of solid grey ice. They did this by surfacing normally (eg. not spy hopping). Most of the observations though were in smaller or bigger openings of open water surrounded of dense drift ice. These opening could be from 10 – 1000meters across. Observations were done in areas with big multiyear floes as well as in areas of thin bigger pancake floe ice with heavy slush in between. All observations were done south of 68 degrees south in our main study area. Antarctic minke whale is listed as Near Threatened with population trend Unknown in the IUCN Red List.

Table 1: Number of whales sighted/species in dedicated survey mode (F or T)

Species	**Number of sightings**	**Pod size (Best number)**
Blue whale	3	4

Sei whale	3	6
Peale's dolphin	1	6
Fin whale	44	81
Unknown	43	66
Sperm whale	2	2
Humpback whale	110	228
Common dolphin	1	200
Minke whale	16	20
Totals	**223**	**613 cetaceans** Of which 547 ID cetaceans 341 whales, 206 dolphins.

Ship noise

There were some tendencies that whales were affected by our ship, and this might have affected our sighting frequency. Even Humpback whales which normally are very tolerant of noise and ships was seen several times even at far distance 700-1000m to change direction when we approached (continued on our course – we never changed direction to drive towards the whales). Some whales just stopped surfacing and disappeared despite that a "normal" surfacing pattern would predict them showing up again. This avoidance effect seemed to be bigger when ship went fast, and especially above 10 knots it was obvious. The Research Vessel Kronprins Haakon is a new ship, and few marine mammal surveys have been done so far from this ship.

Seals:

Very few seals were recorded in open water. Just as we crossed the continental shelf edge of South America on the 1st of March we had a few observations of fur seals in the water most likely of South American fur seal. Another fur seal – probably Antarctic fur seal was seen linked to the same area we had Fin whale concentration on the 3rd of March. All other observations were linked to the sea ice in our main study area. In total 61 hours 51 minutes over 11 days was censused in sea ice habitat.

Crabeater seals seemed to be common as soon as we entered sea ice area on the 14th of March. No huge concentrations but a total of 179 Crabeaters was observed (table 2) during our days in the ice. It seemed that they preferred the break up zone with smaller floes. The density of seals dropped as we came into large multiyear ice where floe size increased to more than 100 meters across. The impression is that percentage of sea ice coverage didn't seem to matter as much as the floe thickness and floe size. We had the same impression for the Adélie penguins in the area, so it might just be that more food was available in the break up zone than in the thicker ice. We also had regular but few observations of Leopard seals in this area with a total of 9 seals recorded. These were not recorded at all in the heavier ice. The only observation of Ross seal for the survey was one that jumped up on the ice next to the ship on the 20th of March at (S68°40). The low number of observations of this species was expected as satellite tracking data has shown that these leave the ice for open water after moulting – which ends during last half of February. We never reach far enough south to enter the continental shelf – this may explain the complete lack of Weddel seal observations in our survey.

Table 2: Number of seals sighted/species

Species	Number sighted
Leopard seal	9
Ross seal	1
Crab eater seal	179
Total	**189 phocids**

Next page.

Table 3: Showing abundance of birds. How many times a species has been logged (not number of individuals) during a 10 minutes period. One particular individual can only be counted once during a particular 10 minutes period, but can be counted again the next 10 minutes period. It means a bird that is circling the ship is only being logged once within the 10 minutes period, but can be logged again the next 10 minutes period. This is double counting but a way to keep Atlas distribution monitoring updated.

Table 3

Species	Scientific name	Ship follower	Feb.28 S52*38 W68*04 - S53*01 W67*10	Mar.01 S54*15 W64*11 - S55*16 W61*40	Mar.02 S56*41 W59*45 - S57*52 W57*26	Mar.03 S59*13 W54*28 - S60*37 W52*03	Mar.04 S61*51 W41*23 - S63*10 W45*53	Mar.05 No Observations due to heavy fog	Mar.06 S66*13 W35*16 - S66*36 W21*21	Mar.07 S66*48 W28*24 - S67*03 W23*45	Mar.08 S67*17 W19*35 - S67*26 W16*26	Mar.09 S67*38 W12*37 - S66*44 W10*59	Mar.10 S67*50 W08*47 - S68*01 W05*19	Mar.11 S68*04 W01*41 - S68*05 E02*03	Mar.12 S68*07 E06*07 - S68*27 E08*01	Mar.13 S68*27 E09*46 - S68*29 E08*06	Mar.14 S68*27 E10*17 - S68*27 E11*09	Mar.15 S68*27 E11*19 - S68*27 E11*21	Mar.16 S37*31 E09*12 - S35*32 E08*55	Mar.17 S67*42 E11*44 - S67*33 E11*30	Mar.18 S68*01 E11*26 - S68*11 E12*15	Mar.19 S68*11 E13*03 - S68*11 E13*18	Mar.20 S68*38 E11*44 - S68*55 E11*44	Mar.21 S68*52 E12*02 - S68*53 E11*41	Mar.22 S69*03 E11*27 - S69*29 E10*48	Mar.23 S69*24 E09*50 - S69*13 E09*20	Mar.24 S68*20 E08*13 - S68*47 E06*21	Mar.25 S68*46 E05*29 - S68*58 E06*08	Mar.26 S69*04 E06*01 - S68*50 E06*04	Mar.27 S68*26 E05*58 - S68*04 E03*04	Mar.28 S66*08 E02*16 - S65*12 E02*19	Mar.29 S65*05 E02*45 - S65*02 E02*38	Mar.30 No Observations	Mar.31 S64*47 E04*33 - S64*44 E05*49	Apr.01 S63*30 E06*09 - S62*50 E06*29	Apr.02 S61*20 E07*45 - S60*36 E05*07	Apr.03 S59*57 E01*03 - S58*04 E03*14	Apr.04 S55*35 E05*40 - S54*15 E06*50	Apr.05 S51*32 E08*56 - S50*05 E10*01	Apr.06 S47*18 E11*47 - S45*27 E12*15	Apr.07 S43*03 E14*09 - S41*56 E14*30	Apr.08 S40*05 E15*38 - S38*37 E16*21	Apr.09 S36*39 E17*09 - S35*20 E17*42
Observation Effort (min)			264	437	383	474	683	0	440	779	404	631	698	562	322	320	178	390	212	237	355	107	242	60	200	470	502	337	145	441	363	70	0	244	495	620	625	465	510	591	378	510	513
Sea temperature C at start					5,6	1,7	-0,3		-0,2	0,1	0	0,3	0,1	0,2	-0,4	-0,3	-0,7	-1,4	-1,7	-1,3	-1,3	-1,7	-1,7	-1,7	-1,7	-1,7	-1,1	-1,6	-1,7	-1,7	0,1	0,1		0,2	0	0,5	0,4	0,9	3,9	7,8	12,4	20,3	19,2
Wandering albatross	Diomedea sp.	yes										3																			4	3				1	20	5		18	2	2	
White-capped albatross	Thalassarche steadi	yes																																							3		
Black-browed albatross	Thalassarche melanophrys	yes	3	9	5	1	2		3	1	2	1																													5		1
Atlantic yellow-nosed albatross	Thalassarche chlorohynchos	yes																																									5
Atlantic/Indian yellow-nosed alb.	Thalassarche sp.	yes																																								1	6
Grey-headed albatross	Thalassarche chrysostoma	no			1		1																																2	1			
Black-browed/Grey headed albatross	Thalassarche sp.	x																																									1
Light-mantled albatross	Phoebetria palpebrata	yes		1	2	1	45		26	13	14	28	32	2						1										3	18			1	2	2			13	4	1		
Sooty albatross	Phoebetria fusca	no																																							1		
Northern Giant petrel	Macronectes halli	yes		1		2					1						1																									2	1
Southern Giant petrel	Macronectes giganteus	yes	3	6			2			2		1	12	1	1	6	11	9	3	41	30	1				5	67	2		11	8	3		20	3	3	3	23	5			1	2
Southern fulmar	Fulmarus glacialoides	yes		1			155		8	13	3	12	6	14	2	9	21		35	24	15	1					25	1		51	29	10		12	21	9	14	19					
Cape petrel	Daption capense	yes		3	1	6	481		8	7		1	4	6	7					14	1						4			26	3			2	2	1	1	13					
Antarctic petrel	Thalassoica antarctica	no					3					3	2	16	3	34	57	3		74	79	2					889	145	9	1480	27												
Lesser snow petrel	Pagodroma nivea	no					1								1	4	11	12	52	26	241	58	11	34	99	64	805	410	55	733													
Great-winged petrel	Ptrerodroma macroptera	yes																																			9	1	8	6	3	10	9
Kerguelen petrel	Lugensa brevirostris	no							3	4		44	30	8	8																13	1		3	11	24	6	20					
			Feb.28	Mar.01	Mar.02	Mar.03	Mar.04	Mar.05	Mar.06	Mar.07	Mar.08	Mar.09	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16	Mar.17	Mar.18	Mar.19	Mar.20	Mar.21	Mar.22	Mar.23	Mar.24	Mar.25	Mar.26	Mar.27	Mar.28	Mar.29	Mar.30	Mar.31	Apr.01	Apr.02	Apr.03	Apr.04	Apr.05	Apr.06	Apr.07	Apr.08	Apr.09
Soft-plumaged petrel	Pterodroma mollis	no			2	1																																	10	83	26	33	
White-headed petrel	Pterodroma lessoni	no													1																				1	6	3	1	4	2	17	4	
Prion sp.	Pachyptila sp.	no				152	65		105	37	11	27	3																					1	3	2	6	163	16	3	806	13	
Blue petrel	Halobaena caerulea	no				1	18		137	65	70	191	71	5	11	16															139	11		27	27	31	25	8					
White-chinned petrel	Procellaria aequinoctialis	yes	1		1				1																											7		1		2		2	6
Grey petrel	Procellaria cinerea	no																																					3	31	1		
Great shearwater	Puffinus gravis	yes	11																																					1		5	19
Cory's shearwater	Calonectris diomedea	no																																									14
Sooty shearwater	Puffinus griseus	yes	14	2										5	131	100				51										1	1	7		1	3	2	3	1					1
Subantarctic little shearwater	Puffinus elegans	no				1																																	4		28		
Manx shearwater	Puffinus puffinus	no																																							1		
Magellanic diving-petrel	Pelecanoides magellani	no	10	1																																							
Diving petrel sp.	Pelecanoides sp.	no			2																																		2	2			
Wilson's storm petrel	Oceanites oceanicus	yes		7	8	1	24							6	1	10	1	2	1	5	2				3	2	1											1				1	1
Leach's storm-petrel	Oceanodroma leucorhoa	no																																									2
Black-bellied storm petrel	Fregatta tropica	no			4	4	7				1																											4	24				
White-bellied storm petrel	Fregatta grallaria	no				1																																					
Emperor penguin	Aptenodytes forsteri	no																							5																		
Chinstrap penguin	Spheniscus antarctica	no				8																																					
Adélie penguin	Pygoscelis adeliae	no															54	39	11		7	14	16		64	55	127	39	48														
Rockhopper penguin	Eudyptes chrysocome	no	3																																								
Magellanic penguin	Spheniscus magellanicus	no	18																																								
Imperial cormorant	Phalacrocorax atriceps	no		8																																							
Arctic tern	Sterna paraisaea	no			1	13	54										6		1	13	130	18	1		5	8	350	141	11							1					6		
Antarctic tern	Sterna vittata	no				5									6		10	29	150																								
Kelp gull	Larus dominicanus	yes																																									
Chilean skua	Catharacta chilensis	no		1																																							
Subantarctic skua	Catharacta antarctica	yes																									3	2											1			1	
South Polar Skua	Catharacta antarctica lonnbergi	no																16	9								3	6															
Brown skua sp.	Catharacta sp.	no	1																																								
Pale-faced sheatbill	Chionis alba	no					1																																				
Great grebe	Podiceps major	no	2																																								

ACOUSTIC RECORDING OF KRILL AND OTHER BIOTA.

Participants: Elvar Hallfredsson (IMR)

The acoustic equipment in use was Simrad EK80 research echosounder with six frequencies; 18, 38, 70, 120, 200, 333 kHz. Rawdata for all frequencies were logged continuously and saved. The38 kHz was scrutinized during the survey and further analyses are pending. All acoustic data are stored, and will be made generally available, by the Norwegian Marine Data Centre (NMDC).

There are two transducers on the ship, one on the drop-keel (3 m from hull when down) and one hull-mounted. Signals from the drop-keel transducer could be scrutinized to 800 m depth, while the data from the hull-mounted transducer were more noisy at depths and were scrutinised to 500 m. In ice-covered areas it is not possible to have the drop-keel lowered, and the hull-mounted transducer was used in these areas. In addition, the drop-keel was not in use during the transit toward Cape Town from approximately 60-55°S. The use of the hull-mounted transducer can be assumed to have minor effect on observations on krill and other plankton in upper layers, but it will severely affect observations fish and plankton in the mesopelagic zone. In general, the speed of the vessel, especially in relation to weather condition, was not optimal for acoustics and this may to some extent have affected the results.

Scrutinization was done in LSSS version 2.5.0 according to IMR procedures. Acoustic signals were allocated to five categories; krill, mesopelagic fish, mesopelagic plankton, plankton in upper layers, and others.

Preliminary data from the acoustics are presented in Figure 3-6. Krill was in generally patchily distributed (Figure 3), and mostly concentrations were very low along the acoustic track. As expected, high concentrations were observed in the Drake passage area, and interestingly also in the ice-covered/ice-edge part of the DML area. Other plankton in upper layers was not as patchily distributed as krill and was found in highest concentrations in the Drake passage and in the southernmost part of the transit towards Cape Town (Figure 4). Registrations allocated to mesopelagic fish and mesopelagic plankton are shown in Figure 5 and 6 but should be interpreted with caution due to the limitations of the hull mounted transducer.

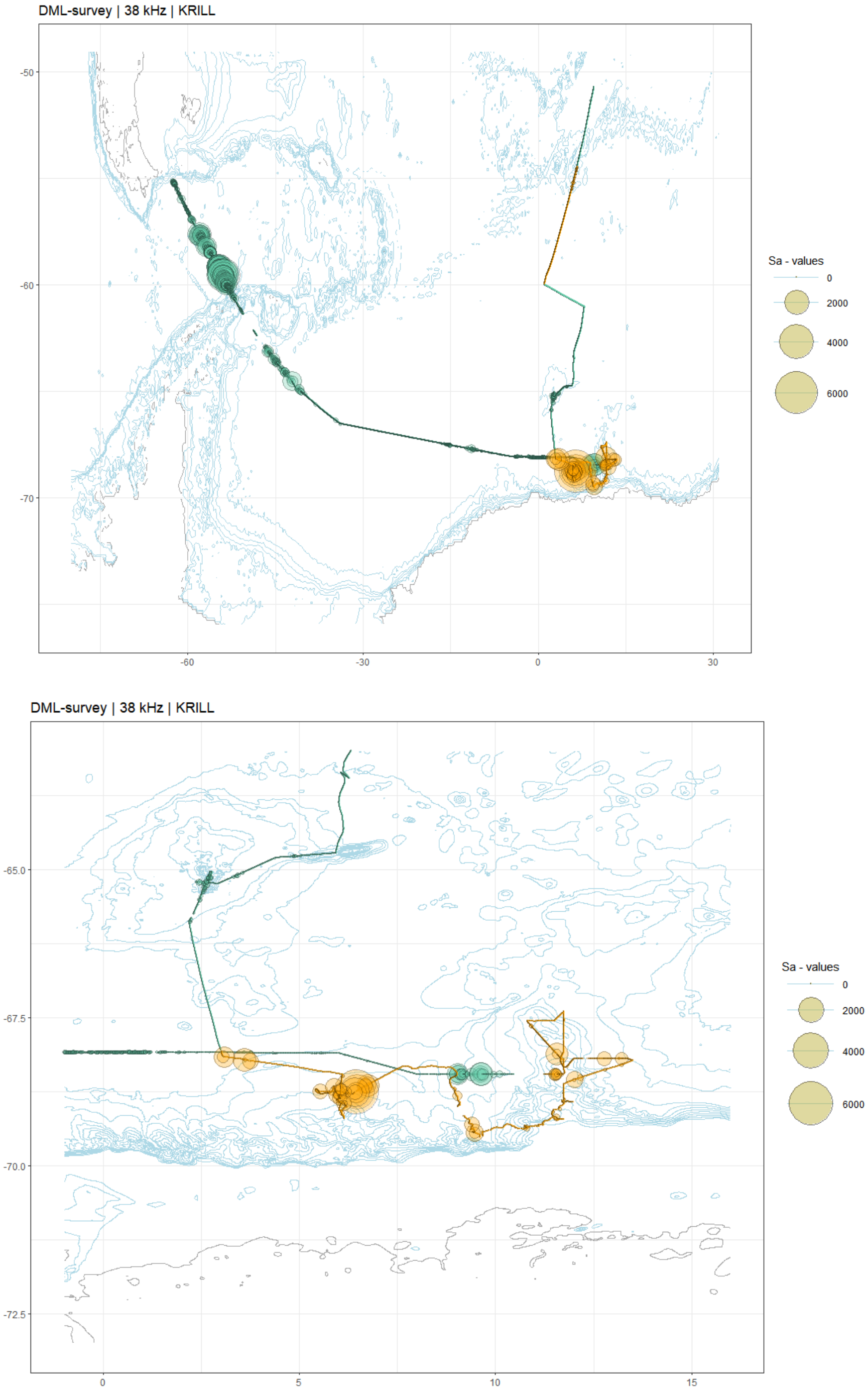


Figure 3. Acoustic observations of krill. Each bubble represents integrated Sa value over 500 m distance. Green is drop-keel transducer (upper 800 m scrutinised), orange is hull mounted transducer (upper 500 m scrutinised). In the DML area hull mounted transducer was used in ice-covered/ice-edge areas.

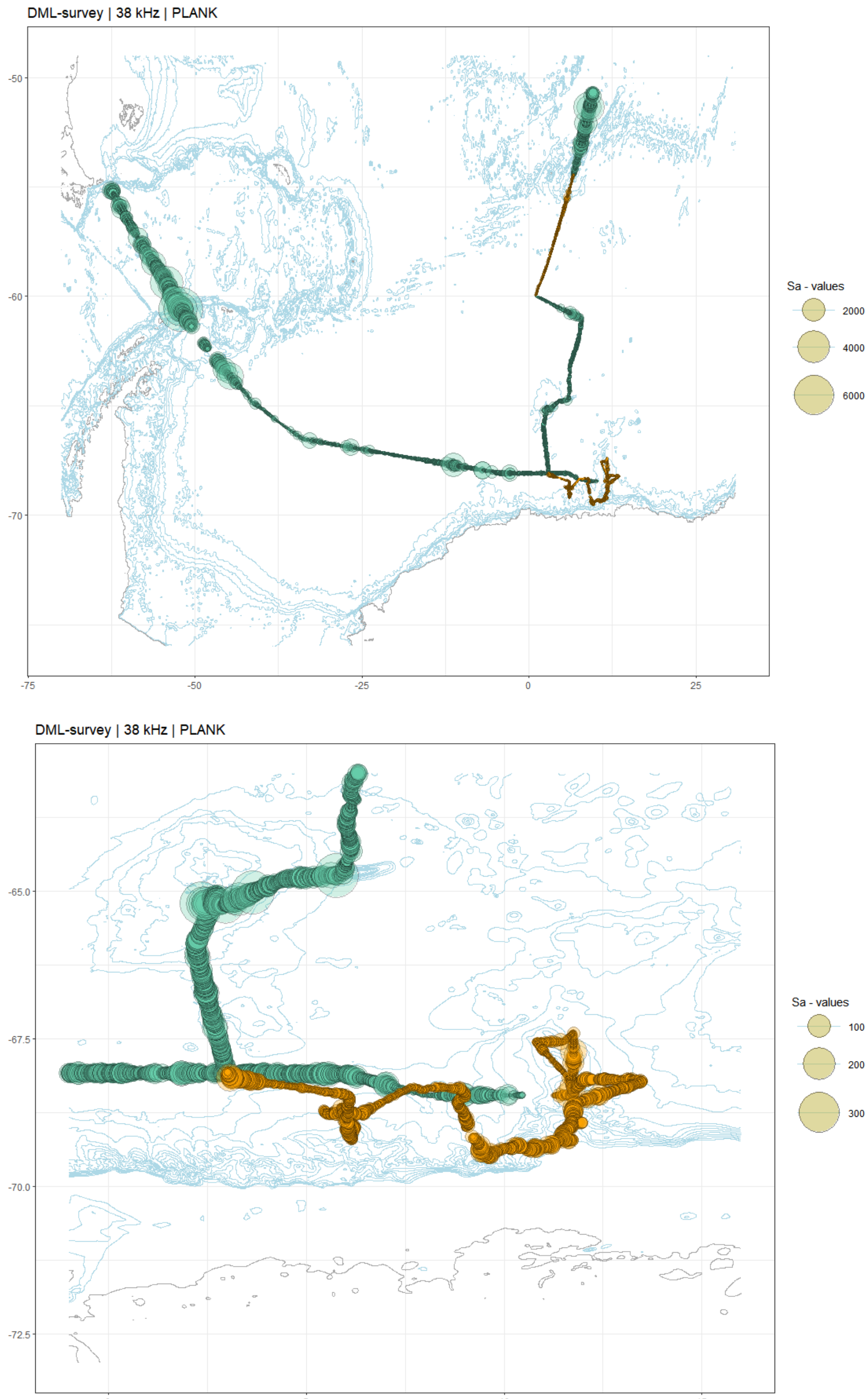
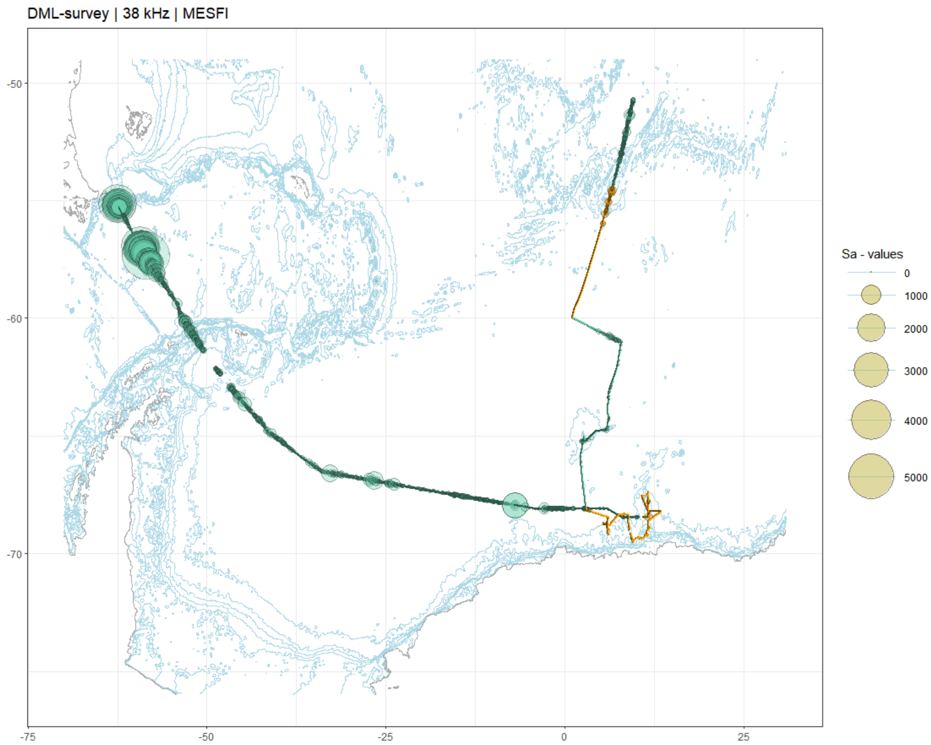


Figure 4. Acoustic observations of plankton, other than krill, in upper layers. Each bubble represents integrated Sa value over 500 m distance. Green is drop-keel transducer (upper 800 m scrutinised), orange is hull mounted transducer (upper 500 m scrutinised). In the DML area hull mounted transducer was used in ice-covered/ice-edge areas.



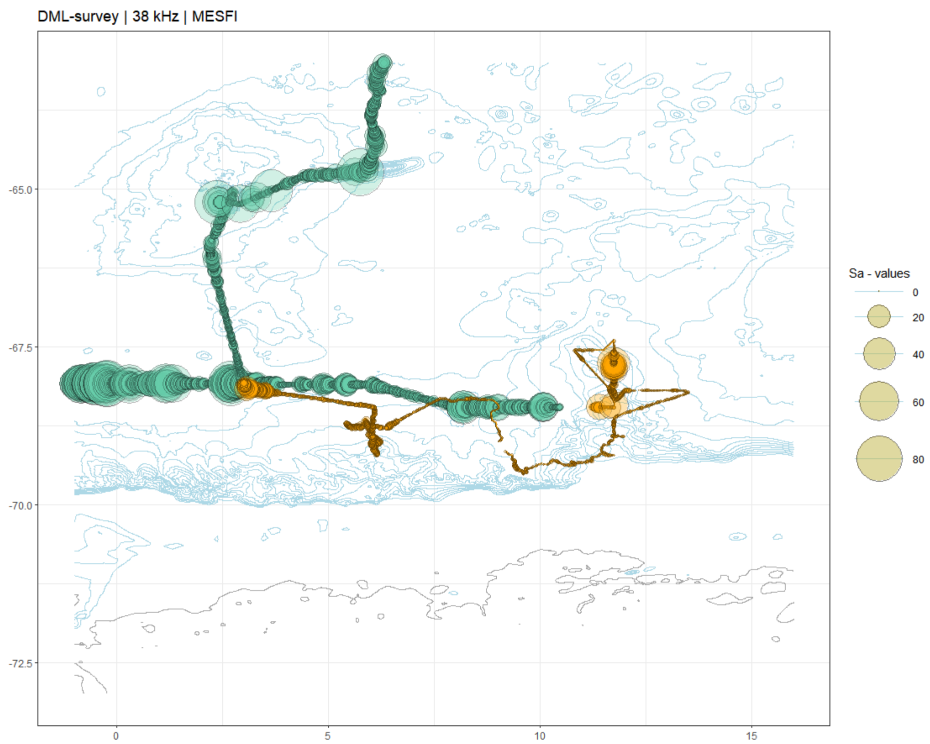


Figure 5. Acoustic observations of mesopelagic fish. Each bubble represents integrated Sa value over 500 m distance. Green is drop-keel transducer (upper 800 m scrutinised), orange is hull mounted transducer (upper 500 m scrutinised). In the DML area hull mounted transducer was used in ice-covered/ice-edge areas.

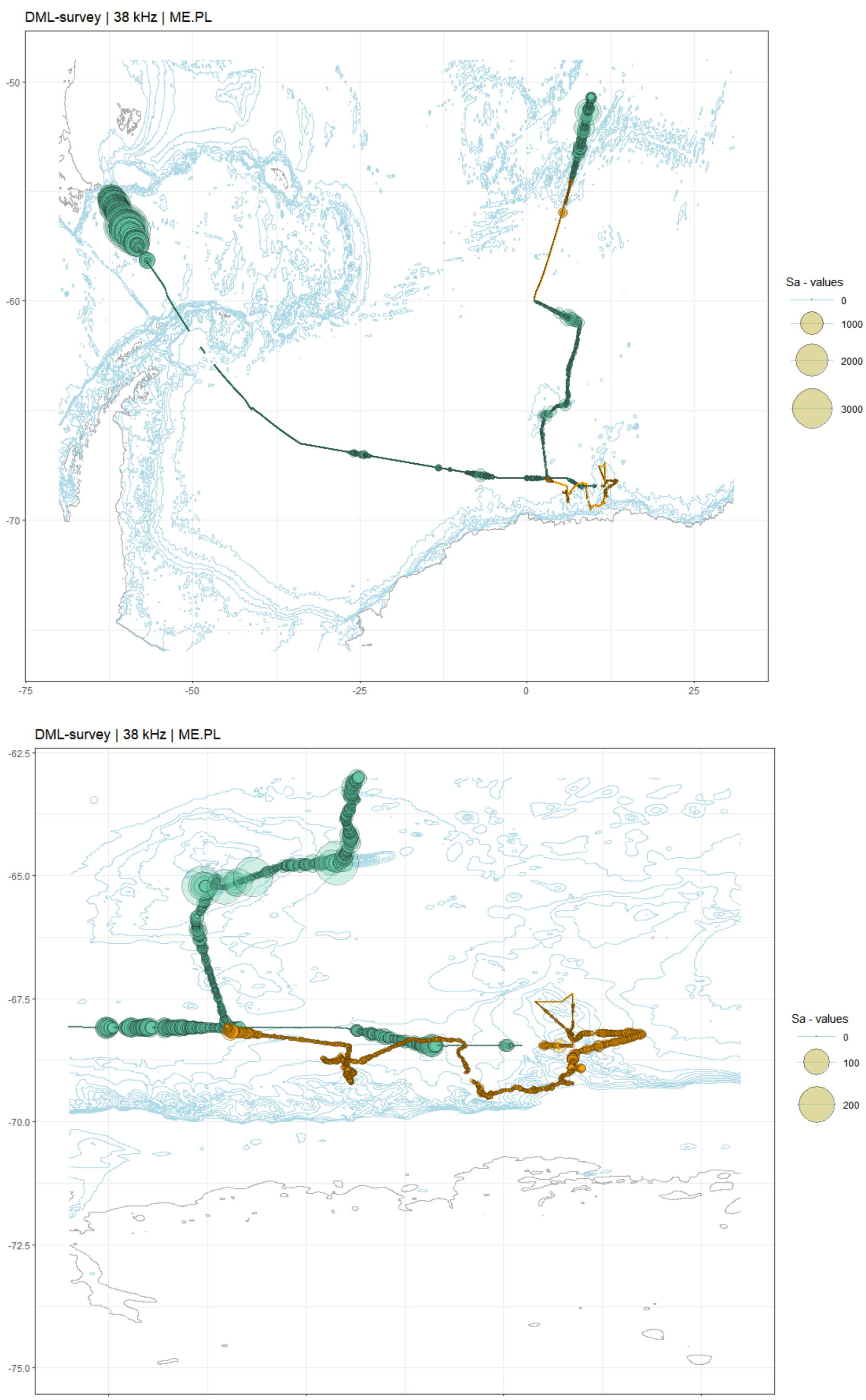


Figure 6. Acoustic observations of mesopelagic plankton. Each bubble represents integrated Sa value over 500 m distance. Green is drop-keel transducer (upper 800 m scrutinised), orange is hull mounted transducer (upper 500 m scrutinised). In the DML area hull mounted transducer was used in ice-covered/ice-edge areas.

SAMPLING OF FISH AND OTHER MEGAFAUNA WITH TRAWLS AND LONGLINES.

Participants: Elvar Hallfredsson (IMR), Tone Falkenhaug (IMR), Anne Sveistrup (IMR), Anne H. Tandberg (UIB), Stefano Ambroso (ICM), Karoline Viberg (UIB)

Fish sampling were conducted with trawls and longlines. Five different trawls were applied:

- Campelen 1800 (IMR gear-code 3270). Bottom trawl C18 20/40. Mesh 20 mm in codend, 40 m sweeps. Rockhopper gear. Sampling of demersal fish and benthos.
- Macroplankton trawl (IMR gear-code 3548). Pelagic trawl, 6x6 m, circumference 92 m, without buoy. With strapping. Mesh size 3x3 mm. Sampling of macro-zooplankton, including krill, and micronekton.
- Pelagic Harstad trawl (IMR gear-code 3513). Pelagic trawl, circumference 320 m, without large floats. Inner lining with 5 mm mesh size in codend. Sampling of mesopelagic fish and larger zooplankton.
- Pelagic Multpelt 832 (IMR gear-code 3535). Pelagic trawl, circumference 832 m. Inner lining with 14 mm mesh size in codend. Sampling of mesopelagic fish and larger zooplankton.
- Beamtrawl (IMR gear-code 3513). Dragged at bottom, 2 m beam. Primarily used to sample benthos but catches also some bottom dwelling fish.

Tyboron 7 trawldoors were used with all otter trawls.

A list of trawl stations is given in Table 4. Results in terms of catches and species composition will not be provided here pending further post-processing.

Table 4. Trawl stations

											bottom	fishingdepth (m)		fishingdepth
serialno.	gear no	gear name	startdate	starttime	stopdate	stoptime	lat. start	lon. start	lat. end	lon. end	depth (m)	min	max	temp. (°C)
4401	3548	Macroplankton trawl	11/3/2019	15:33:25	11/3/2019	16:03:26	-68.0885	1.263	-68.087	1.315	4500	24	45	-0.9
4402	3535	Pelagic Multpelt	12/3/2019	19:45:51	12/3/2019	20:51:53	-68.4433	8.134	-68.432	7.939	1099	40	250	-0.5
4403	3535	Pelagic Multpelt	13/03/2019	17:56:37	13/03/2019	19:11:29	-68.4972	7.934	-68.505	7.741	3600	153	563	0.2
4404	3513	Pelagic Harstad	15/03/2019	17:32:54	15/03/2019	18:17:07	-68.4624	11.243	-68.464	11.130	2000	38	416	-0.35
4405	3270	Bottom trawl	16/03/2019	08:30:27	16/03/2019	09:11:07	-68.464	11.908	-68.466	11.992	1500	1500	1515	0.2
4408	3270	Bottom trawl	21/03/2019	09:24:36	21/03/2019	09:56:06	-68.8711	11.845	-68.869	11.922	1090	1090	1147	0.4
4409	3548	Macroplankton trawl	21/03/2019	12:06:37	21/03/2019	13:07:50	-68.8817	11.790	-68.875	11.874	1076	24	1074	-0.7
4410	3548	Macroplankton trawl	24/03/2019	13:52:32	24/03/2019	14:57:56	-68.6523	6.728	-68.660	6.682	3275	5	66	-1.7
4411	3513	Pelagic Harstad	25/03/2019	12:29:32	25/03/2019	13:09:14	-68.7272	5.857	-68.688	5.874	3050	322	520	0.05
4412	3548	Macroplankton trawl	27/03/2019	15:03:30	27/03/2019	15:11:46	-68.2144	3.587	-68.215	3.599	3875	39	98	-1.5
4413	3513	Pelagic Harstad	28/03/2019	09:15:24	28/03/2019	09:45:26	-65.7904	2.274	-65.764	2.293	2830	390	492	0.35
4415	3548	Macroplankton trawl	30/03/2019	15:33:16	30/03/2019	16:38:49	-65.2386	2.873	-65.243	2.949	2250	58	1112	-0.35
4416	3548	Macroplankton trawl	30/03/2019	17:26:57	30/03/2019	17:57:51	-65.243	2.947	-65.242	2.905	2460	8	51	-1
4417	3440	Beamtrawl	16/03/2019	02:45:42	16/03/2019	02:55:42	-68.4582	11.516			1730	1730	1730	0.06
4418	3440	Beamtrawl	29/03/2019	19:15:47	29/03/2019	19:25:48	-65.2003	2.646			1210	1210	1210	0.12

In addition to the trawl sampling a horizontal bottom longline (IMR gear-code 5110) adapted for scientific sampling was used to sample demersal fish. The longlines was designed, based on experience from the commercial fisheries, to minimize incidental bird catch/mortality. This was further facilitated by extending the distance between hooks to 4 meters. No birds were got entangled during operation of the longline. Three settings were carried out, two on Astrid Ridge and one on Maude Rise (Table 5)

Table 5. Longline stations

serialno.	gear name	startdate	starttime	stopdate	stoptime	lat. start	lon. start	line total length (m)	fishingdepth (m) min	max	fishingdepth temp. (°C)
4406	Longline	16/03/2019	21:18:52	18/03/2019	11:19:20	-68.0395	11.750	720	1560	1563	0.2
4407	Longline	20/03/2019	14:04:02	20/03/2019	23:57:07	-68.9214	11.735	720	1102	1111	0.4
4414	Longline	29/03/2019	10:43:22	30/03/2019	11:39:41	-65.2226	2.570	900	1267	1294	0.11

Our experience shows that it is feasible to operate longline on the research vessel but some adjustments would be beneficial.

The entire catch was sorted to lowest possible taxonomical level, and each category was counted and weighed. In case of large numbers, a random subsample of 30 specimens was measured, and the weight of the subsample recorded in addition to the total weight. A photograph of a specimen of each species was taken, and up to 10 specimens of each species were frozen. The frozen samples will be preserved at the University Museum in Bergen, Norway.

For toothfish more thorough individual sampling was conducted. For each individual length, weight, sex, and maturity stage was registered. Otoliths, genetic samples, stomach samples and gonad samples were also collected.

A special project was conducted as a toxicologic exposure study on two Antarctic icefish: *Chionodraco hamatus* and *Trematomus leonnbergii* (see special report below).

All trawl and longline stations were at bottom deeps exceeding 1000 m, and fishing temperature below 0.35°C. In the demersal fishing gears rattails of the genus Macrourus and Antarctic deepsea smelt (*Bathylagus antarcticus*) were dominating species in the catches. In addition, four large Antarctic toothfish (*Dissostichus mawsoni*) (25.3-52.6 kg, 130-170 cm) were taken on longlines at Maud Rise. In pelagic trawls Antarctic deepsea smelt and Antarctic lanternfish (*Electrona antarctica*) were most abundant in the catches.

BENTHOS

Participants: Anne Sveistrup (IMR), Anne H. Tandberg (UIB), Tone Falkenhaug (IMR), Elvar Hallfredsson (IMR), Stefano Ambroso (ICM); Tone Ulvatn (UIB)

GOALS

Macro- and megabenthic sampling along the coastal region of DML east of the zero meridian has been very scarce. Little is known about community composistion or structure in this area. The focus in this benthic fauna WP are distribution patterns in relation to habitats and geomorphology.

TECHNOLOGY AND METHODS

Beam Trawl

A 2 meter wide beam trawl with a 4 mm mesh sized cod end, was used for collecting macro- epifauna in two different locations, Astrid Ridge and Maud Rise. Sampling time at the sea floor was 10 minutes, mean haul speed 1.5 knots, and wire length 1.5-2.5 times station depth. The samples were sieved through a 4mm and 1 mm mesh sieve, sorted into phyla and biomass of each phyla was measured. The sample was then identified down to lowest possible taxon on board, and specimens were photographed and fixed in ethanol and formalin.

Campelen Trawl

(see specifications in overview WP2)

Campelen Trawl (Bottom trawl) was used for collecting fish and benthos at two locations in Astrid ridge (Table 3.1). Benthos bycatch was sorted from the total catch, and biomass measured for the different phyla.

Epibenthic sled

For this cruise, a modified Rothlisberg-Piercy sled (RP-sled) was used for sampling of epibenthos. The RP-sled has a sampling-width of 1m, and the net mesh-size is 0.5mm. The sample height is 26-59 cm above bottom, and the upturned frontal runners create turbulence in front of the sled that results in a sample that consists of both superficial fine sediments and near-bottom water. The RP-sled and its modified varieties (including the German Brenke-sled) are widely used for epibenthic sampling in both the Arctic and Antarctic. All material sampled with the RP-sled was fixed in absolute ethanol.

Baited traps

Simple tube-traps (diameter 12 cm, funnel in one end, 0.5mm mesh in the opposite end) baited with fish were attached at the splices between each of the connected longlines, and deployed together with the longlines. This was done at all longline deployments, and the samples received sample numbers as the longline (seriesnumber and stationnumber).

ROV

The UiB-owned ROV Ægir6000 was used for filming and sampling the seafloor. Ægir6000 was operated through the moonpool in the main hangar, and is equipped with a tether management system (TMS) giving it 200m reach away from the TMS and the heavy winch-wire at dives. Ægir6000 is equipped with a 5 chamber suction sampler (Metas), Niskin watersample bottles, push-corers and a lidded scoop that can be operated using the arms. The front tray is equipped with a watertight lining enabling sampling of both small and large fauna using the arms of the ROV. All sampled fauna received a hand-pick number or suction sample number in the sampling log. This number is reflected in the sample number later to allow a connection between the video footage and the physical specimen in a sample.

Video logging

CampodLogger (ver 3.0.39), developed at Institute for Marine Research, was used for annotation of seabed observations during the ROV dive. The program is used for recording navigational data and time, connected to each observation. Additionally, the ROV was recording its accurate position and depth during the dives. The fauna was annotated simultaneously together with seabed sediments, and identified to lowest possible taxa. Notes were taken for additional details for further work on identification.

Sample preservation and further handling

Physically sampled specimens were sorted to relevant levels of identification and preserved in absolute ethanol, 4% formalin or frozen at -20°C as most proper for the different taxa. Most samples were preserved in absolute ethanol (which was changed after 24 hours to maintain an alcohol level higher than 85%). Cnidaria and some Mollusca were mainly preserved in 4% formalin, with subsamples (if large individuals, a small piece of the animal) for genetic analyses in absolute ethanol. Fish from all gears were packed in plastic bags and frozen at -20°C.

All sampled specimens from WP3 will, in addition to a selection of samples from WP1 and WP2, are being curated by the University Museum Bergen, where they will constitute a separate “Antarctic collection”. Specimens from this collection will be made available to researchers on a similar basis as other specimens from the museum’s collection.

RESULTS

Three benthic stations were sampled, two at the Astrid Ridge and one at Maud Rise. For a complete list of deployed benthic gear, see Table 6.

Five ROV stations were taken within the three stations, and transects were recorded at a speed of 0.2-0.5 knot. Stops were done along the transect for collection of samples and specimens. Laser points, 15 cm apart, are used for determining vision field and fauna size.

Astrid Ridge

Astrid Ridge had two full stations including ROV-sections, epibenthic sled, bottom trawl and beam trawl. (Figure 7, Table 6).

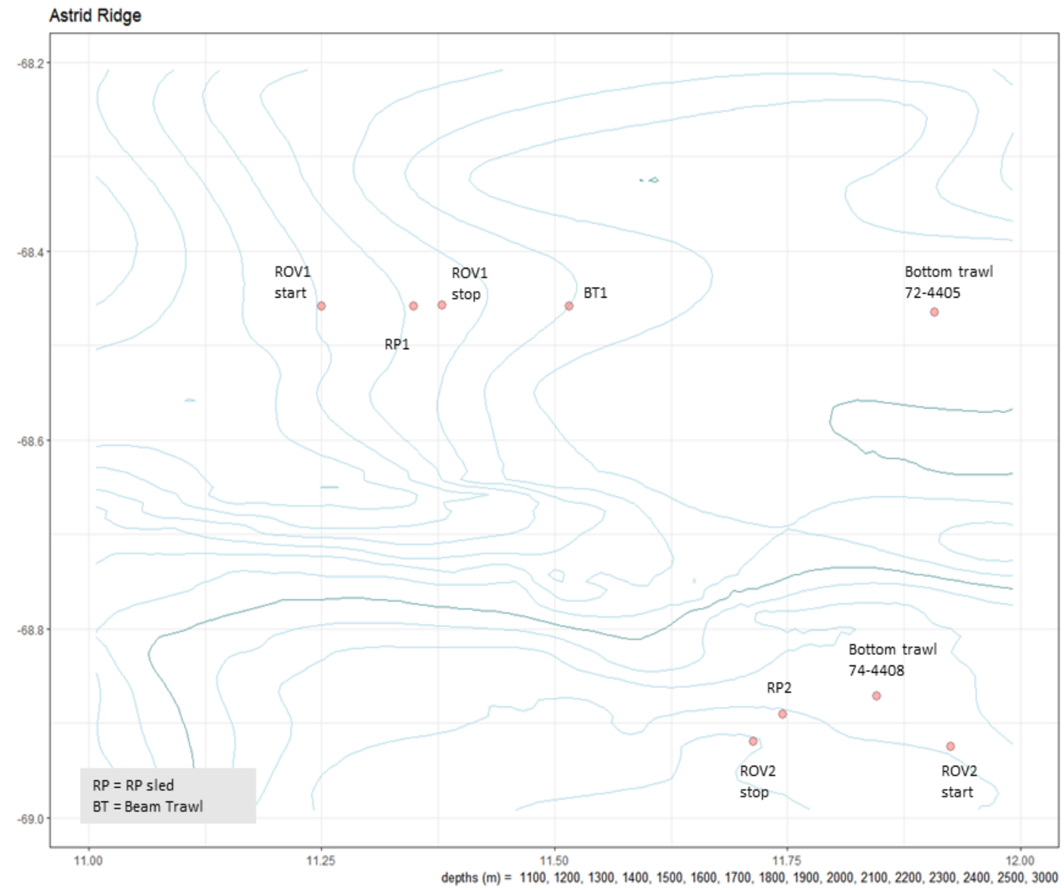


Fig 7: Benthic stations on Astrid Ridge

Table 6: Station list of benthic sampling

Super station	Loc.St.No	Gear	Date start	Time start	Date stop	Time stop	Latitude	Longitude	Depth	Latitude	Longitude	Depth	Area
9	ROV1	ROV	15/03/19	06:20:20	15/03/19	15:13:46	-68.4589	11.2742	1990	-68.4571	11.3797	1838	Astrid ridge
9	RP1	RP sled	15/03/19	22:55:35	16/03/19	02:10:21	-68.45813533	11.34844937	1740	-68.4579027	11.53169883	1740	Astrid ridge
9	BT1	Beam trawl	16/03/19	02:45:42	16/03/19	06:03:22	-68.45826915	11.51556335	1730	-68.47358202	11.39518242	1730	Astrid ridge
9	72-4405	Bottom trawl	16/03/19	08:30:27	16/03/19	09:11:07	-68.4639222	11.90772967	1500	-68.4657783	11.9922724	1515	Astrid ridge
25	73-4406	Baited traps	16/03/19	21:18:52	18/03/19	11:19:20	-68.0395	11.75033333	1563	-68.0395	11.75033333	1560	Astrid ridge
30	73-4407	Baited traps	20/03/19	14:04:02	20/03/19	23:57:07	-68.92143952	11.73533295	1102.1	-68.92143952	11.73533295	1111	Astrid ridge
30	ROV2	ROV	20/03/19	16:48:24	20/03/19	03:02:42	-68.9187	11.97	1320	-68.9209	11.7647	1120	Astrid ridge
30	74-4408	Bottom trawl	21/03/19	09:24:36	21/03/19	09:56:06	-68.87107023	11.84496072	1090	-68.86923083	11.92157925	1147	Astrid ridge
30	RP2	RP sled	21/03/19	17:16:54	21/03/19	18:45:20	-68.889502	11.74478802	1043	-68.8831641	11.79730402	1055	Astrid ridge
72	ROV3	ROV	28/03/19	19:29:08	29/03/19	00:03:35	-65.2217	2.4762	1760	-65.2246	2.516	1380	Maud Rise
99	80-4414	Baited traps	29/03/19	10:43:22	30/03/19	11:39:41	-65.22259437	2.570434217	1294	-65.22259437	2.570434217	1267	Maud Rise

73	ROV4	ROV	29/03/19	13:29:12	29/03/19	14:47:27	-65.20004001	2.6468	1207	-65.1916	2.660001	1197	Maud Rise
73	BT4	Beam trawl	29/03/19	19:15:47	29/03/19	19:25:48	-65.20034018	2.646309483	1210	-65.20348575	2.640486417	1210	Maud Rise
73	RP4	RP sled	29/03/19	21:52:47	29/03/19	22:06:32	-65.20359392	2.644293983	1210	-65.20753047	2.636757067	1210	Maud Rise
74	ROV5	ROV	30/03/19	02:39:37	30/03/19	06:46:07	-65.2358	2.7844	1798	-65.2356	2.7513	1335	Maud Rise

ROV1

A transect from 1990 - 1838m depth, 9 hours duration, on the western slope of Astrid Ridge, was filmed (Table 3.1). The substrate consisted of very fine sediments, mud/sandy mud with gravel and cobbles now and then. Some big boulders.

Echinoderms and shrimps were dominating the transect. Holothuroids were especially abundant and included at least five different species. Echinoids, asteroids, Ophiuroids, crinoids; both antedonoids and stalked crinoids, were common. Gorgonians, the deep-water sea pen, *Umbellula*, hexactinellids and actinians were also recorded.

ROV2

Eastern slope of Astrid Ridge, 1320 – 1120m depth, 10 hours duration, was recorded (Table 3.1).The substrate was mostly gravelly sandy mud with patches of coarser sediments with cobbles and boulders. Ophiuroids, holothuroids and shrimps were most common in the finer sediments, together with the irregular echinoid; pourtalesia, pennatulaceans and cerianthids. Several specimens of a long-armed asteroid were observed, also “arm” prints of it were common in the sand. Various ophiuroids and crinoids were most common in the coarser patches. Here were also actinians, anthomastus, hexactinellids, bryozoans and hydrocorals common on rocks. Lebensspuren of echinoids were seen in the sand. We passed an area with walls of compacted sediments, here crinoids and ophiuroids were abundant.

The slopes of Astrid Ridge were covered mainly by very fine sediments of sandy mud, with patches of coarser sediments. Shrimps and echinoderms, especially holothuroids were the most abundant taxa. Echinoids, ophiuroids, asteroids, crinoids, gorgonians and pennatulaceans were also common in both sampling areas. A wall of compacted sediments, with high abundance of crinoids and ophiuroids were filmed.

Two stations with epibenthic sleds, bottom trawls and beamtrawls were sampled at Astrid ridge.

Maud Rise

Maud Rise had three ROV-transects combined with one epibenthic sled and one beam trawl. (Figure 8, Table 6)

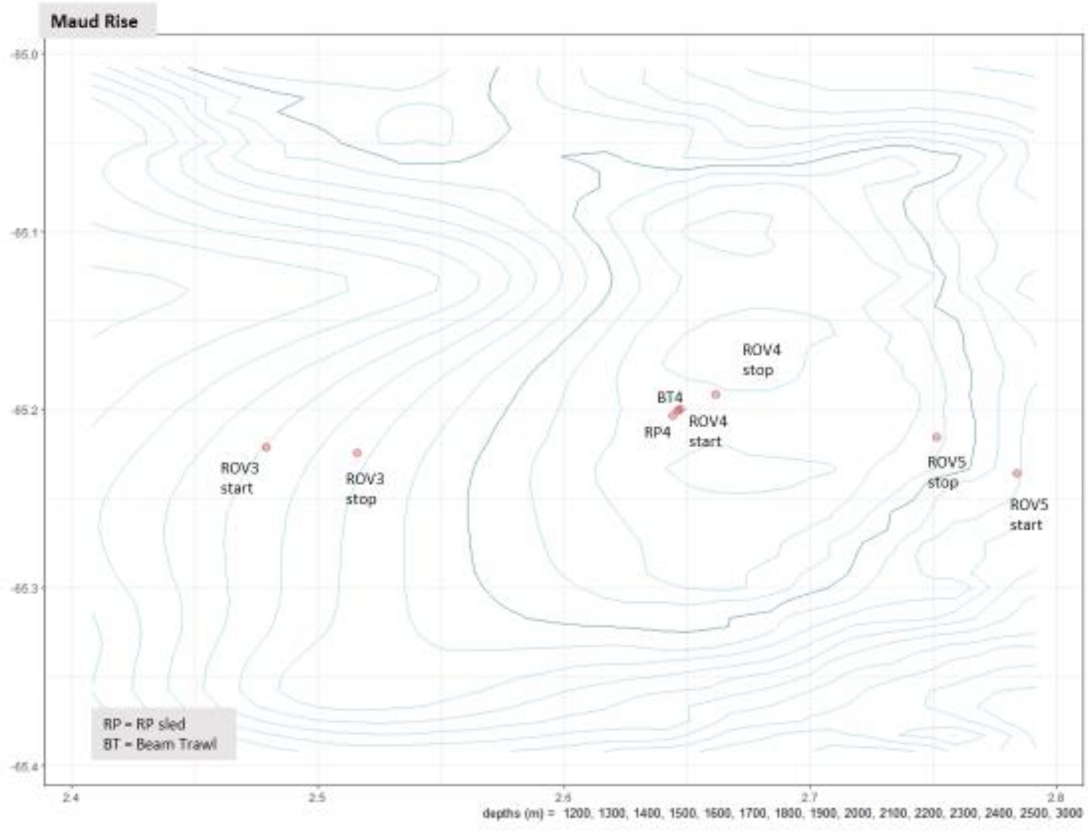


Fig 8: Benthic stations on Maud Rise

ROV3

Western slope of Maud Rise, from 1760 m – 1383 m depth, 4.5 hours transect.

White sand mainly consisting of calcareous Foraminifera at the lower part, areas with lava rocks and continuous lava fields partly covered with sand as it became steeper. Transparent Ascidians and Brisingidae were very common on lava. Asteroids, Hexactinellids, Ophiuroids and Pycnogonids, Gorgonians and Antipatharia, also on lava. Umbellula were recorded in the sandy patches.

ROV4

A 1 hour short transect on top of Maud Rise for inspection of seafloor before trawling. Depth 1207 - 1197m. Flat terrain with a few patches of lava blocks. Brisingidae, shrimps, ophiuroids, holothuroids, asteroids and crinoids were most common. A few gorgonians and *Umbellula* were also observed.

ROV5

A transect from 1798 - 1335m depth, duration of 4 hours, up the eastern slope of Maud Rise was recorded. The sediments consisted of white, calcareous foraminifera sand with lava blocks and continuous lava fields. Current ripples in the sand.

Transparent Ascidians were the dominating fauna on lava. Umbellula and Holothuroides dominating in the sandy patches. From 1400-1500 meters depth and up, a somewhat denser fauna with Gorgonians, Hexactinellids, Brisingidae and Crinoidea were seen. Also a few specimens of Antipatharia. Dead Balanoidae shell fragments were covering the sand from 1500-1350m depth. Less density of life at the shallowest part of the transect.

Maud Rise is characterised by steep slopes with exposed volcanic rocks. The fauna is dominated by hard-bottom semi-sessile species such as crionoids, ascidia, porifera, gorgonians and brisingiids. In between the exposed volcanic rocks, calcareous foraminifera were abundant to the level of seeming like sandy areas. In this biological sediment, sea-pens of the genus *Umbellula* dominated, as did Ophiouridea and brisingiids. The rocks were more brittle at the start of the ROV-transects (1750 m) than at the top (1400m). Near the top of the eastern transect (1500m-1350m) dead barnacle-shells dominated the seafloor to the extent that it could be described as a separate bottom type. The 1200m deep “top-transect” revealed an almost homogenous sandy platform with a few volcanic rocks, and the fauna was dominated by holothurians, brisingiids and a few shrimp.

One station with epibenthic sled and beamtrawl was sampled at the top of Maud Rise.

ZOOPLANKTON AND MICRONEKTON

Participants: Tone Falkenhaug (IMR), Anne Sveistrup (IMR), Anne H. Tandberg (UIB), Elvar Hallfredsson (IMR), Stefano Ambroso (ICM); Tone Ulvatn (UIB)

The main aim of the zooplankton studies was to collect information on abundance, diversity and ecology of zooplankton in order to meet the following objectives:

To provide information on species diversity and distributional information on key planktonic organisms in support of the WSMPA planning process.

1. To gain data and information to better understand the population structure of krill stocks
2. To improve our knowledge about trophic pathways in the pelagic food web.

The zooplankton studies were targeting meso-zooplankton (0.2-20 mm) and microzooplankton/ micronekton (2-20 cm).

Methods

Zooplankton and micronekton was sampled on preselected stations along CTD transects and within three intensive study areas (Figure 9). Sampling extended from 1000 m depth to the surface, by oblique or vertical tows. Pelagic sampling was made with 5 different gear, providing data of different size- and depth resolutions (Table 7).

Mesozooplankton (0.2-20 mm) was sampled with the Multiple Plankton Sampler (MultiNet Mammoth, 180µm mesh; 1m^2 mouth area) and a standard ring-net (double WP2, 180 mm mesh, 0.25 m^2). A total of 28 mesozooplankton stations (24 WP2 and 4 Multinet) were successfully completed during the survey. Mesozooplankton was preserved on board for later biomass estimations, enumeration and species identification.

Sampling of macrozooplankton (2-20 cm, including euphausiids) was made with the Macroplankton trawl (Krill trawl; 36 m^2 mouth opening, 7 mm mesh). Samples of large sized macrozooplankton, were also obtained from the larger pelagic fish trawls (Harstad trawl and Multpelt). In addition to nets and trawls, acoustic recordings provided continuous data on large scale horizontal distribution patterns and vertical distributions. A total of 11 pelagic trawl hauls were completed during the survey, including 6 hauls with the Macroplankton trawl. Of these, seven stations were targeting echo registrations, and four hauls were made on pre-determined superstations. Macrozooplankton from pelagic trawls was sorted and identified to the lowest taxonomic level possible, and preserved for later studies on taxonomy, trophic studies and genetic analyses. Biological analyses of euphausiids were carried out onboard, including determination of species, maturity stages and size distributions.

Preliminary results

Mesozooplankton

Analyzes of species composition, abundance and biomass of mesozooplankton (0.2-20 mm) will be made after the cruise. Preliminary results obtained from Flow Cam analyzes on board the ship, indicated strong spatial variations in species composition of zooplankton communities. Large sized calanoids (*Calanoides acutus, Rhincalanus gigas*) and Acantharians (Radiolaria) made up a significant portion of the mesozooplankton biomass.

Macrozooplankton

A total of 44 taxa of macrozooplankton/ micronekton was recorded from the three pelagic trawls combined (Table 8, fish not included). Euphausiids were patchy distributed in the survey area and concentrations were generally low. Trawls targeting echo registrations of euphausiids was dominated by *E. superba* accounting for >99% of the total catch weight (wet weight). In areas with low abundances of euphausiids, trawl catches were dominated by mesopelagic fish (23-62%), gelatinous zooplankton (21-58%), and high abundances of sea butterflies (Pteropoda) in the upper 50 m. The abundance of Salps were low at all stations. The two dominant species of jellyfish were *Periphylla periphylla* and *Atolla* sp., but also large scyphozoans such as *Stygiomedusa gigantea* and *Desmonema glaciale* were encountered. An additionally four taxa of gelatinous zooplankton were observed during ROV dives: *Pectis* sp., *Aegina* sp., *Lampocteis cruentiventer* and *Paraphyllina* sp. The list of taxa is not exhaustive, since the preliminary identifications were made to genus level or higher. A more detailed picture of the species composition will be available when samples have been analyzed after the cruise.

Euphausiids

Three species of euphausiids were recorded during the survey; *Euphausia superba*, *Thysanoessa macrura* and *E. triacantha*. *E. superba* was the most abundant euphausiid species occurring at 9 out of 11 trawl stations, and with maximum densities 0.26-0.28 g/m^3. The average body length of *E. superba* was 47.7 ± 6.9 (SD) mm, with range 24–67 mm (Table 9). The sexual maturation stage development composition was highly variable between stations (Figure 10). This spatial variation in demography may reflect different subpopulations or stocks in the area, but conclusions cannot be made without studies on the genetic population structure of this species. Subsamples of *E. superba* from all trawls were fixed on ethanol for future genetic studies.

Table 7. Sampling gear and strategies

Gear /instrument	**Size class sampled**	**Type of sample**	**Sampling strategy**
Multinet Mammoth (Hydro Bios). 180 µm, 1 m^2	*Mesozooplankton (0.2-20 mm)*	Quantitative, depth stratified (9 strata)	Intensive study areas 1000-0m
Double WP2 ring net (WP2-duo). 180 µm, 0.25 m^2	*Mesozooplankton (0.2-20 mm)*	Quantitative, depth integrated	On CTD transects 200-0m
Macroplankton trawl (Krill trawl). 7mm mesh, 36 m^2	*Macrozooplankton (2-20 cm)*	Quantitative. depth integrated	a) Intensive study areas (1000-0m) b) Ground truthing (targeting registrations)
Harstad trawl and Multpelt	*Macrozooplankton (2-20 cm)*	Non-quantitative	Ground truthing

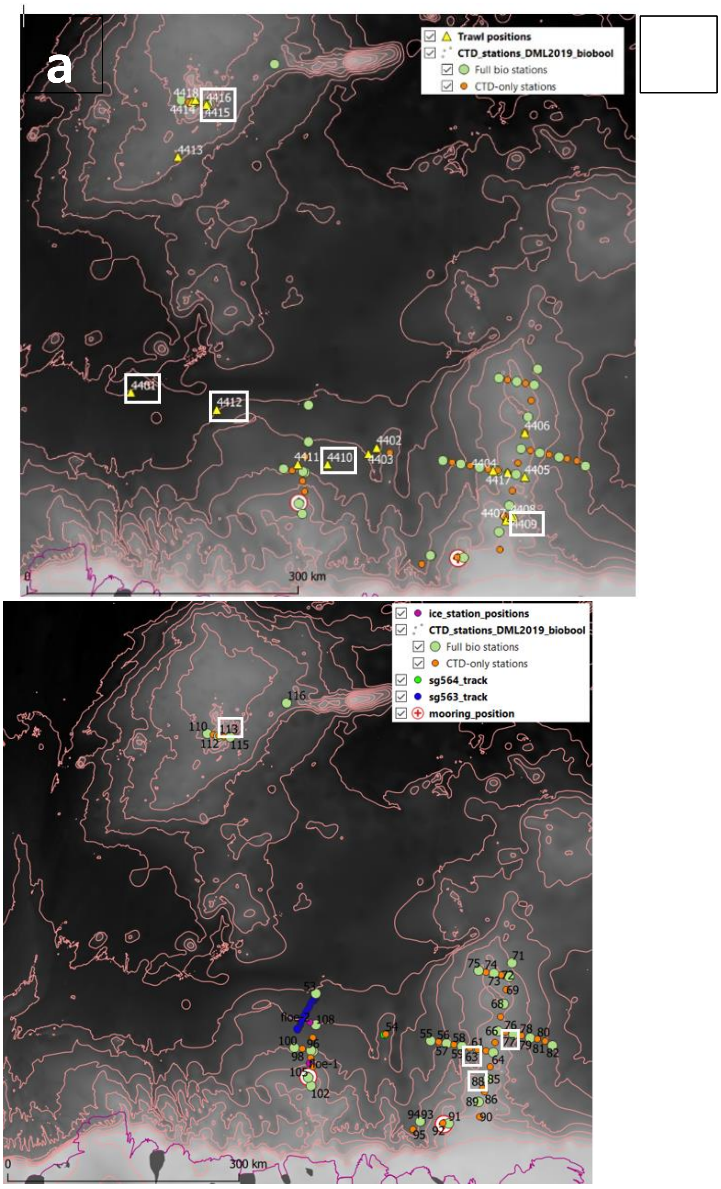


Figure 9. a) Trawl stations. Macroplankton trawls indicated by white squares. b) CTD stations with zooplankton sampling. Zooplankton net hauls (WP2-duo, 0-200 m) were made at "full bio station" (green). Positions of the 4 hauls with Multinet Mammoth (0-1000 m) are indicated by white squares.

Table 8. Macrozooplankton taxa registered in pelagic trawls.

		Macroplankton trawl						Harstad trawl			Multpelt	
	Taxa	**4401**	**4409**	**4410**	**4412**	**4415**	**4416**	**4411**	**4404**	**4413**	**4402**	**4403**
Amphipoda	*Primno* sp	+	+		+	+	+					
	Cyphocaris sp		+			+	+					
	Amphipoda		+	+		+	+	+		+		
	Hyperiidae		+		+	+	+					
	Cyllopus cf. lucasii	+	+		+	+	+		+		+	
	Scina sp					+						
	Lysianassidae		+			+						
	Themisto sp	+				+						
	Hyperoche sp	+				+						
	Stegocephalidae					+						
Cephalopoda	Cephalopoda		+			+	+	+				
	Alluroteuthis antarcticus	+							+		+	+
	Galiteuthis glacialis											+
	Mesonychotheuthis sp									+		
	Psychroteuthis glacialis										+	
Chaetognatha	Chaetognatha		+			+	+			+		
	Sagitta sp	+										
Cnidaria	Siphonophora		+		+	+	+	+		+	+	+
	Ctenophora					+	+	+				
	Beroe abyssicola					+						
	Calycopsis borchgrevinki	+	+	+	+	+		+	+	+	+	+
	Atolla sp		+			+		+	+	+	+	+
	Periphylla periphylla		+			+		+	+	+	+	+
	Stygiomedusa gigantea					+		+		+		
	Desmonema glaciale					+						
	Halicreas cf. minimum					+						
	Diphyes sp	+										
Copepoda	Calanoida		+			+	+	+		+		
	Rhincalanus gigas	+										
Decapoda	Caridea	+	+			+		+	+		+	
	Nematocarcinus lanceopes		+									
Euphausiacea	*Thysanoessa macrura*		+			+	+	+		+		
	Euphausia superba		+	+	+	+		+	+	+	+	+

	Euphausia triacantha									+
Leptostraca	Leptostraca					+				
Lophogastrida	Lophogastrida					+	+			
Mysida	Mysida		+							
Ostracoda	Gigantocypris		+			+				
Polychaeta	*Tomopteris* sp	+				+	+		+	
	Polychaeta		+	+	+	+	+			
	Alciopa reynaudii	+								
Pteropoda	*Spongiobranchaea* sp	+		+	+					
	Pteropoda		+	+		+	+	+		
	Clio pyramidata	+				+	+			
	Clio sp		+		+				+	
	Clione limacina	+								
Salpa	Salpa		+	+	+	+				+

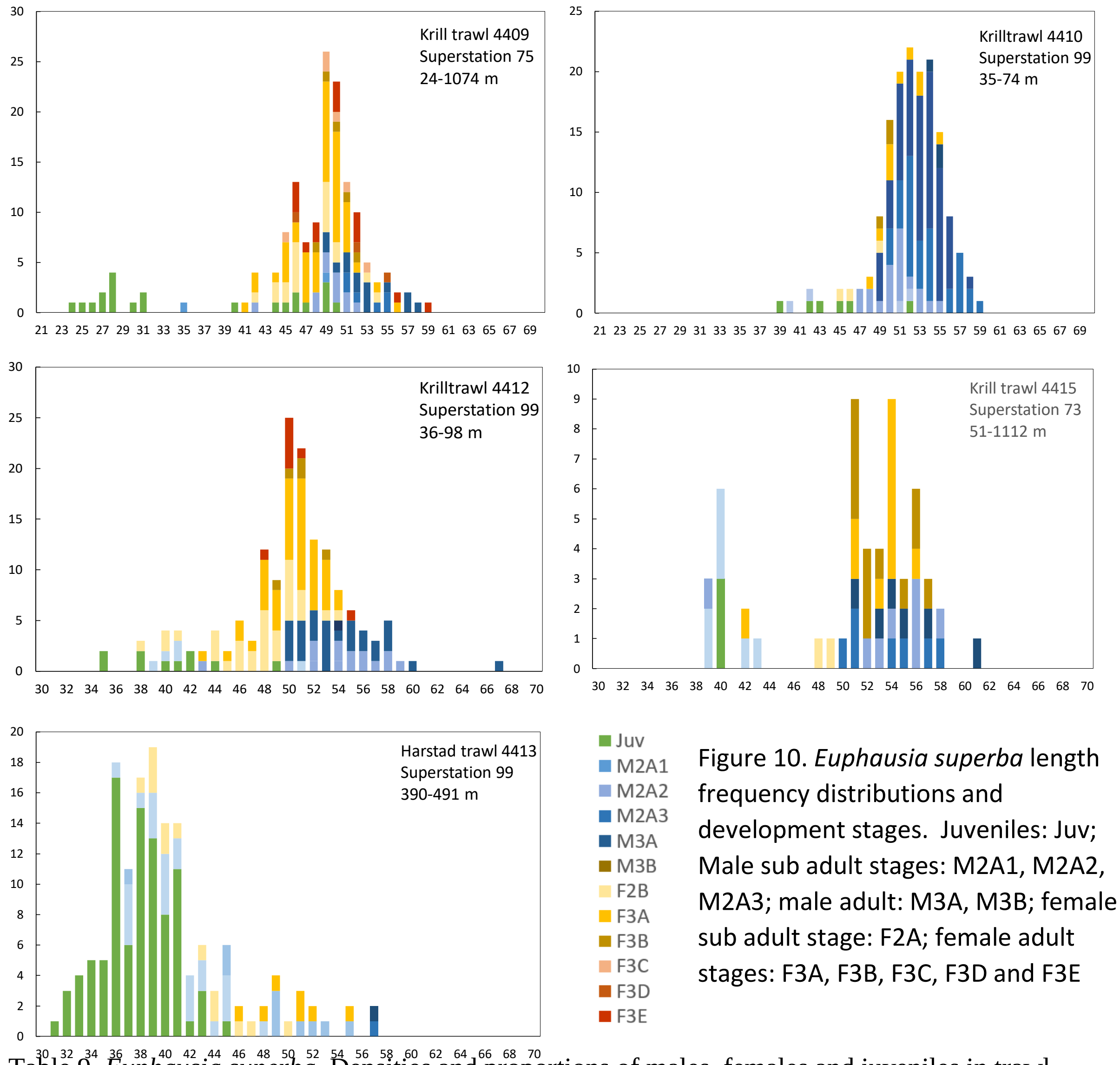


Figure 10. *Euphausia superba* length frequency distributions and development stages. Juveniles: Juv; Male sub adult stages: M2A1, M2A2, M2A3; male adult: M3A, M3B; female sub adult stage: F2A; female adult stages: F3A, F3B, F3C, F3D and F3E

Table 9. *Euphausia superba*. Densities and proportions of males, females and juveniles in trawl catches

	4409	**4410**	**4412**	**4415**	**4413**
Numbers/m^3	0.006	0.25	0.28	0.0005	NA
Weight (g)/m^3	0.004	0.28	0.26	0.0005	NA
Average length (mm +/-SD)	47.4 +/-6.8	52.1 +/-3.3	49.9 +/- 5.1	50.8 +/-6.03	40.2 +/-5.2
% males	22	85.6	33.1	49.1	24.7
% females	63.3	10.5	60.4	45.6	13.3
% juveniles	14.7	3.9	6.5	5.3	62
sex ratio (M:F)	1:3	8:1	1:2	1:1	2:1

PRIMARY PRODUCTION AND PHYTOPLANKTON DYNAMICS

Participants: Sebastien Moreau (NP lead), Hanna Kauko (NP), Thomas Ryan-Keogh (CSIR) Asmita Singh (CSIR)

The study took place in March-April, a time of year when large Southern Ocean phytoplankton blooms are terminated and the microbial food-web typically dominates microbial assemblages.

Methods

Sampling was done via four main methods: seawater profiles done with the CTD rosette, a phytoplankton hand-net lowered to 20 m deep from the side of the ship, underway sampling and sea ice stations. Our group studied phytoplankton pigments (Chlorophyll a (Chl-a) and other pigments via HPLC), the content in Dissolved Organic Carbon (DOC), Particulate Organic Carbon (POC) and Particulate Organic Nitrogen (PON), total Biogenic Silica and Silicon isotopes (to study the contribution of diatoms to the total phytoplankton), the stable isotopes of Carbon and Nitrogen (to look at trophic interactions with secondary consumers such as krill, in collaboration with WP4), and Particulate Absorption (to estimate primary productivity rates). From the CTD, we also took unfiltered seawater samples to look at: phytoplankton composition, microbial community composition and Nitrate isotopes. Finally, our group also studied the physiology of phytoplankton by running Fast Light Curves on a Fast Repetition Rate Fluorometer (FRRF) as well as Metabolic Proteins **(**including photosystem I, photosystem II and Rubisco**)**.

A large phytoplankton fall bloom in deep open waters

Early March, "en route" to Astrid Ridge, we received Sentinel 3 satellite images of a very strong and large phytoplankton bloom taking place between Maud Rise and Astrid Ridge (Figure 11, March 8th 2019). We decided to deploy our first glider directly in the bloom and take a CTD with full biological sampling.

The Chl-a concentration in the upper 50 m was 3 µg l^{-1}. This is a very high and unusual concentration of phytoplankton at this time of the year, fall, when phytoplankton is expected to show low concentration as the spring and summer blooms are terminated, nutrients are exhausted in the surface mixed layer and daylight is decreasing. The other striking feature of this bloom is its wide geographical extent which seemed to follow the north-east to south-west flow and the bathymetry between Maud Rise and Astrid Ridge.

The first glider did ~30 profiles inside in this bloom before it was retrieved. This data will allow us to re-assess the importance of fall phytoplankton blooms in the Southern Ocean, both in terms of carbon export (i.e. the biological carbon pump) and in terms of food web ecology. For instance, the birds, seals and whales explorers (WP1) observed more than 60 humpback whales in 1 days while we were crossing this bloom, when they typically observed 4 to 5 per day in the other biological provinces visited during the cruise. The zone also seems to be rich in krill as well as WP4 successfully harvested krill there.

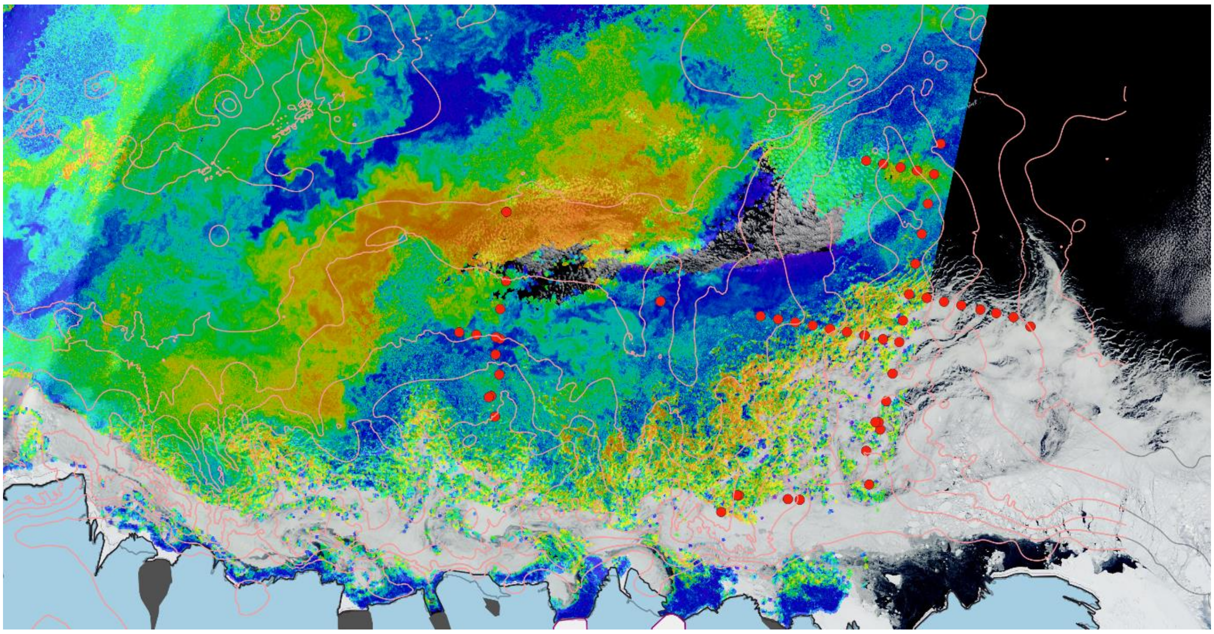


Figure 11: Phytoplankton bloom (SAR, Sentinel 3) between Maud Rise and Astrid Ridge, March 8th 2019.

Astrid Ridge

Following the study of this deep bloom, we studied phytoplankton dynamics across west-east and north-south sections of Astrid Ridge (March 13th to 23rd, 2019). Sea ice was progressively covering Astrid Ridge the few weeks before and during our transit there. Satellite imagery never indicated the presence of a strong phytoplankton bloom in these waters. However, due to its shallow plateau, the region might be an interesting source of sedimentary iron, which may fertilize the neighboring waters.

At Astrid Ridge, the Chl-a concentration in the surface mixed layer was relatively low, between 0.2 and 0.8 µg l^{-1}, except at the northern end of the ridge where Chl-a concentration were between 0.8 and 1.2 µg l^{-1} in the surface mixed layer, a rather large Chl-a concentration for such a late time of the year.

The marginal ice zone

West of Astrid Ridge, we studied the marginal ice zone as sea ice cover kept increasing northwards (March 24th to 26th, 2019). In that region, we found similar Chl-a concentrations compared to Astrid Ridge (up to 0.9 µg l^{-1}). However, the total phytoplankton biomass was much higher in that zone as the phytoplankton was distributed homogeneously throughout a thick (i.e. 100m) surface mixed layer.

Maud Rise

We then travelled North to study Maud Rise (March 28th to 31st, 2019). At Maud Rise, the phytoplankton distribution was more typical of the Southern Ocean open waters. A deep and relatively thick layer of phytoplankton was observed between 80 and 120 m deep, below the surface mixed layer. There the maximum Chl-a concentration was at 2.5 µg l^{-1}. As a consequence, the total phytoplankton biomass was high at Maud Rise, but too deep to be captured by satellites such as Sentinel 3.

Interestingly, Maud Rise was not a hot spot for krill and copepods dominated the zooplankton community. However, the high phytoplankton productivity probably contributed to a strong export of carbon to the ocean's floor as we observed Chl-a fluorescence spikes down to 500 m, probably showing the export of senescent phytoplankton.

Physical Oceanography off the coast of Dronning Maud Land

Participants: Laura de Steur (NPI lead), Tore Hattermann (NPI), Kristen Fossan (NPI), Nadine Steiger (UiB)

Objectives

The objective was to map the hydrographic properties (temperature and salinity) and currents (speed and direction) off the coast of DML and around Astrid Ridge between 1°E and 12°E. There is relatively little known about the currents structure in this region. The Antarctic Slope Front is a distinct feature and dips down toward the shelf and coast as seen in literature from the Prime Meridian where AWI has had moorings and surveys. The ASF separates the (warm and salty) Warm Deep Water from the (cold and fresh) Eastern Shelf Water. Associated with this front there is a westward current, the Antarctic Slope Current, and in addition, there is likely a separate coastal current on the shelf. It is unclear how these currents look like east of the Meridian, how large their transport is, and how they behave around the large topographic feature Astrid Ridge: quantify the fraction that flows over the ridge and how much goes around it.

To map the hydrographic properties during the cruise, Conductivity, Temperature, Depth (CTD) stations and two glider surveys were planned. The CTD sections were planned north-south on top of the Astrid Ridge, east-west across the Astrid Ridge, and several north-south across the continental shelf slope between 1°E and 12°E. In the deep interior the Lazerev Sea and well away from sea ice, glider surveys with two Seagliders were planned to map the hydographic structure there in the upper 1000 m.

The dynamics of the front and currents are important for regulating the access of warmer water that gets to and under the ice shelves in DML. To quantify the year-round dynamics of the thermocline and ASF and relate those observations to oceanographic data collected under and glaciological data on top of two major ice shelves in the region (Fimbul and Nivl ice shelves), three oceanographic moorings were planned to be deployed in the Antarctic Slope Current: two just east of Fimbul, and one just north of Nivl, west of Astrid Ridge. The shallowest one of the two near Fimbul Ice Shelf was a contribution of the University of Bergen (Collaborator: Elin Darelius). These moorings will also contribute to the project "*iMelt: Ocean-ice shelf Interaction and channelized Melting in Dronning Maud Land*", funded by the Norwegian Research Council, 2019-2022).

Data collection

Stations that were covered in the WP6 are shown in Figure 2. Most CTD data were collected along and across the Astrid Ridge (Figure 12), and some stations near the sea ice zone, and some over Maud Rise. Due to the heavy sea ice conditions on the continental shelf and slope, none of the planned CTD sections could be completed in these regions. Both gliders (rented from Norglider) stopped working too soon after deployment and could not make as many dives or cover a large region as planned. They stopped after 2 and 5 days respectively. One glider that was deployed in a phytoplankton bloom in the deep ocean was able to make 30 dives still (Figure 13). To accompany the mapping of the circulation in the region, underway velocity data was collected with the Vessel Mounted Accoustic Doppler Current Profiler (VMADCP). Velocity data of the upper 900 and 150 m were collected with the hull-mounted VMADCPs, though these were of variable quality when the vessel is steaming (bubbles under hull) and when going through sea ice.

Heavy sea ice conditions and in particular very strong sea ice drift speeds in the Antarctic Slope Current made it impossible to deploy the shallowest mooring provided by UiB (to go at 700 m isobath) since an appropriate target location could not be reached. The other two moorings were deployed although at different locations than first planned, and in particular the one that was targeted near Fimbul Ice Shelf was deployed much further north-east, having limited connection with Fimbul Ice Shelf.

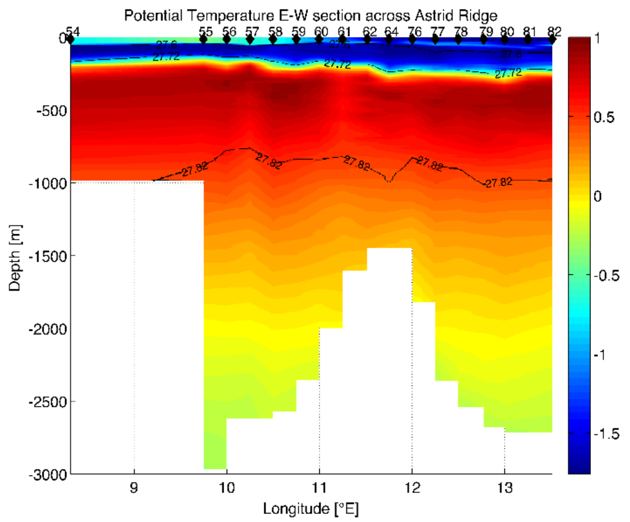


Figure 6.2 CTD section across Astrid Ridge.

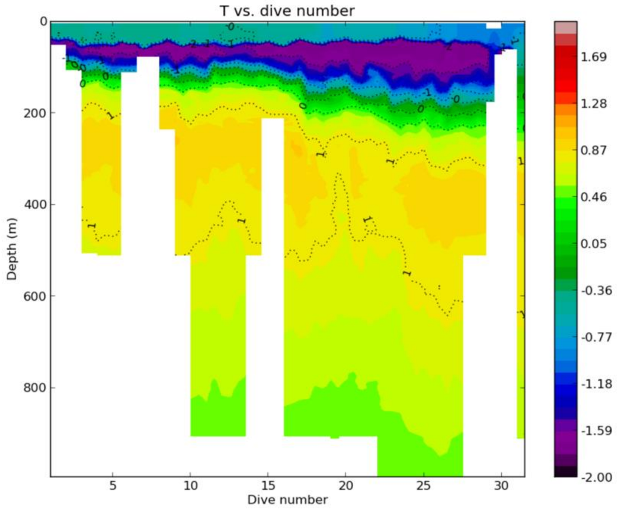


Figure 6.3 Glider section across the Study area.

SEA ICE AND OCEAN CHEMISTRY

Participants: Agneta Fransson (NPI lead), Melissa Chierici (IMR), Murat Ardelan (NTNU), Nicolas Sanchez (NTNU), Tommy Ryan-Keogh (CSIR), Asmita Singh (CSIR)

Ocean acidification, air-sea CO_2 exchange, effects of sea ice, meltwater and biological processes

Main focus: Our focus was to investigate the inorganic carbon cycling, nutrients and dissolved oxygen chemistry for the study of ocean acidification, biological CO_2 uptake and air-sea CO_2 exchange in the surface water, water column and sea ice environment (snow, brine, melt ponds) in the Dronning Maud Land, Antarctica, and biogeochemical drivers such as sea ice, meltwater, trace metal availability, and currents and wind.

Seawater sampling: We sampled the water column and sea ice for carbonate chemistry (total alkalinity, dissolved inorganic carbon, pH), nutrients (nitrate, phosphate, silicic acid), dissolved oxygen, and carbon and oxygen isotopes ($\delta^{13}C$, $\delta^{18}O$). Samples and data on physical and biological parameters were used in collaboration with WP5 and WP6 (Fig 2).

Underway sampling: seawater was collected every four hours from the ship water intake at 4 m, from Punta Arenas (Drake Passage) to DML and to Cape Town, in collaboration with Council of Science and Industrial Research (CSIR) and Stellenbosch University (SU), South Africa and WP5.

Sea-ice sampling and observation: sea ice, snow, brine and under-ice water were collected and analysed from two sea ice stations. Physical and chemical parameters were sampled, such as ice and snow thickness, temperature, salinity, and the same parameters as were sampled and analysed as for seawater. Cores were collected for ice stratigraphy and plastic. Regular observations were taken on the ice cover and ice characteristics several times a day in DML.

Sediment sampling: samples of surface sediment were collected at one ROV station at Maud Rise for further analyses regarding calcium carbonate on shore.

Analyses: samples were analysed onboard for determination of total alkalinity (AT), total dissolved inorganic carbon (DIC), pH and dissolved oxygen (selected) In addition, underway surface water (4 m seawater intake) was sampled and analysed at 107 stations between Punta Arenas and Cape Town as well as bottom water sampled from the ROV at 6 locations from 1200 to 2000 m and. Nutrients, $\delta^{13}C$, and $\delta^{18}O$ (double samples for inter-laboratory calibration between Amsterdam and Stellenbosch University), were stored for post-cruise analysis. The $\delta^{13}C$ were stored cool until analyses at UiB. For biological sampling and analyses, see WP5. Samples from pH-iron availability experiments performed in T2 were collected, where pH, DIC and AT were analysed onboard. Nutrients were stored for post-cruise analysis at IMR, Bergen.

Continuous measurements: the underway instrumentation for autonomous high-frequency surface water measurements of partial pressure of CO_2, pCO_2, (General Oceanics) and dissolved oxygen (Aanderaa sensor) were installed in the clean seawater laboratory 102.

pCO_2 sensor on mooring located at about 160 meters depth, for autonomous measurements of partial pressure of CO_2 in the water every other day for 1-2 years (hopefully). For location see map WP6.

T2 Iron availability and ocean acidification (Ardelan and Sanchez)

Main focus: investigate the iron availability for phytoplankton/primary production at ocean acidification in the Southern Ocean, performing water sampling and iron experiments at different pH and different phytoplankton conditions in the Dronning Maud Land.

Water sampling and analyses: Fe, Hg and MeHg and other trace metal samples (dissolved forms (<0.2 µm) and Total acid-leachable fractions) have been collected by clean sampling technique (GO-FLO bottles deployed on Kevlar line and sampled in the clean lab) for a total of 12 CTD stations from 8 depths (20, 30, 50, 75, 100, 200, 300). The pre-concentration (seaFAST-pico ESI method) and analysis (High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS) will be performed at Stellenbosch University.

For characterization of dissolved organic matter (DOM), ca 7-10 liter water from three depths (surface, 200-300m and 500 m) have been filtrated, passed the C-18 columns and extracted by methanol for subsequent analysis by Ultra performance liquid chromatography - tandem mass spectrometer (UPLC- MS/MS) at NTNU.

Incubation experiment: Incubation experiment under temperature and light controlled conditions was run for 12 days (test Goethite availability under ambient (8.1) and reduced pH (7.4) with 4 separate treatments, 1-control-ambient pH, 2-Low pH (RCP 8.5 scenario), 3-Goethite FeOOH addition under ambient pH, 4- Goethite FeOOH addition under low pH). 20 Liter PE collapsible containers have been used. Each treatment has three replicates. *Measurements and Samples:* In-Vivo Fluorescence, Chl-a, taxonomic (formalin fixed) for Microscope analysis, pH, DIC, Photosynthetic efficiency, Tal-Fe and DFe samples were collected every 3rd to 5th day.

Sediment sampling: sediment samples were collected by ROV at two locations; sediment core 50 cm at Astrid Ridge and surface sediment (10 cm) at Maud rise

Underway sampling: surface water samples for THg (test) and organic contaminants were collected in the transect from Drake passage to DML zone using the trace-metal clean sampling (torpedo fish pump), and in the transect from DML zone to Cape Town from the underway system, in collaboration with CSIR, SU and WP5.

Sea ice sampling: two separate sea ice samples have been collected. After collecting ice samples were kept in plastic bags at – 20°C until to process the sample. The first sea ice sample was 20 cm thickness, it was separated two pieces as upper and lower sections with two replicates each are ca 10 cm. the second ice samples was ca 96 cm and was divided into 9 pieces, each ca 10 cm. Those ice samples have been melted under Class-100 laminar flow chamber in the PE bags. The first melt-swill discharged 4 times, after that we allowed to accumulate the melt water and transfer it to acid washed PE bottles for total Fe and other trace metal analysis (to glass bottles for THg). Additional 100 ml melted water has been filtrated for DFe and DTM analysis.