Ichthyoplankton and pelagic fish assemblages in the Greenland Sea in 2017

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English Summary

Following a Strategic Environmental Study Plan for Northeast Greenland commissioned by the Danish Centre for Environment and Energy (DCE), the Greenland Institute of Natural Resources (GINR) and The Bureau of Minerals and Petroleum Greenland (BMP), a scientific cruise was conducted onboard the R/V Dana from 23 august to 11 September 2017. The main objective of the cruise was to provide environmental information for the planning and the regulating of oil exploration activities in the Greenland Sea. The specific objective of the present report is to provide information on ichthyoplankton and pelagic fish in the region. The methods used include ichthyoplankton nets, pelagic trawl and hydroacoustics. The ichthyoplankton collected belong to a very low number of species, predominantly polar cod (*Boreogadus saida*), a key species in arctic marine ecosystems. Spatially, polar cod dominated the assemblage on the continental slope and offshore while the other species dominated the shelf assemblage. Preliminary investigations suggested an apparent shift towards earlier hatching for polar cod, which could be associated with a relaxation in the extreme environmental conditions typical of the region (long sea-ice season and freezing sea surface temperature) over the past 25 years. This shift, if confirmed, could represent an increase in the recruitment of polar cod populations in the Greenland Sea. To investigate further this issue, a study based on otolithometric measurements of the polar cod larvae collected will be initiated in the coming months, and the results will be published in a peer-reviewed scientific journal such as Polar Biology. Combining the data from the echosounder with those of the trawl allowed to associate different echo patterns to specific organisms in the water column. Spatially, the acoustic data showed that the northeastern part of the study area appeared as a region of high biomass for the entire water column. The area encompassed the shelf break, an habitat polar cod is known to occupy in large biomass in other Arctic regions. Further analyses linking the acoustic data will with environmental parameters such as salinity, temperature and sea-ice dynamics will be done, compared with similar studies from other arctic seas, and synthesized in a publication to be submitted in a peer-reviewed scientific journal such as Progress in Oceanography.

Greenlandic Summary – Kalaallisut Naalisarneqarnera

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Danish Summary - Dansk Oversigt

Efter en strategisk miljøstudieplan for Nordøstgrønland bestilt af Nationalt Center for Miljø og Energi (DCE), Grønlands Naturinstitut (GINR) og den Bureau of Minerals and Petroleum (BMP) blev der gennemført et videnskabeligt krydstogt ombord på R/V Dana fra 23. august til 11. september 2017. Hovedformålet med krydstogt var at levere miljøoplysninger til planlægning og regulering af olieudforskningsaktiviteter i Grønlandshavet. Det specifikke formål med denne rapport er at give information om fisk og deres larver i regionen. De anvendte metoder omfatter planktonnet, fisketræl og hydroakustik. Den opsamlede fisk larver tilhører et meget lavt antal arter, overvejende polar torsk (*Boreogadus saida*), en nøgleart i arktiske marine økosystemer. Polar torsk larver dominerede på den kontinentale hældning og offshore, mens de andre arter dominerede nær kysten. Præliminære undersøgelser foreslog et tilsyneladende skift i retning af tidligere udklækning for polar torsk, hvilket kunne være forbundet med en afslapning i de ekstreme miljøforhold, der er typiske for regionen (lang havis sæson og frysning temperatur) i løbet af de sidste 25 år. Dette skifte, hvis det bekræftes, kunne repræsentere en stigning i rekrutteringen af polar torsk populationer i Grønland. For yderligere at undersøge dette problem vil der blive indledt en undersøgelse baseret på otolithometriske målinger af polar torsk larverne i de kommende måneder, og resultaterne vil blive offentliggjort i et videnskabelige tidsskrift som Polar Biology. Kombination af data fra ekkoloddet med trawlerne tillades at forbinde forskellige ekko mønstre med bestemte organismer i vandkolonnen. Akustiske data viste, at den nordøstlige del af undersøgelsesområdet optrådte som en region med høj biomasse til hele vandkolonnen. Området omfattede den kontinentale hældning, en habitat polar torsk er kendt for at optage i stor biomasse i andre arktiske regioner. Yderligere analyser, der forbinder de akustiske data, vil med miljøparametre som saltholdighed, temperatur og havis dynamik udføres sammenlignet med lignende undersøgelser fra andre arktiske have og syntetiseres i en publikation, der skal indsendes i et videnskabelige tidsskrift som Progress in Oceanography.

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1. Introduction

This report was commissioned by the Danish Centre for Environment and Energy (DCE), the Greenland Institute of Natural Resources (GINR) and The Bureau of Minerals and Petroleum Greenland (BMP) as part of the Strategic Environmental Study Plan for Northeast Greenland 2016-2019 to provide environmental information for planning and regulating oil exploration activities and oil spill response in the Greenland Sea. The main objective consisted in documenting the horizontal and vertical distribution of ichthyoplankton and pelagic fish assemblages in the Greenland Sea using ichthyoplankton nets, a pelagic trawl and hydroacoustics.

2. Materials and Methods

2.1. Field sampling

A survey was conducted in Northeast Greenland onboard the R/V Dana from 23 august to 11 September 2017.

Ichthyoplantkon sampling comprised 36 net deployments performed at 25 stations. Two Bongo (consisting in two 0.6 m-diameter frames equipped with one 335 and one 500 µm mesh nets) deployments allowed a first assessment of the size structure and density of fish larvae in the area. Numbers collected were low and the smaller larvae collected with the Bongo were large enough to be sampled adequately with the MIKnet (a 2 m-diameter frame carrying a 1500 µm mesh net), hence the latter gear was used to sample ichthyoplankton for the remaining of the cruise. Larval and juvenile fish were measured fresh onboard, identified to the lowest taxonomical level possible, and preserved in ethanol 95%.

Real-time echograms from the EK60 (hull-monted split-beam echosounder operating at frequencies of 18, 38 and 120 kHz) were scrutinized each day between UTC 6:00 and 18:00 whenever the ship was transiting between stations. Two dedicated ten-hours survey were also carried in the southern and eastern parts of the sampling grid. Eight FOTÖ trawl (a pelagic midwater trawl with an opening of 20 x 15 m) deployments in scattering layers identified on the echograms allowed to associate different echo patterns to specific organisms in the water column.

2.2. Data analysis

Ichthyoplankton data have been analyzed to document the geographical patterns of the assemblages and length data for the main species.

Catch data from the pelagic trawl were used to assess the taxonomic composition of different scattering layers identified on the echosounder.

Raw acoustic data was visually inspected to exclude regions where data was corrupted by station-based noise from sampling operations. Further selection of poor data regions was based on excessive noise from ice breaking and electrical interference from other instruments. A standardized algorithm was developed for signal conditioning and simpler interpretation of low target density across large spatial scales (Kornellisun and Ona 2003). It included a combination of background, impulse and transient noise removal algorithms followed by smoothing with a median filter and ping resampling (De Robertis and Higginbottom 2007, Ryan et al. 2015). Data was integrated across 250 m distance sampling units and the following depth, representing individual ecological niches: surface (5-25 m), epipelagic (25-200 m), mesopelagic (200-800 m), and demersal (Bottom 50 m). Geographical regions where specific depth-related niches were not available were excluded from analysis. Nautical Area Scattering Coefficient (NASC) values were reported for each sampling distance and depth niche. NASC values were normalized by 1+log/µ transformation. Interpolated spatial surfaces were created using an Akima cubic spline interpolation algorithm using R statistical software (Akima and Gebhardt 2016).

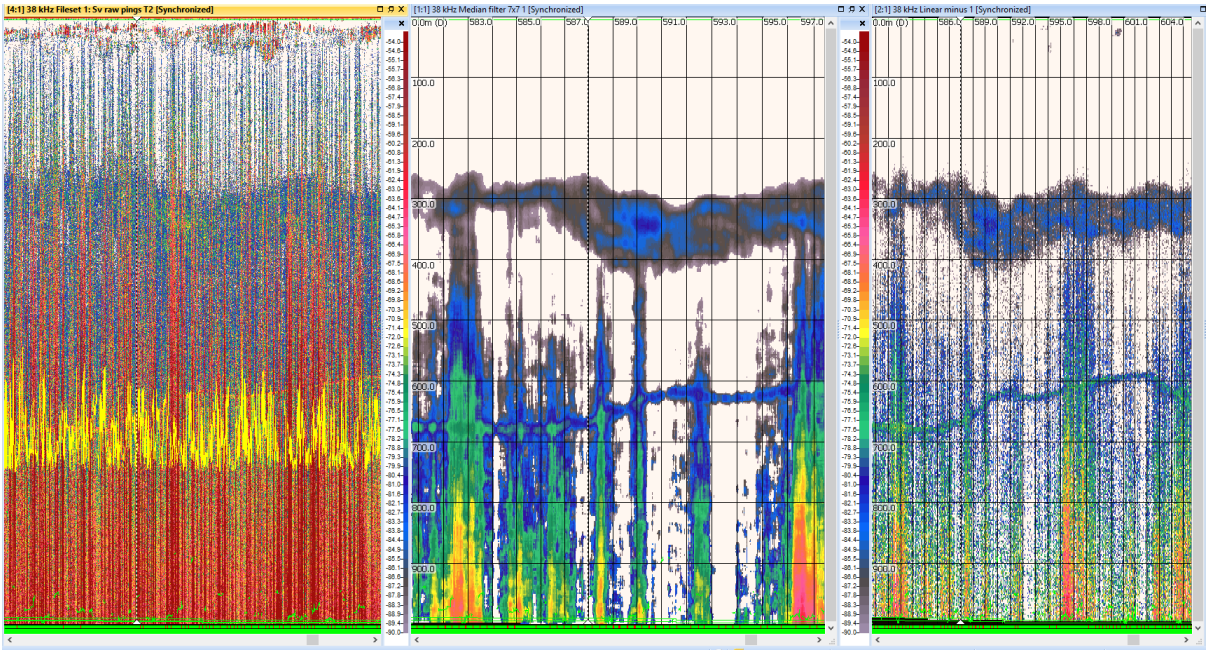

Figure 1. Example of acoustic data before (left panel) and after (middle and right panels) signal conditioning combining a background, impulse and transient noise removal algorithms and smoothing with a median filter and ping resampling.

3. Results

3.1. Ichthyoplankton

In total, 862 fish larvae were collected and identified to species or to the highest taxonomical level possible, for a total of 4 taxa. The ichthyoplankton was composed of 53% of the Gadidae, *Boreogadus saida*/*Arctogadus glacialis* (which at this stage are extremely similar and can only be identified using genetics or otolith microstructure analysis, Bouchard et al. 2013), 29% *Triglops nybelini* and 17% *Liparis fabricii*. Two specimens of *Gymnocanthus tricuspis* were also captured. The Cottidae and Liparidae were dominant on the shelf, while the Gadidae were dominated the assemblages on the continental slope and offshore (Fig. 2). Standard length ranged from 12 to 36 mm (mean = 20.0) for the Gadidae, from 12 to 37 mm for *Liparis fabricii* (mean = 21.6) and from 14 to 36 mm for *Triglops nybelinii* (mean = 25.5).

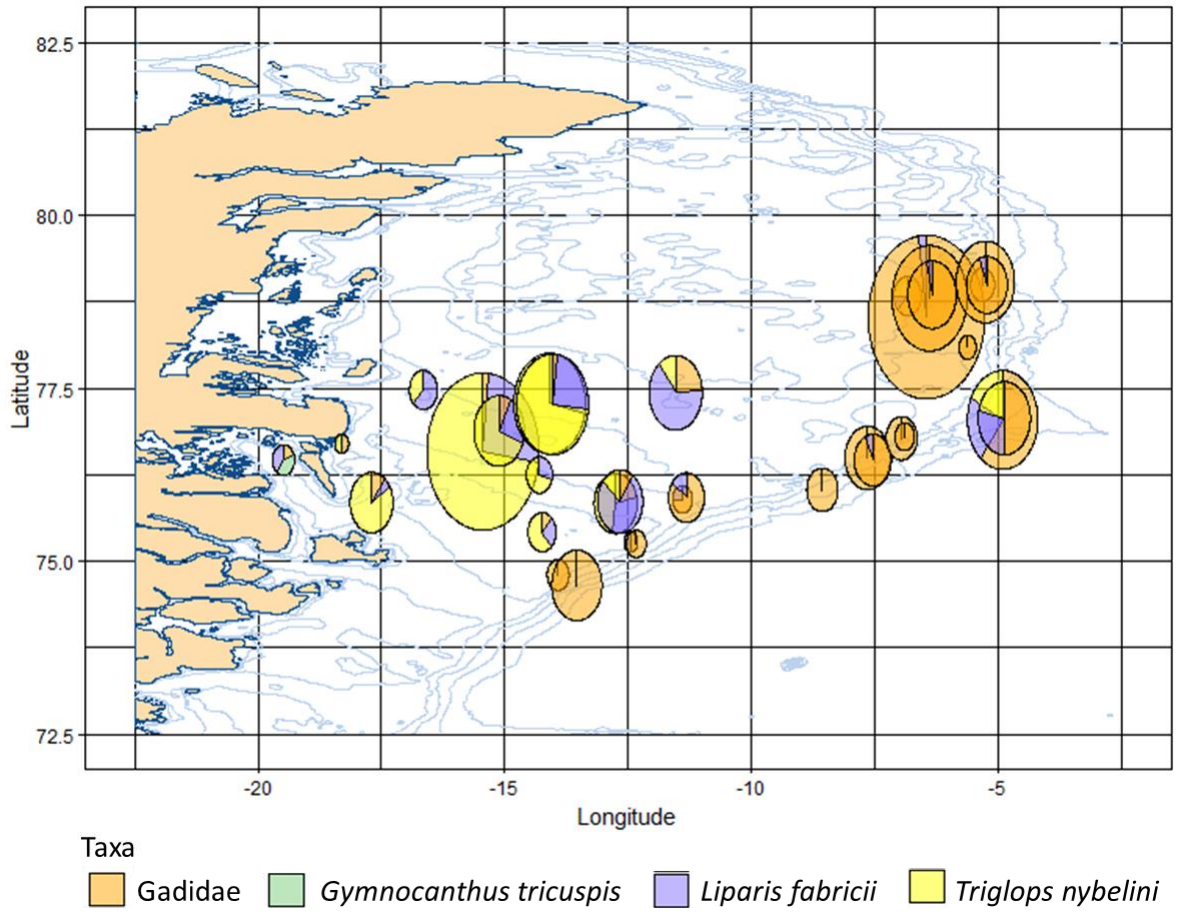

Figure 2. Abundance and taxonomical composition of ichthyoplankton sampled during the 2017 survey in Northeast Greenland.

3.2. Pelagic fish and other fauna

A total of 12 taxa were collected in the mesopelagic trawl: *Benthosema glaciale* (Myctophid fish), *Liparis fabricii* (snailfish), *Triglops nybelinii* (Cottid fish), *Boreogadus saida* (polar cod), *Arctogadus glacialis* (ice cod), *Gadus morhua* (Atlantic cod), unidentified Gadidae, *Gonatus fabricii* (squid), *Themisto libellula* (amphipod), *Periphila periphila* (jellyfish) and *Meganyctiphanes norvegica* (krill) and unidentified Euphausids (krill). Two deployments yielded no catch (Fig. 3, Table 1).

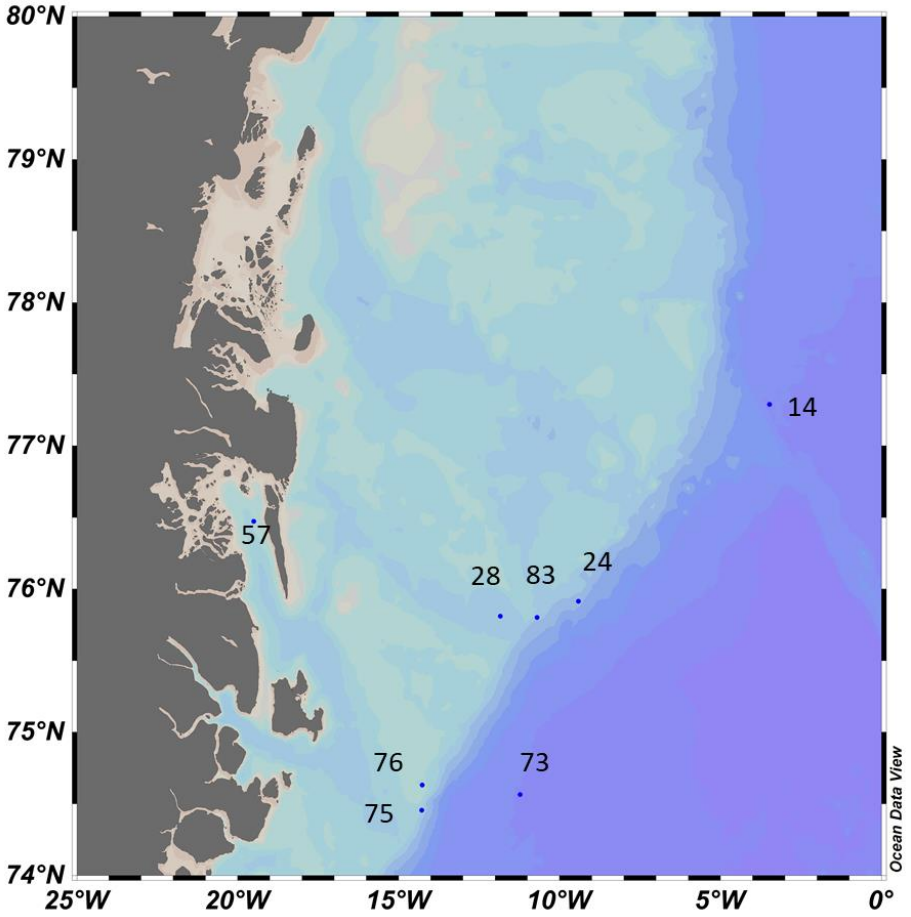

Figure 3. Localization of the stations sampled with the FOTÖ mesopelagic trawl during the 2017 survey in Northeast Greenland. Color scale indicates bathymetry.

Table 1. Main taxa collected in the FOTÖ mesopelagic trawl.

Station	Date	Max sampled depth (m)	Main taxa collected
14	27-Aug	455	*Benthosema glaciale* (Myctophid fish)
24	29-Aug	52	*Gonatus fabricii* (squid)
28	30-Aug	224	-
57	3-Sep	300	Euphausids (krill), *Liparis fabricii* (snailfish), polar cod
73	6-Sep	380	Myctophids, krill
75	7-Sep	550	Krill, polar cod, squids, Myctophids
76	7-Sep	30	-
83	9-Sep	380	Krill, *Themisto libellula* (amphipod), polar cod, squids, Myctophids

3.3. Hydroacoustics

Pelagic trawl deployments allowed to associate echo patterns to specific organisms in the water column. For example, deployment of the trawl at station 14 to a maximum depth of 455 m identified the thick scattering layer between ca. 300-500 m as the typical acoustic signature of Myctophids aggregations (Fig. 4). This scattering layer was present every time the ship was in water depths greater than ca. 400 m.

Another typical acoustic pattern that could be associated with a specific taxa consisted in multiple, thin, often strong scattering layers in water depth ca. 50-150 m. These were associated with the squid *Gonatus fabricii*, as confirmed by the catch in pelagic trawl at station 24 (Fig. 5).

At station 76, the pelagic trawl was deployed in the surface (0-30 m) to document a scattering layer present almost consistently throughout the survey (Fig. 6). The net came up empty, confirming that the surface echoes were not from organisms that can be sampled with the pelagic trawl; a mix of mesozooplankton and ichthyoplankton is most likely responsible for the surface scattering layer.

Pelagic trawl deployments at stations 57, 75 and 83 yielded interesting mixes of taxa and complex echograms. In these cases, matching scattering layers to specific organisms may be hazardous, although some interpretation can be tempted. For example, on the echogram recorded during pelagic trawl deployment at station 83 (Fig. 7), the signal at ca. 150 m is similar to the pattern typical of *Gonatus fabricii*, the echoes from ca. 280 m could be associated with Myctophids, and the bottom scattering layer could have come from a mix of krill and polar cod.

Other interesting features recorded by the echosounder include the presence of upwellings near the continental shelf break (Fig. 8).

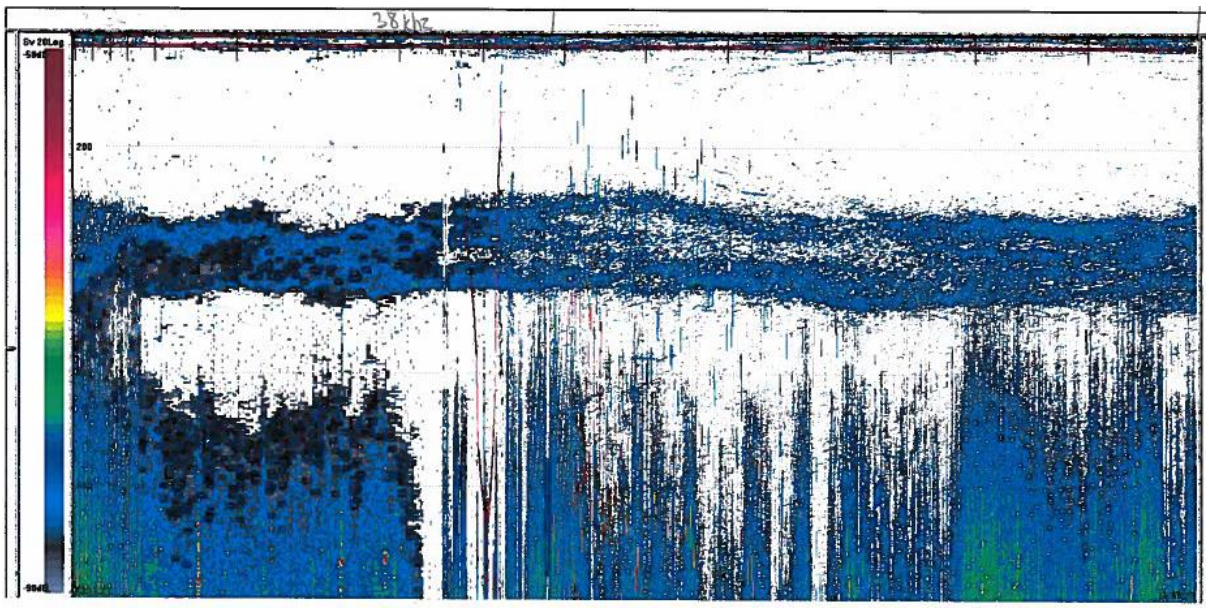

Figure 4. Echogram at 38 Khz recorded during the pelagic trawl deployment at station 14. The thick scattering layer between ca. 300-500 m was associated with aggregations of the Myctophid fish *Benthosema glaciale*.

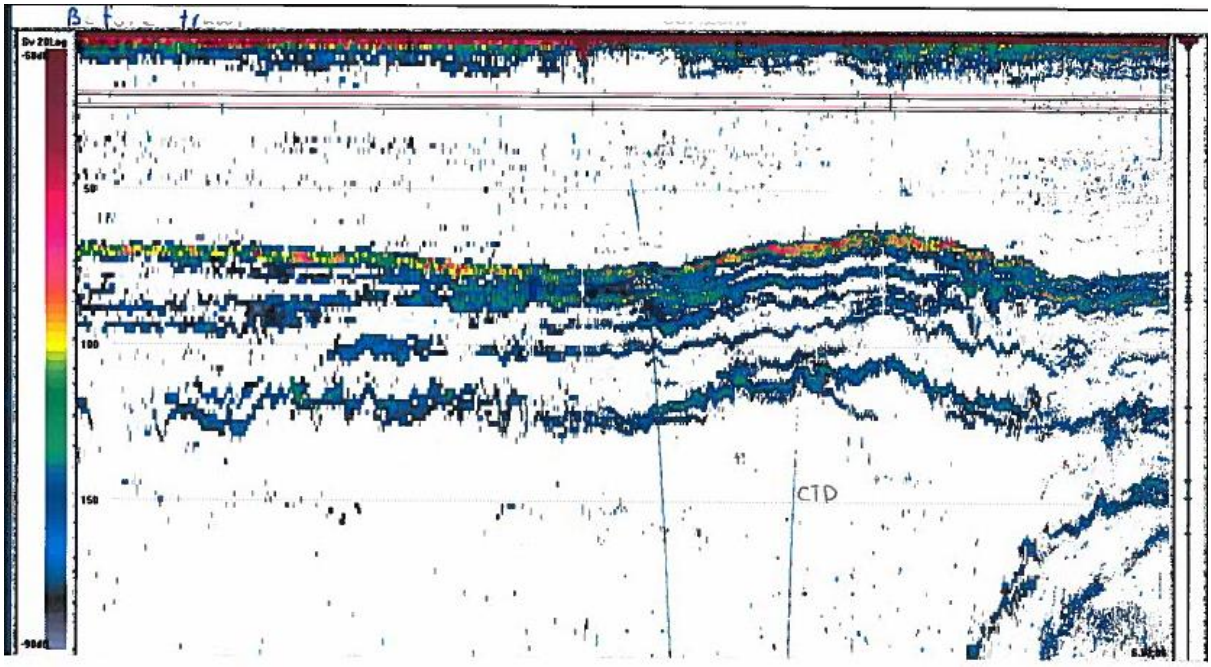

Figure 5. Echogram at 38 Khz recorded during the pelagic trawl deployment at station 24. The thin scattering layers between ca. 60-120 m were associated with aggregations of the squid *Gonatus fabricii*.

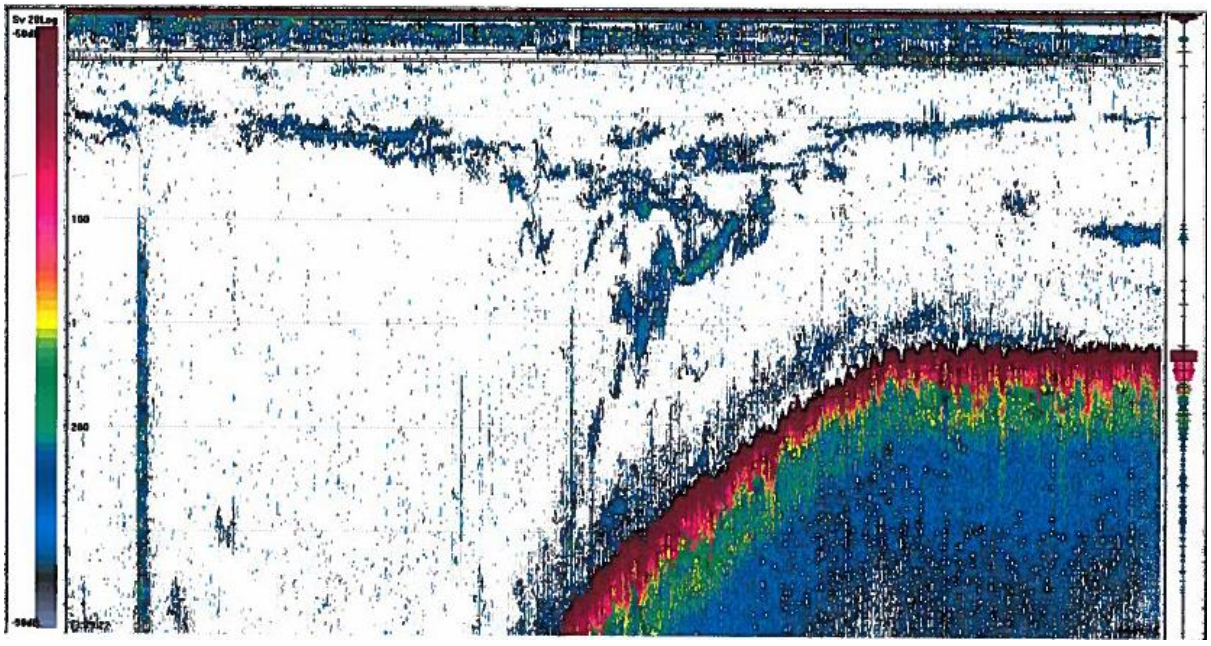

Figure 6. Echogram at 38 Khz recorded during the pelagic trawl deployment at 30 m at station 76 which resulted in an empty net.

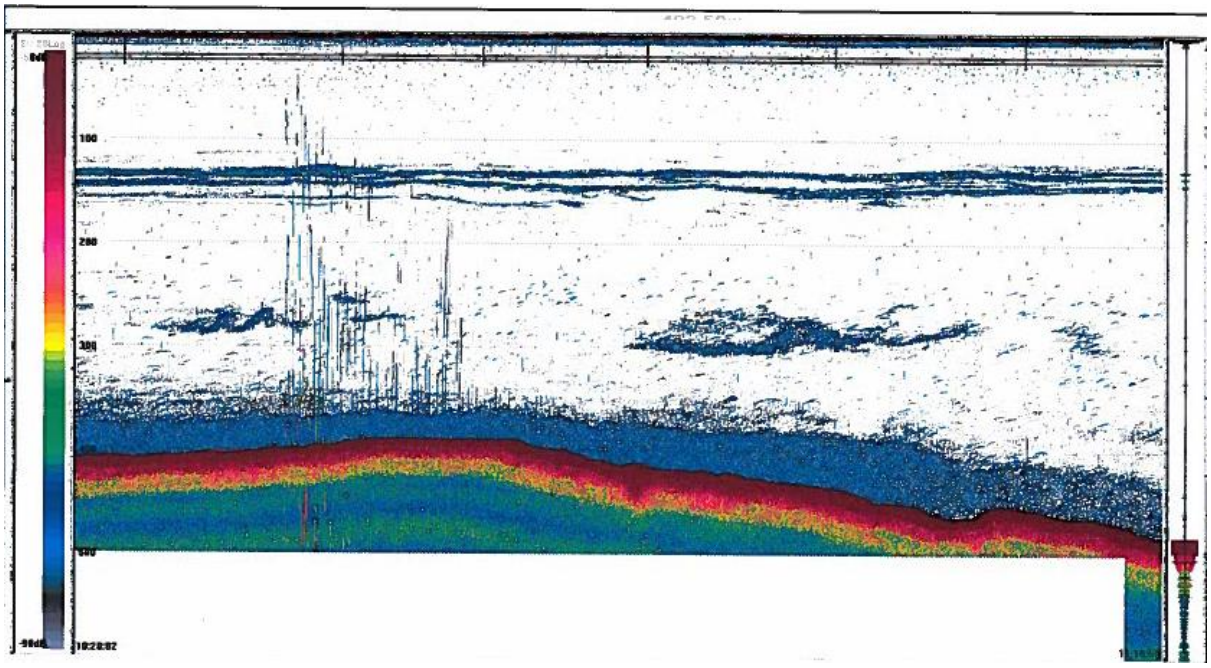

Figure 7. Echogram at 38 Khz recorded during the pelagic trawl deployment at station 83 which yielded a mix of krill, the amphipod *Themisto libellula*, polar cod, squids and Myctophids.

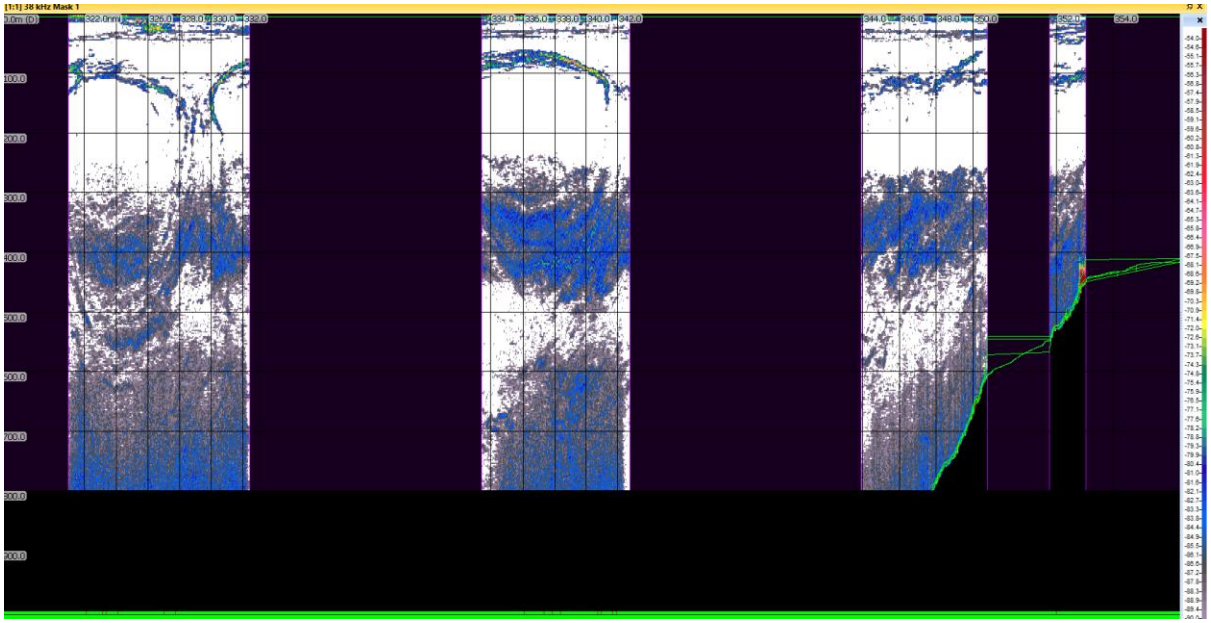

Figure 8. Echogram at 38 Khz recorded at 500 m bottom depth near the continental shelf break) showing an upwelling. Black color indicates periods of unusable data.

To show the vertical and horizontal distribution of the acoustic signal, maps of the nautical area scattering coefficient (NASC in unit m^2 nmi^{-2}) at 38 Khz were prepared for three depth strata: the surface (5-25 m), the epipelagic (25-200 m), and the mesopelagic (200-800 m) layer. Additionally, part of the acoustic data at 18 kHz were clean near the bottom, and were used to build a map of demersal acoustic backscatter (bottom 50 m). Each map is presented both along the ship's route and interpolated over the study area (Fig. 9-12).

Acoustic backscatter in the surface was higher in the northeastern part of the study area (Fig. 9), coinciding with the are where the most larval and juvenile Gadidae were collected in the nets (Fig. 2). For the epipelagic layer, the strongest acoustic backscatter was found on the shelf at ca. 76-77°N (Fig. 10). Areas of strong epipelagic backscatter also included the coastal south of the Wollaston Foreland peninsula, the continental shelf break above 76°N, and deep water regions in the northeastern part of the study area (Fig. 10). Acoustic backscatter in the mesopelagic layer was higher near the shelf break in the northeastern part of the study area (Fig. 11). The demersal acoustic backscatter varied little among the available data along the ship's route (Fig. 12).

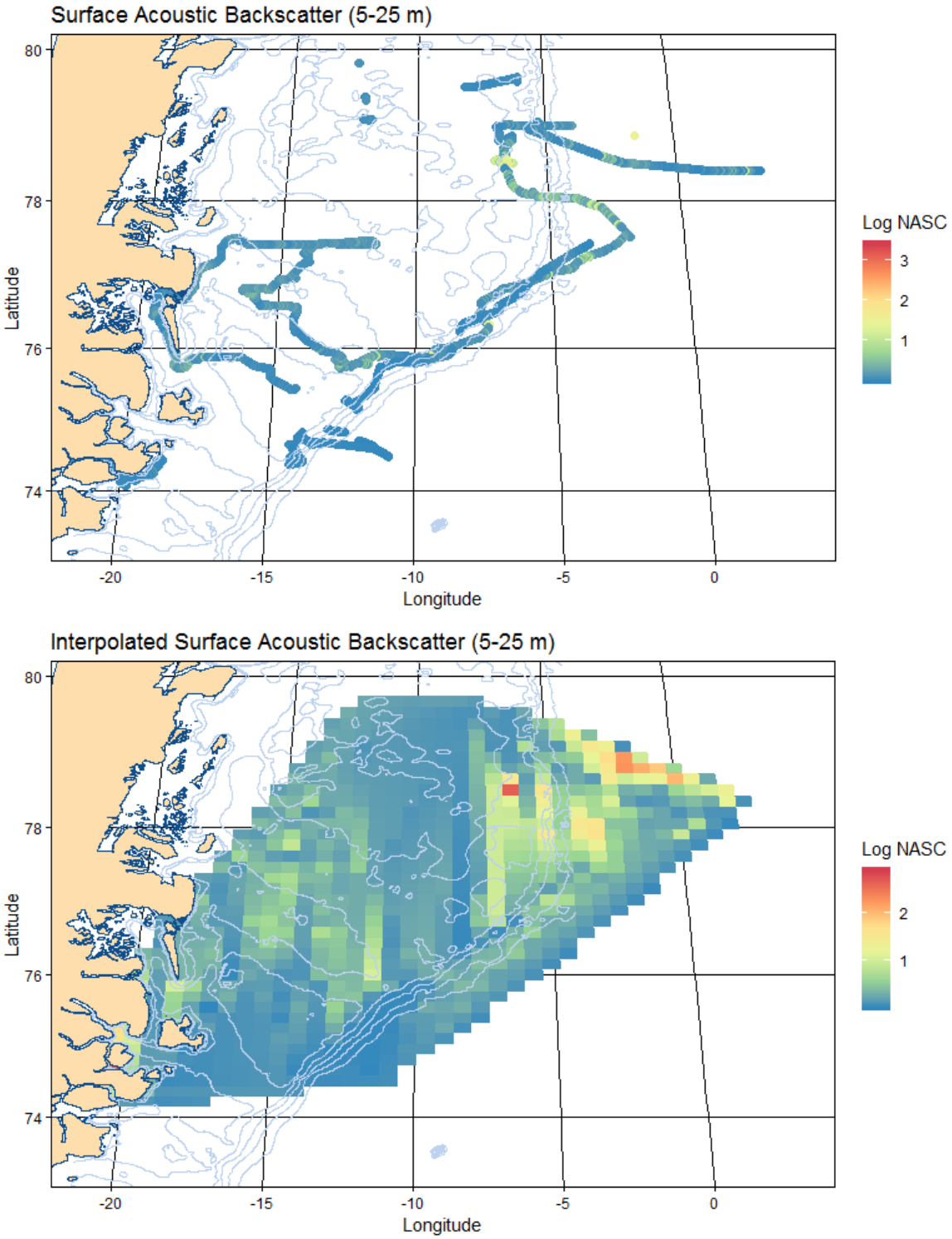

Figure 9. Maps indicating acoustic backscatter (log NASC at 38 Khz) along the ship's route (top panel) and interpolated over the study area (bottom panel) for the surface layer. Grey contour lines show 50, 100, 250, 500, 1000, 1500, and 2000 m isobaths.

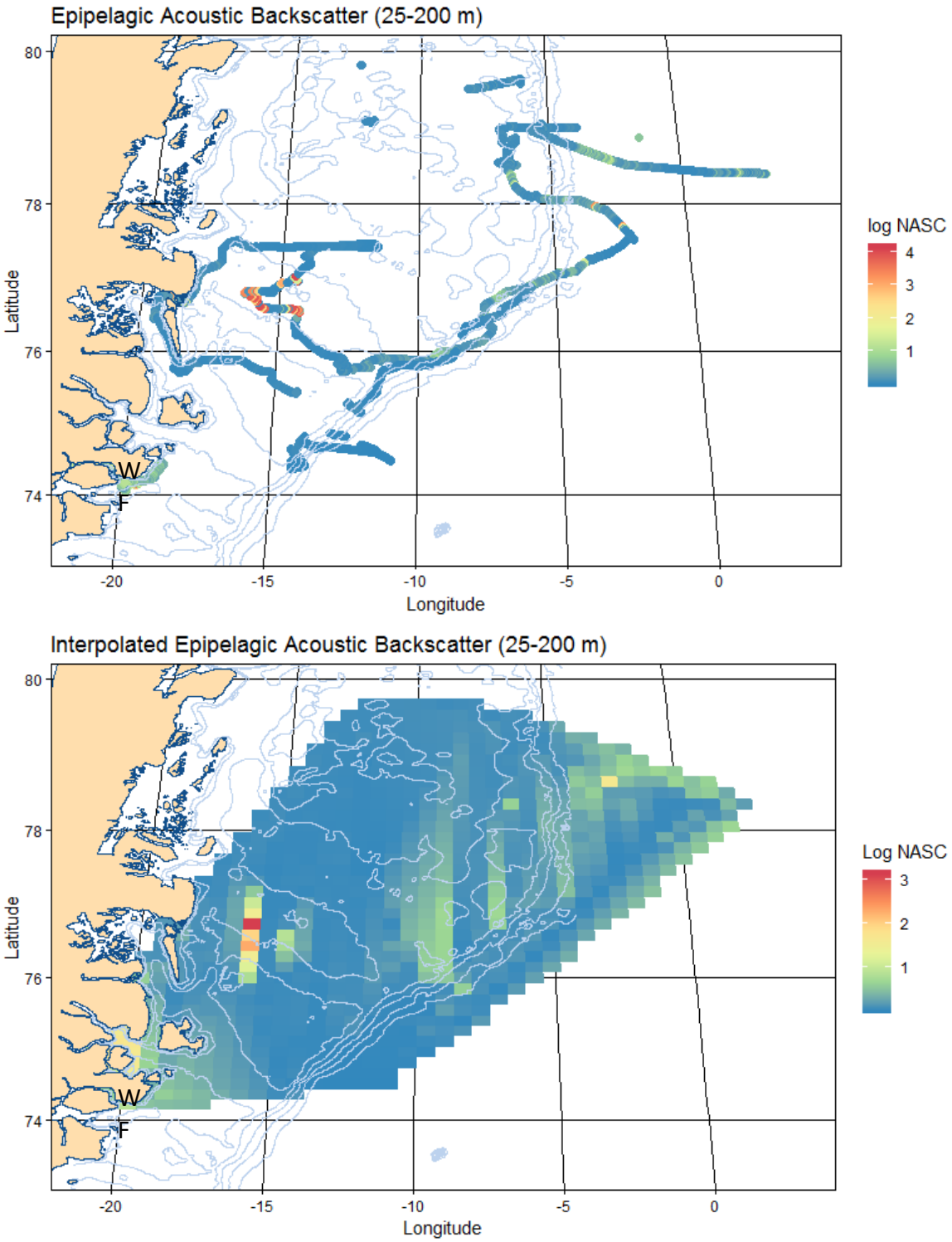

Figure 10. Maps indicating acoustic backscatter (log NASC at 38 Khz) along the ship's route (top panel) and interpolated over the study area (bottom panel) for the epipelagic layer. Grey contour lines show 50, 100, 250, 500, 1000, 1500, and 2000 m isobaths.

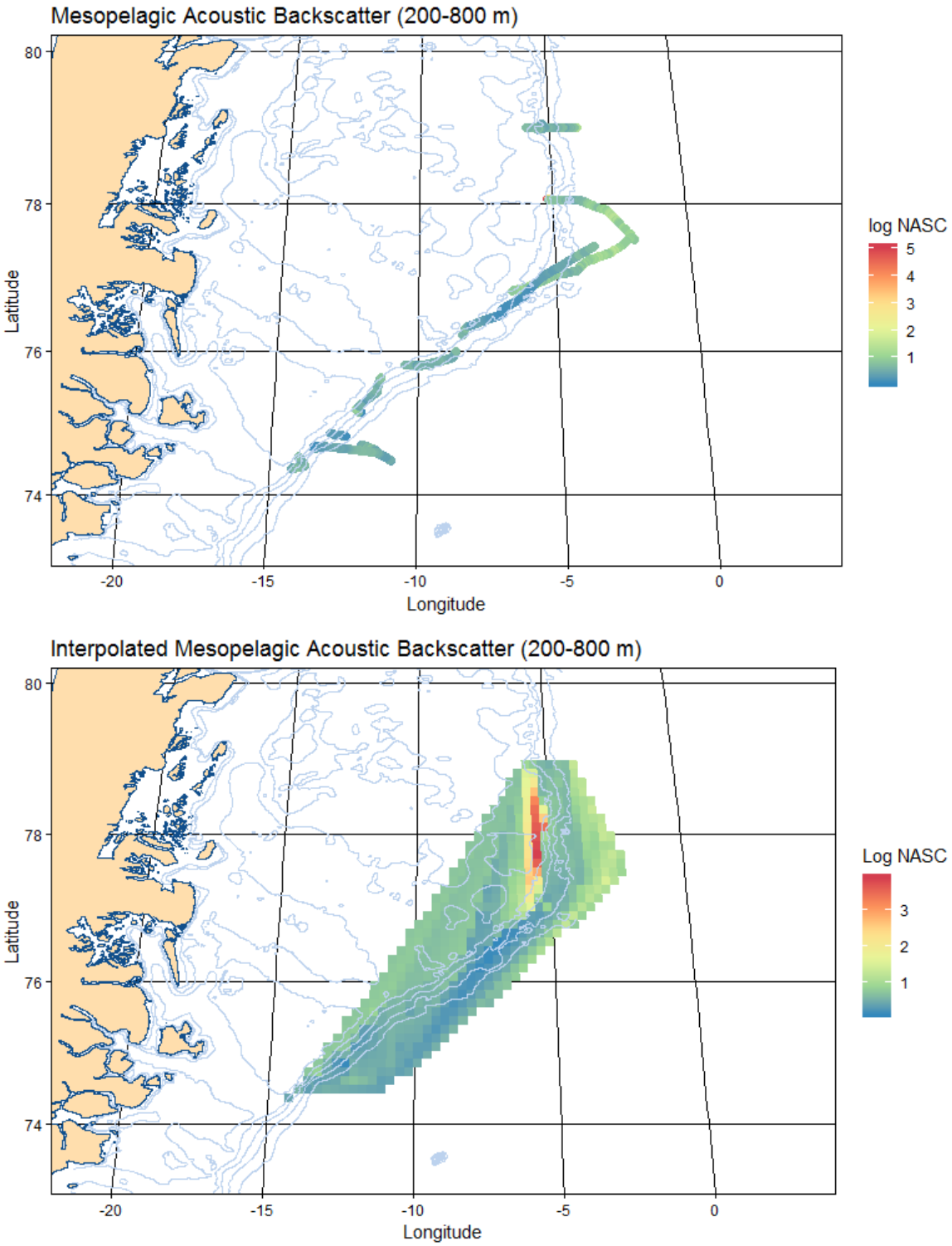

Figure 11. Maps indicating acoustic backscatter (log NASC at 38 Khz) along the ship's route (top panel) and interpolated over the study area (bottom panel) for the mesopelagic layer. Grey contour lines show 50, 100, 250, 500, 1000, 1500, and 2000 m isobaths.

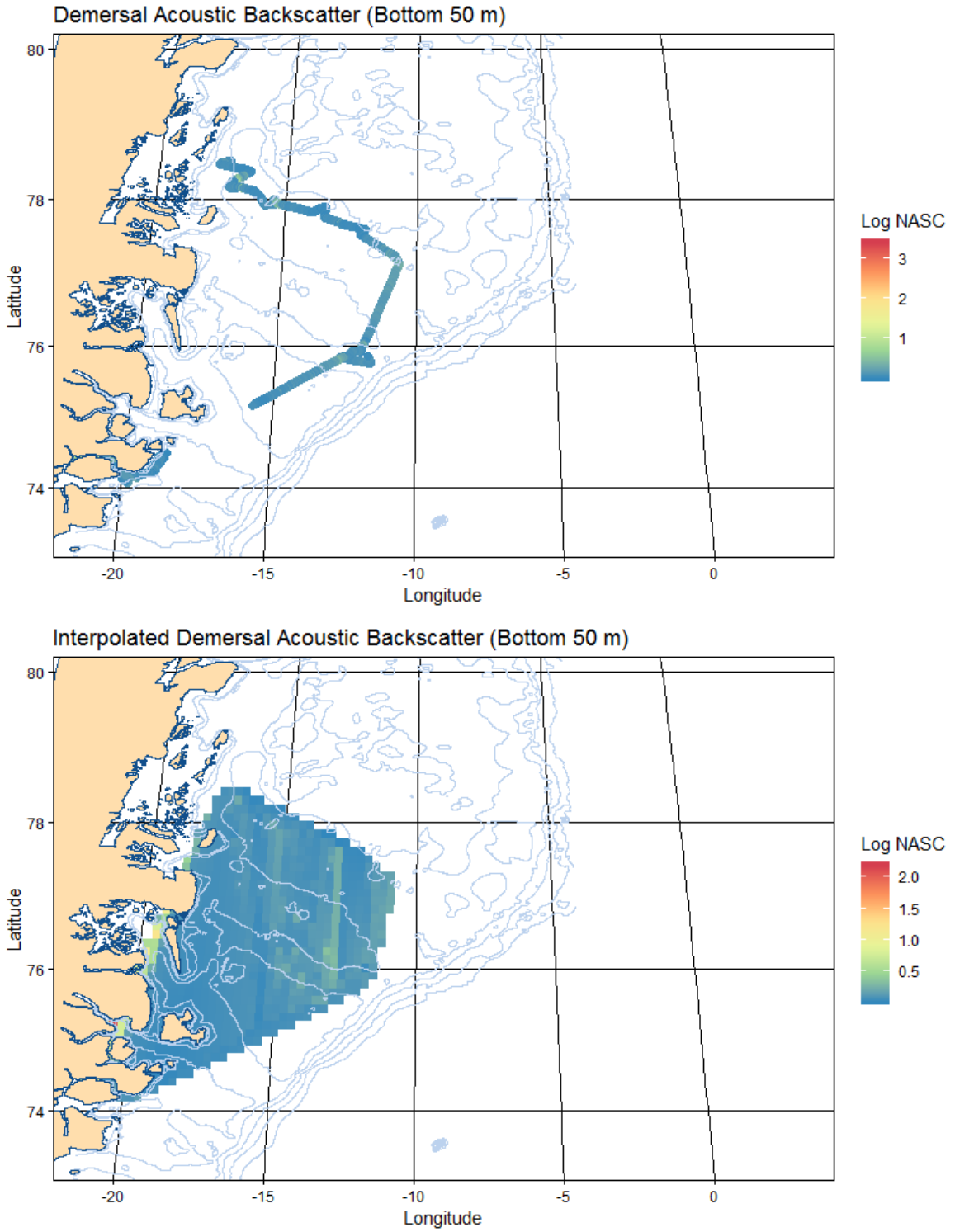

Figure 12. Maps indicating acoustic backscatter (log NASC at 18 Khz) along the ship's route (top panel) and interpolated over the study area (bottom panel) for the demersal layer. Grey contour lines show 50, 100, 250, 500, 1000, 1500, and 2000 m isobaths.

4. Discussion

4.1. Ichthyoplankton

With very few species, the taxonomical composition of the larval and juvenile fish assemblages collected during the present study was similar to that of another survey carried out in the Greenland Sea in 1993 (Michaud et al. 1996). However, the early life dynamics of polar cod *Boreogadus saida*, a key species in this ecosystem, may have changed since then. Considering the size range of the individuals collected in the present study, their capture date, and growth rates typical of the species in the circumpolar Arctic (Bouchard and Fortier 2008; 2011), it appears that the hatching season was from mid-March to mid-July in 2017, compared to mid-May to the end of July in 1993 (Fortier et al. 2006). As documented in the Canadian Arctic, the apparent shift towards earlier hatching could result from an increase in the survival of early hatchers following a relaxation in the extreme environmental conditions typical of the region (long sea-ice season and freezing sea surface temperature) over the past 25 years (Bouchard and Fortier 2011). This change may be synonymous with a transient increase in recruitment (Bouchard et al. 2017), although no conclusion can be drawn from the data currently available.

4.2. Pelagic fish and other fauna

The most abundant fish species collected with the pelagic trawl was the Myctophid *Benthosema glaciale*. The other fish species collected in the pelagic trawl corresponded to the species captured as larvae and juveniles in the MIKnet: polar cod, *Triglops nybelinii* and *Liparis fabricii*. Euphausids (krill) was the taxa collected in the highest biomass in the pelagic trawl and was also collected in large quantities by the MIKnet. From the acoustic data, the northeastern part of the study area appeared as a region of high biomass for the entire water column. The area encompassed the shelf break, an habitat polar cod is known to occupy in large biomass in other Arctic regions, such as the Canadian and the Alaskan Beaufort Sea (Geoffroy et al. 2016, Parker-Stetter et al. 2011). The acoustic data also provided anecdotal evidence of upwelling at the shelf break in this area, a feature that could enrich surface waters with nutrients and support relatively high biomass of phyto-, zoo-, and ichthyoplankton and create a local pelagic ‘’hotspot’’.

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