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Survey report from the joint Norwegian/Russian Ecosystem Survey in the Barents Sea and the adjacent waters

August-October 2019

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Summary (English):

The aim of the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October (BESS) is to monitor the status of abiotic and biotic factors and changes of these in the Barents Sea ecosystem. The survey has since 2004 been conducted annually in the autumn, as a collaboration between the Institute of Marine Research (IMR) in Norway and Polar branch of the VNIRO (PINRO) in Russia. The general survey plan and tasks are agreed upon at the annual IMR-PINRO Meeting in March. Ship routes and other technical details are agreed on by correspondence between the survey coordinators. BESS aims to cover the entire, ice-free area of the Barents Sea. Ecosystem stations are distributed in a 35×35 nautical mile regular grid, and the ship tracks follow this design. Exceptions are the area around Svalbard (Spitsbergen), some additional bottom trawl hauls for demersal fish survey index estimation, and additional acoustic transects for the capelin stock size estimation. Due to technical problems, deviations from the general design resulted in reduced coverage of the survey area in 2019. The 17-th joint Barents Sea autumn Ecosystem Survey (BESS) was carried out during the period from 13-th August to 04-th October 2019 by the Norwegian research vessels: “G.O. Sars”, “Johan Hjort”, and “Helmer Hanssen”, and the Russian vessel “Vilnyus”. Survey coordinators in 2019 was Dmitry Prozorkevich (PINRO) and Geir Odd Johansen (IMR). 2 Russian experts participated in the Norwegian vessels in 2019. We would like to express our sincere gratitude to all the crew and scientific personnel onboard RVs “Vilnyus”, “G.O. Sars”, “Johan Hjort” and “Helmer Hanssen” for their dedicated work, as well as all the people involved in planning and reporting of BESS 2019. Photos and video documentation of the survey routines was taken at Norwegian vessels to start building up a freely available collection of documentation of the methods used at BESS. This report is a summary of the observations and status assessments based on the survey data. Further interpretation on drives, trends and consequences will be reported by ICES WGIBAR and other ICES working group reports.

Content

1 Background

Text by: D. Prozorkevich and G.O. Johansen

The aim of the joint Norw

egian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October (BESS) is to monitor the status of abiotic and biotic factors and changes of these in the Barents Sea ecosystem. The survey has since 2004 been conducted annually in the autumn, as a collaboration between the Institute of Marine Research (IMR) in Norway and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in Russia. (The PINRO is the Polar Branch of VNIRO now). The general survey plan and tasks are agreed upon at the annual IMR-PINRO Meeting in March. As earlier, ship routes and other technical details are agreed on by correspondence between the survey coordinators. BESS covers the entire, ice-free area of the Barents Sea and usually progresses from south to north. Ecosystem stations are distributed in a 35×35 nautical mile regular grid, and the ship tracks follow this design. Exceptions are the area around Svalbard (Spitsbergen), some additional bottom trawl hauls for demersal fish survey index estimation, and additional acoustic transects for the capelin stock size estimation. Additional bottom trawls were also planned in places of significant distribution of commercial invertebrates (snow crab and northern shrimp). The general survey design can be seen in figure 2.1. Deviations from the general design are described in chapter 2 of this report. The 17-th BESS was carried out during the period from 13-th August to 04-th October 2019 by the Norwegian research vessels: “G.O. Sars”, “Johan Hjort”, and “Helmer Hanssen”, and the Russian vessel “Vilnyus”. Survey coordinators in 2019 was Dmitry Prozorkevich (PINRO) and Geir Odd Johansen (IMR). Two Russian experts participated in the Norwegian vessels in 2019. The scientists, technicians and guests taking part in the survey onboard the research vessels are listed in Table 1 below. We would like to express our sincere gratitude to all the crew and scientific personnel onboard RVs “Vilnyus”, “G.O. Sars”, “Johan Hjort” and “Helmer Hanssen” for their dedicated work, as well as all the people involved in planning and reporting of BESS 2019. This report is a summary of the observations and status assessments based on the survey data. Further interpretation on drivers, trends and consequences will be reported by ICES WGIBAR. Other ICES working group and workshops (WGMME, WGZE, WGOH WGPDMO, AFWG, WGWIDE, NIPAG, WGCRAB, WGEF, WKBAR) will use BESS information for future work.

Table 1. *Vessels and participants in the Barents Sea Ecosystem Survey 2019.*

Research vessel	Participants
”*Vilnyus*” (14.08–04.10)	Krivosheya Pavel (Cruise leader), Amelkin Alexey, Gavrilik Tatyana, Amelkina Anna, Gubanishchev Maxim, Antipin Rodion, Harlin Sergey, Klepikovsky Roman, Sergeeva Tatyana, Velikzhanin Alexey, Uzbekova Olga, Kalashnikova Marina, Uglova Tatyana.
”*G.O. Sars*” (13.08–11.09)	Part 1 (13.08-28.08) Erik Olsen (Cruise leader), Michael Bank, Mette Strand, Maria Fossheim, Anja Helene Alvestad, Jannicke Skadal, Fredrike Böhm, Jon Neteland-Kyte, Ove Misje Aakre, Egil Frøyen, Frøydis Tousgaard Rist Bogetveit, Gaston Ezequiel Aguirre, Andrey Voronokov, Olga Zimina, Elise Eidset, Eirik Odland, Yasmin Hunt, Monica Martinussen, Bjørn Arild Ersland, Gary Elton, Sarah Maes, Andrea Luna. Part 2 (28.8-11.9) Silje Elisabeth Seim (Cruise leader), Andrey Voronokov, Olga Zimina, Elise Eidset, Eirik Odland, Yasmin Hunt, Monica Martinussen, Penny Lee Liebig, Erlend Langhelle, Celina Eriksson Bjånes, Anthony Mayer, Reidar Johannesen, Sindre Nygård Larsen, Stine Karlson, Ståle Kolbeinson, Magnus Reeve, Per Fauchald, Kim Vane, Irina Prokopchuck.
”*Johan Hjort*” (20.08-03.10)	Part 1 (20.08-11.09) Harald Gjøsæter (Cruise leader), Johanna Fall, Piotr Balazy, Hildegunn Mjanger, Malin Lie Skage, Ine Moksness, Else Holm, Tiu Similä, Magnar Mjanger, John Nesheim, Inger Henriksen, Vilde Regine Bjørdal, Julio Erices, Alexander Plotkin, George McCallum, Jon Rønning, Jon Ford, Matthew R. D. Cobain, Tatyana Prokhorova. Part 2 (11.09-03.10) Georg Skaret (Cruise leader), Alexander Plotkin, George McCallum, Jon Rønning, Jon Ford, Matthew R. D. Cobain, Tatyana Prokhorova, Natalia Zhuravliova, Gunnar Didriksen, Vidar Fauskanger, Arne Storaker, Frode Holen, Bjarte Kvinge, Jostein Solhaug, Anne Liv Johnsen, Jostein Røttingen, Justine Diaz, Gaston Ezequiel Aguirre.
“*Helmer Hanssen*” (19.09-04.10)	Randi Ingvaldsen (Cruise leader), Tom Van Engeland, Erik Askov Mousing, Lis Lindal Jørgensen, Felicia Keulder-Stenevik, Alexey Golikov, Merete Vik Ottesen, Gunnar Langhelle, Anne Sæverud, Grethe Thorsheim, Atle Børje Rolland, Gunnar Rikardsen, Ove Misje Aakre, Jarle Kristiansen, Adam Custer, Eilert Hermansen, Espen Strand, Espen Bagøien, Philip Dutt, Mathea Born, Kine Sofie Steffensen.

2 Survey execution 2019

Text by: D. Prozorkevich and G.O. Johansen

Figures by: G.O. Johansen and S. Karlson

BESS 2019 was planned to progress according to the “standard scheme”, from south to north. The survey map with planned stations and vessel tracks are presented in Figure 2.1.

It was decided to keep all the main tasks of the survey similar to previous years. In addition, the standard oceanography sections Vardø-Nord, Sørkapp-Vest, and a test section, Hinlopen strait, was sampled in the Norwegian survey area (Fig 2.1), and the Kola section and Kanin section in the Russian survey area. The BESS 2019 survey coverage was much better than in 2018, but the central part of the Barents sea (Loophole) was uncovered by bottom trawls. Norwegian vessels cannot perform bottom trawls in this area, and “Vilnyus” could not leave the REEZ due to the limited navigation mode. Thus, only pelagic trawls were made by Norwegian vessels in the Loophole. A part of the Russian zone in the north-eastern Barents Sea was also uncovered due to lack of time. (Fig. 2.2 and 2.3). Most ecosystem components were well examined in 2019. However, some data on polar cod, Greenland halibut, snow crab, and shrimp have not been obtained. The capelin distribution area was well covered in the last half of the survey and the stock assessment was successful. The resulting survey coverage was: “Vilnyus” covered the most of REEZ in the Barents Sea. The Norwegian RVs covered the NEZ of the Barents Sea, with “Johan Hjort” in the central west and northeast, “G.O. Sars” in south and the central eastern parts (including the Loophole), and “Helmer Hanssen” in the areas west, north and northeast of Svalbard (Spitsbergen). The effective vessel days in 2019 amounted to 111 days. The realized research vessel tracks and trawl stations for the 2019 ecosystem survey are shown in Figure 2.2. Hydrography and plankton stations are shown in Figure 2.3.

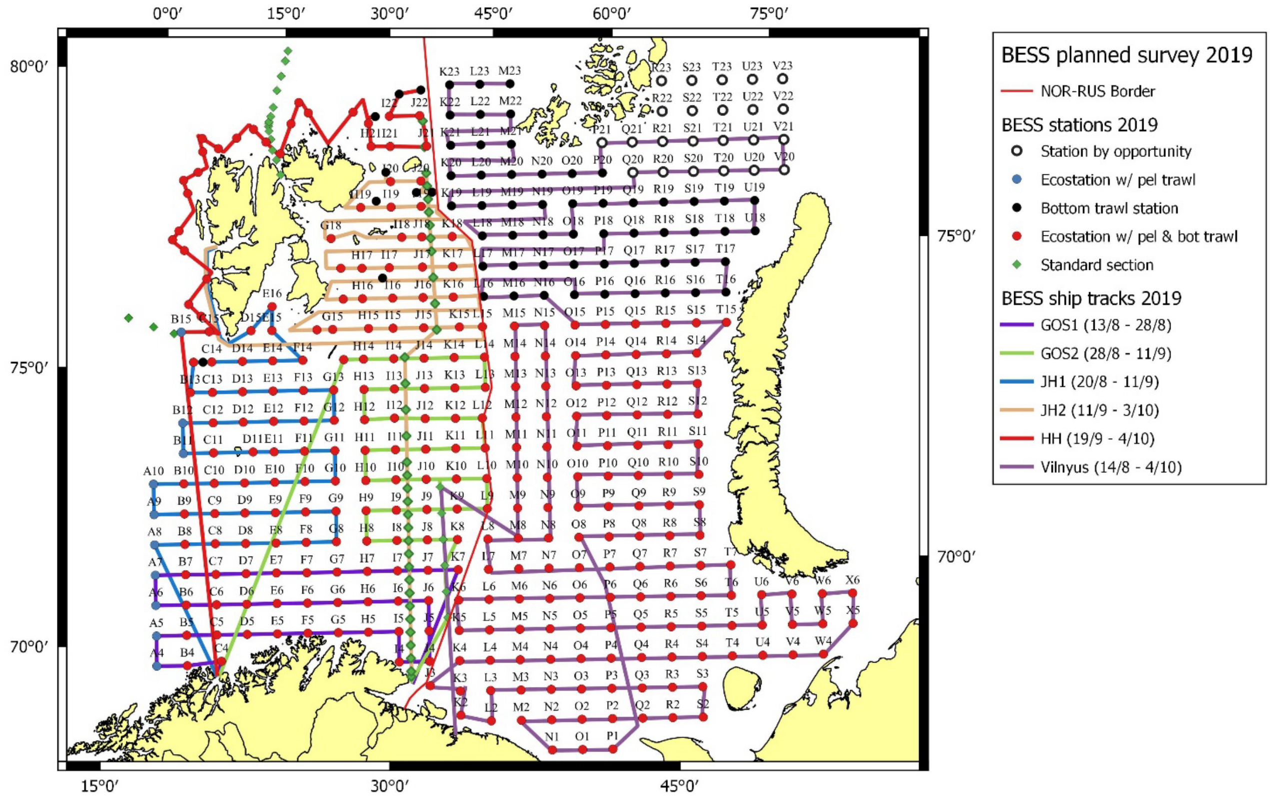

Figure 2.1 *BESS 2019, planned survey map with ecosystem stations and vessel tracks.*

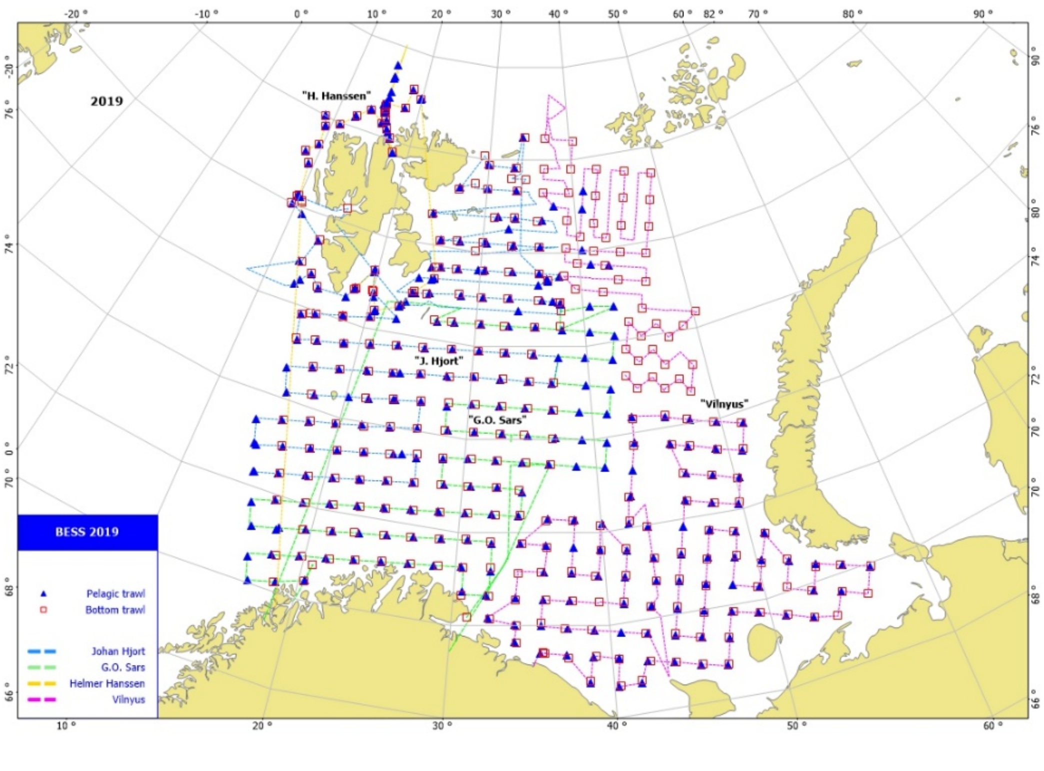

Figure 2.2 *BESS 2019, realized vessel tracks with pelagic and bottom trawl sampling stations, note that some trawl stations are taken in addition to the regular ecosystem stations.*

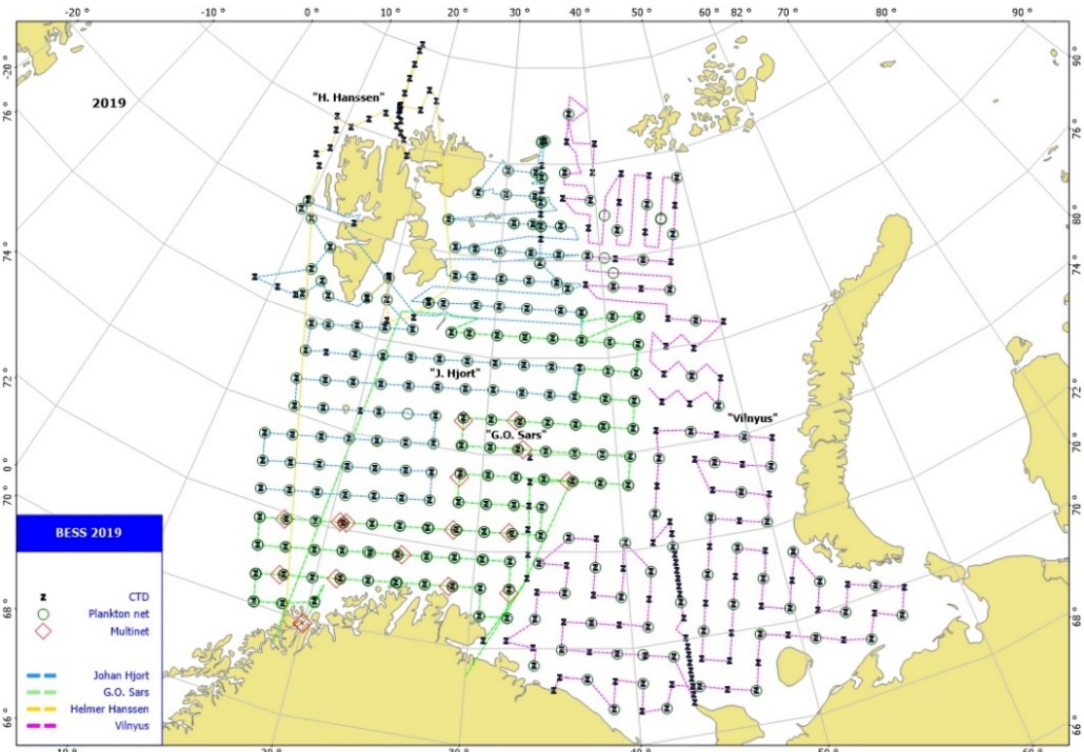

Figure 2.3 *BESS 2019, realized vessel tracks with hydrography and plankton samples at ecosystem stations.*

2.1 Sampling methods

The survey "Sampling Manual" has been developed since 2004 (last updated in 2012) and published on the BESS homepage by specialist and experts from IMR and PINRO (https://www.hi.no/hi/tokt/havforskningsinstituttets-ulike-tokt/okosystemtoktet-i-barentshavet) This web page have been terminated, but the manual for the survey can be obtained by contacting the survey coordinators.

This manual includes methodological and technical descriptions of equipment, the trawling and capture procedures by the samplings tools, and the methods that are used for calculating the abundance and biomass of the biota.
The trawl rigging of the bottom trawl (Campelen-1800) at all vessels was the same as in 2018. The pelagic trawl (Harstad) on Norwegian vessels were equipped with heavier bottom line for a stable position and trawl opening. This change is not significant and does not change substantially the trawling procedure. But the change makes the Norwegian and Russian rigging more similar.

Contact: A. Engås, IMR (aril.engaas@hi.no) *and D. Prozorkevich,PINRO* (dvp@pinro.ru).

2.2 Special investigations

BESS is a useful platform for conducting additional studies in the Barents Sea. These studies can be testing of new methodology, sampling of data additional to the standard monitoring, or sampling of other types of data. It is imperative that the special investigations do not influence the standard monitoring activities at the survey. The special investigations vary from year to year, and below is a list of special investigation conducted on Russian Norwegian vessels at BESS 2019, with contact persons.

2.2.1 Fish pathology research

PINRO undertakes yearly investigations of fish and crabs diseases and parasites in the Barents Sea (mainly in REEZ). The main purpose of the pathology research is annual estimation of epizootic state of commercial fish and crabs species. The observations are entered into a database on pathology. This investigation was started by PINRO in 1999. Results are available in the report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO).

Contact: Tatyana Karaseva, PINRO.(karaseva@pinro.ru)
Link to more information: http://www.ices.dk/community/groups/Pages/WGPDMO.aspx https://www.amazon.com/Barents-Sea-Ecosystem-Management-Cooperation/dp/8251925452 (pp. 743-749)

2.2.2 Special investigation of snow crab and northern shrimp

Due to the great interest in these commercial invertebrates, several extra bottom trawls were carried out in the main distribution area in the Russian EEZ. The plan was to take 23 additional trawls, but only 11 trawls were performed due to lack of time. Nevertheless, this is important additional information about these commercial invertebrate species. More information about snow crab and northern shrimp is available in ICES Working Groups (WGCRAB and WGNIPAG) reports.

Contact: Konstantin Sokolov, PINRO (sokol_km@pinro.ru), *Jan Sundet, IMR* (jan.h.sundet@hi.no)

2.2.3 Annual monitoring of pollution levels

In 2019 PINRO continued the annual monitoring of pollution levels in the Barents Sea in accordance with a national program. Samples of seawater, sediments, fish and invertebrates was collected and analysed for persistent organic pollutants (POPs) (e.g. PCBs, DDTs, HCHs, HCB) and heavy metals (e.g. lead, cadmium, mercury) and arsenic. The samples were collected at R/V "Vilnyus" during BESS in the southern and eastern parts of the Barents Sea. The results from chemical analyses will be reported in 2020.

Contact: Andrey Zhilin, PINRO (zhilin@pinro.ru)

2.2.4 Test of microplastic sampling methods

BESS 2019 tested Manta trawl, WP2 and biota samples from four locations to test sampling efficiency of microplastic. This was in collaboration between Norway and Russia (The Norwegian-Russian Environmental Commission agreement). The aim is developing future monitoring series on microplastic.

Contact: Bjørn Einar Grøsvik, IMR (Bjorn.grosvik@hi.no)
Link to more information: https://www.highnorthnews.com/en/norwegian-russian-cooperation-against-plastic-pollution-barents-sea

2.2.5 Hinlopen section (Hydrography, plankton, fish)

BESS 2019 delivered data on hydrography, plankton and fish, based on standard section procedures from the Hinlopen Strait. The samples will be used in different research projects and are part of developing a long-time monitoring of the Arctic.

Contact: Randi Ingvaldsen, IMR. (randi.ingvaldsen@hi.no)
Link to more information: http://siarctic.imr.no/

2.2.6 Ocean acidification

BESS 2019 collected samples from the Vardø-N transect, as part of IMR monitoring routines.

Contact: Melissa Chierici. (Melissa Chierici@hi.no)

2.2.7 Biological samples of polar cod

BESS 2019 provided tissue samples of gills and fins from adult polar cods and frozen juveniles. The samples will be used to evaluate the genetic population structure of this species in the Barents Sea. This is a project in collaboration with VNIRO, Equinor and UIT.

Contact: Torild. Johansen, IMR. (torhild.johansen@hi.no)

2.2.8 Radioactivity in deep sea shrimps

BESS 2019 collected samples of deep sea shrimp from two specific areas to be analysed for radioactive contamination of shell and meat, in raw and boiled shrimps. This is a collaboration between IMR and the Norwegian Radiation and Nuclear Authorities.

Contact: Hilde Elise Heldal, IMR. (hilde.elise.heldal@hi.no)

2.2.9 Trace metal water sampling

BESS 2019 collected water samples from different depths at selected stations, to be analysed for trace metals, to the IMR project Ocean Health.

Contact: Michael Bank, IMR (Michael.Banks@hi.no)

2.2.10 Mackerel and saithe samples

BESS 2019 was asked to collect and freeze mackerel and saithe for contaminant analyses at the food security labs at IMR, from two locations.

Contact: Bente Nilsen,IMR (Bente.Nilsen@hi.no)

2.2.11 Greenland halibut population structure

BESS 2019 collected samples from Greenland halibut north and east in the Barents Sea, to analyse the population structure of the Greenland halibut. This is a project supported by the AFF, the Norwegian national advisory group against organized IUU-fishing.

Contact: Mikko Juhani Vihtakari, IMR (Mikko.juhani.vihtakari@hi.no)

2.2.12 Krill samples

BESS 2019 provided a small sample of krill to the for food web studies in the TIBIA project.

Contact: Elena Eriksen, IMR. (elena.eriksen@hi.no)

2.2.13 *Sampling for isotope studies of food web*

BESS 2019 provided fish and invertebrate tissue samples for isotope food web analyses to the COLDFISH project, a cooperation between UK (Newcastle and Southampton Universities) and Germany (AWI) focused on the fish community across the Barents Sea. Personnel from the project participated as guests on Norwegian vessels.

Contact: Nicholas Polunin (nick.polunin@newcastle.ac.uk)
Link to more information: https://www.changing-arctic-ocean.ac.uk/wp-content/uploads/2019/01/26-Coldfish.pdf

2.2.14 *Sampling of baleen whale prey species*

BESS 2019 provided small freezing samples of krill species, Themisto isopods, polar cod, capelin, herring, cod, haddock and blue whiting to the Nansen Legacy project. These will be used in analyses of fatty acids and isotopes to evaluate the relationship between baleen whales and their prey in northern areas of the Barents Sea.

*Contact: Tore Haug, IMR. (*Tore.haug@hi.no *)*
Link to more information: https://sciencenorway.no/blog-nansen-legacy-project

2.2.15 *Extended stomach content samples*

BESS 2019 provided fish samples from several species for stomach content analyses in the northern Barents Sea, west, north and east of Svalbard (Spitsbergen) for food web studies in the Nansen Legacy project

Contact: Randi Ingvaldsen, IMR. (randi.ingvaldsen@hi.no)

Link to more information: https://sciencenorway.no/blog-nansen-legacy-project

2.2.16 *Sampling of cephalopod species*

BESS 2019 provided freezing samples of cephalopods for biodiversity studies.

Contact: Lis Lindal Jørgensen, IMR. (lis.lindal.joergensen@hi.no)

3 DATA MANAGEMENT

Text by: and D. Prozorkevich and G.O. Johansen

3.1 Databases

A wide variety of data are collected during the ecosystem surveys. All data collected during the BESS are quality controlled and verified by experts from IMR and PINRO during the survey. The data are stored in IMR and PINRO national databases, with different formats. However, the data are exchanged so that both institutions have access to each other's data in their respective databases (i.e. both institutes use equal joint data).

Age readings and fish stomach analyses will be finished by April 2020 and the data will be subsequently downloaded to the joint databases.

3.2 Data application

The main aim of the BESS is to cover the whole Barents Sea ecosystem geographically and provide survey data for commercial fish and shellfish stock estimation. Stock estimation is particularly important for capelin, because capelin TAC is based on the survey result, and the Norwegian-Russian Fishery Commission determines TAC immediately after the survey. In addition, a broad spectrum of physical variables, ecosystem components and pollution are monitored and reported. The survey data will be used by ICES working groups and workshops (WGMME, WGZE, WGOH WGPDMO, AFWG, WGWIDE, NIPAG, WGCRAB, WGEF and WKBAR) as well as the Norwegian ecosystem status report on selected indicators from the Norwegian EEZ of the Barents Sea.

This survey report is based on joint data and contains the main results of the monitoring. The survey report is published as part of the IMR/PINRO joint report series when assembled into a complete pdf-report when the main components are completed. Some post-survey information, not included in the written report (e.g. plankton and fish stomach samples which need longer processing time) will be published as individual parts of the report later.

3.3 Time series of distribution maps

Maps from this and previous year's surveys will be made available in a redesigned IMR web site for the joint Norwegian/Russian Barents Sea Ecosystem Surveys.

4 MARINE ENVIRONMENT

4.1 Hydrography

Text by: A. Trofimov and R. Ingvaldsen
Figures by: A. Trofimov

4.1.1 Geographic variation

Horizontal distributions of temperature and salinity are shown for depths of 0, 50, 100 m and near the bottom in Figs 4.1.1.1–4.1.1.8, and anomalies of temperature and salinity at the surface and near the bottom are presented in Figs 4.1.1.9–4.1.1.12. The anomalies have been calculated using the long-term means for the period 1931–2010.

In August–September 2019, surface temperature was on average 0.7°C higher than the long-term mean in about two thirds of the surveyed area (Fig. 4.1.1.9). Negative anomalies (about –0.5°C on average) took place mostly in the northernmost and south-western Barents Sea. Compared to 2018, the surface temperature in 2019 was much lower (by 1.1°C on average) in most of the surveyed area (~80%), with the largest negative differences (>2°C) in the south-eastern and south-westernmost parts of the sea as well as north and east of the Spitsbergen Archipelago.

Arctic waters were mainly found, as usual, in the 50–100 m layer north of 77°N (Fig. 4.1.1.3 and 4.1.1.5). Temperatures at depths of 50 and 100 m were higher than the long-term means (on average, by 1.1 and 0.7°C respectively) in about two thirds of the surveyed area with the largest positive anomalies in the east, especially at 50 m depth. Negative anomalies (about –0.4°C on average) were mainly found in the northern and south-western Barents Sea with the largest values in the north at a depth of 100 m. Compared to 2018, the 50 and 100 m temperatures in 2019 were lower (on average, by 0.9 and 0.7°C respectively) in most of the surveyed area (80 and 85% respectively) with the largest negative differences in the northern Barents Sea at 50 m depth; positive differences were mainly observed in the south-eastern part of the sea.

Bottom temperature was in general 0.8°C above average in most of the Barents Sea (~70% of the surveyed area) with the largest positive anomalies in the south-east (Fig. 4.1.1.10). Negative anomalies (–0.8°C on average) were mainly observed in the northern part of the sea with the largest values east of the Spitsbergen Archipelago. Compared to 2018, the bottom temperature in 2019 was on average 0.7°C lower in 75% of the surveyed area with the largest differences in the north. Bottom waters were warmer (on average, by 0.5°C) than in 2018 mainly in the south-eastern part of the sea. In August–September 2019, the area covered by bottom water with temperatures below zero has almost tripled compared to 2018; temperatures of below –1°C were found in a rather large area east of the Spitsbergen Archipelago.

Surface salinity was on average 0.3 higher than the long-term mean mainly in the central and northern parts of the surveyed area with the largest positive anomalies (>0.8) mostly in the northern Barents Sea (Fig. 4.1.1.11). Negative anomalies (about –0.3 on average) were mainly observed in the western, southern and south-eastern parts of the sea with the largest values in some areas in the south-east. In August–September 2019, the surface waters were on average 0.4 fresher than in 2018 almost all over the surveyed area (87%) with the largest negative differences east of the Spitsbergen Archipelago and in the south-eastern Barents Sea.

The 50 and 100 m salinity was lower than average (by about 0.1 on average) in two thirds of the surveyed area with the largest negative anomalies in the south-eastern part of the Barents Sea. Positive anomalies were mainly observed in the north-western part of the sea with the largest values east of the Spitsbergen Archipelago. In August–September 2019, waters at 50 and 100 m were fresher (by 0.1 on average) than in 2018 in most of the surveyed area (58 and 67% respectively) with the largest negative differences in the east of the area. Significant positive differences (>0.1) in salinity between 2019 and 2018 were mainly observed in the northern Barents Sea and in the coastal waters of its south-western part. At a depth of 100 m, salinity anomalies and differences of less than 0.1 occupied about 80 and 90% of the surveyed area respectively.

Bottom salinity was slightly lower than average in two thirds of the surveyed area with the largest negative anomalies (>0.1) in the south-eastern and northernmost Barents Sea (Fig. 4.1.1.12). Slightly positive anomalies were found in the central part of the sea and anomalies of more than 0.1 took place mainly south and south-east of the Spitsbergen Archipelago as well as in shallow waters in the south-easternmost part of the sea. In August–September 2019, the bottom waters were a bit fresher than in 2018 in most of the surveyed area (80%). The largest negative differences (>0.1) in bottom salinity between 2019 and 2018 were mostly found in small areas north of the White Sea Opening and Kanin Peninsula as well as north of Bear Island. Only coastal waters in the south-western Barents Sea and waters around the Spitsbergen Archipelago were saltier than in 2018. As a whole, bottom salinity anomalies and differences were small (<0.1) almost all over the surveyed area (78 and 86% respectively).

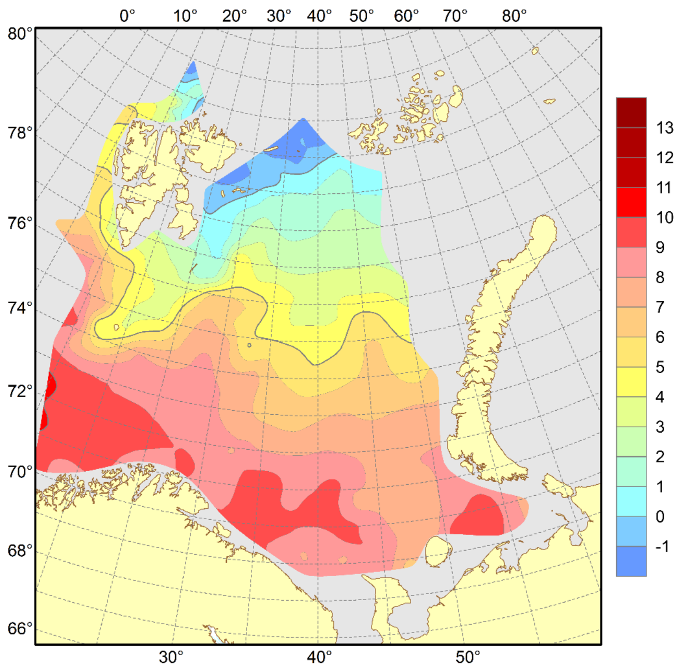

Figure 4.1.1.1 *Distribution of surface temperature (°C), August–October 2019.*

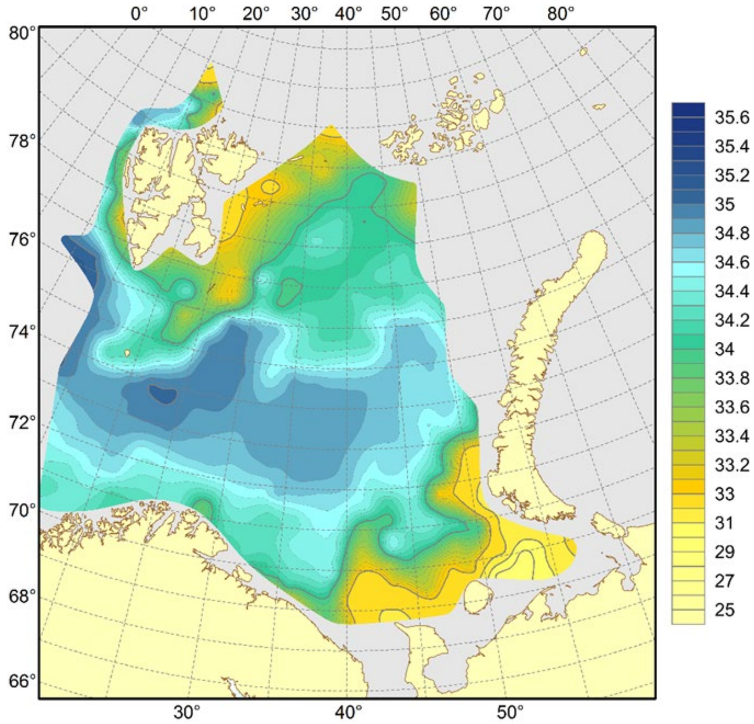

Figure 4.1.1.2. *Distribution of surface salinity, August–October 2019.*

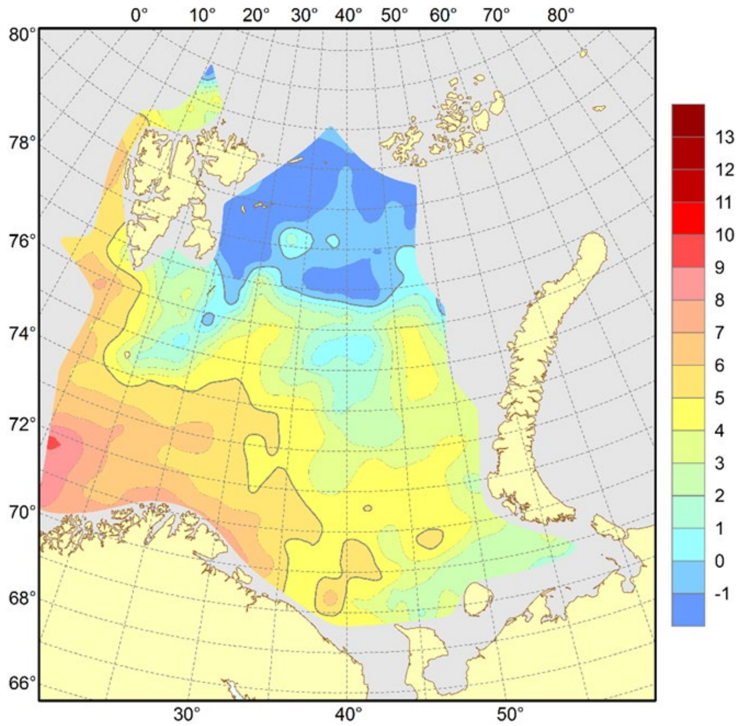

Figure 4.1.1.3. *Distribution of temperature (°C) at the 50 m depth, August–October 2019.*

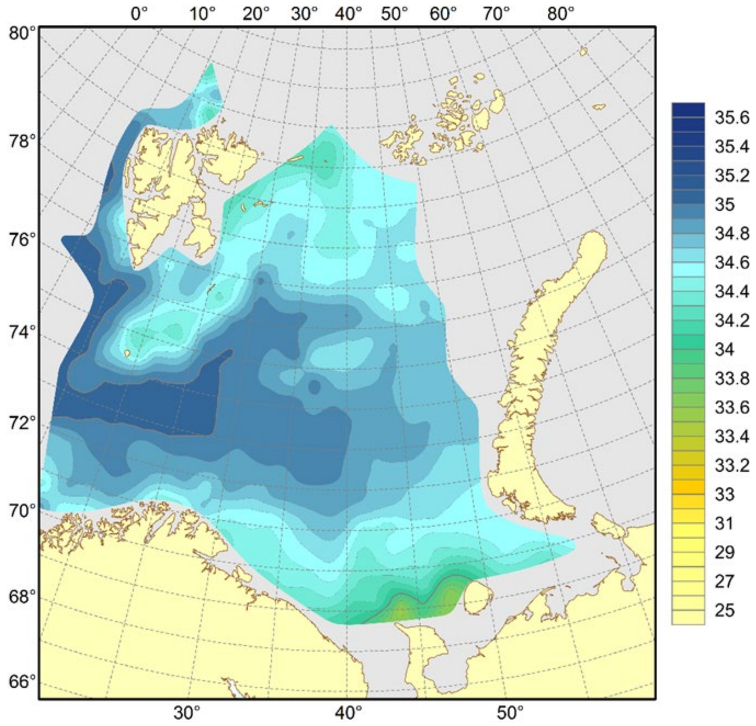

Figure 4.1.1.4. *Distribution of salinity at the 50 m depth, August–October 2019.*

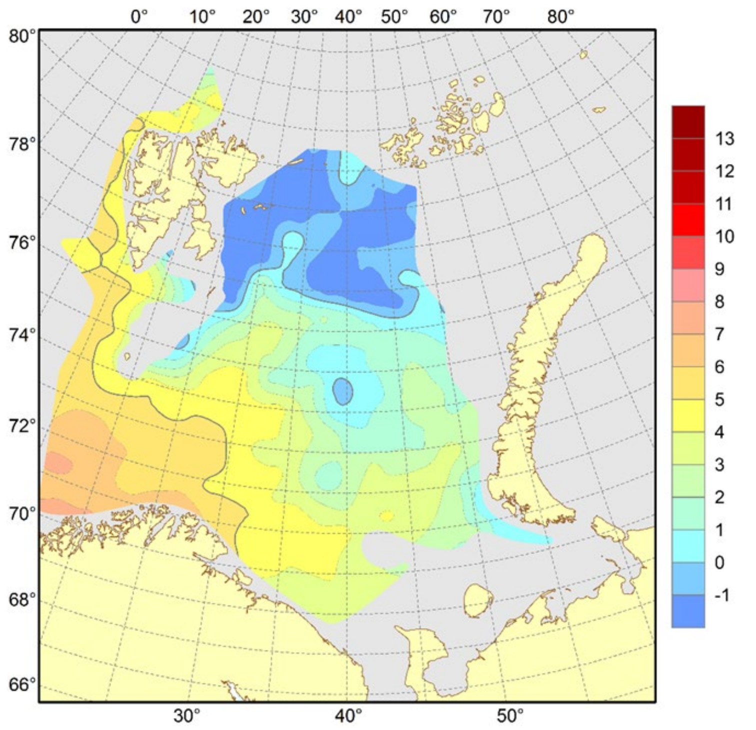

Figure 4.1.1.5. *Distribution of temperature (°C) at the 100 m depth, August–October 2019.*

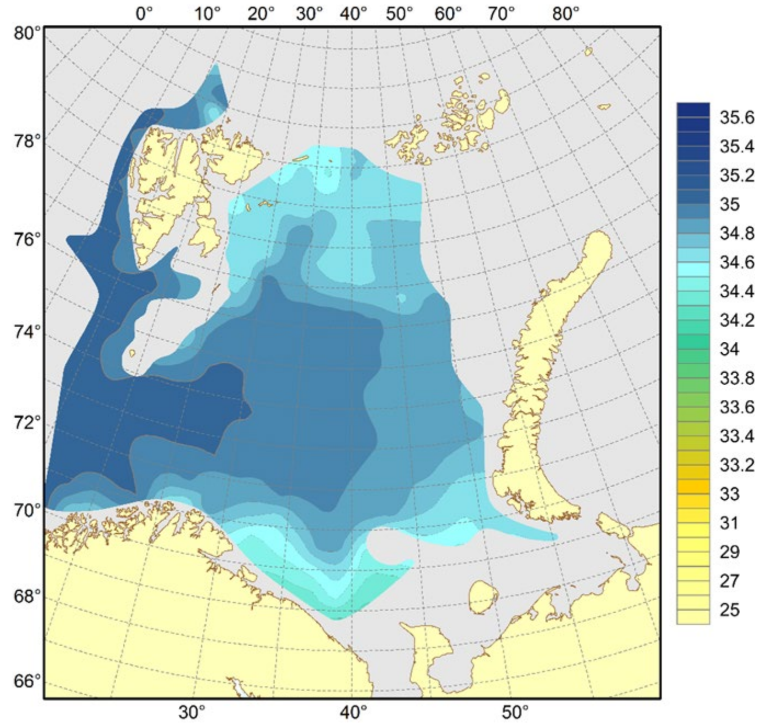

Figure 4.1.1.6. *Distribution of salinity at the 100 m depth, August–October 2019.*

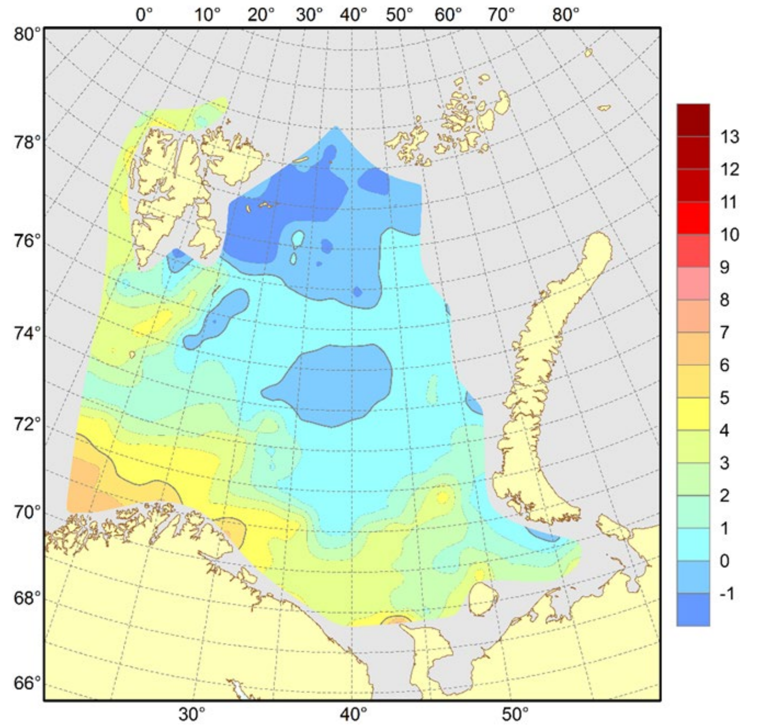

Figure 4.1.1.7. *Distribution of temperature (°C) at the bottom, August–October 2019.*

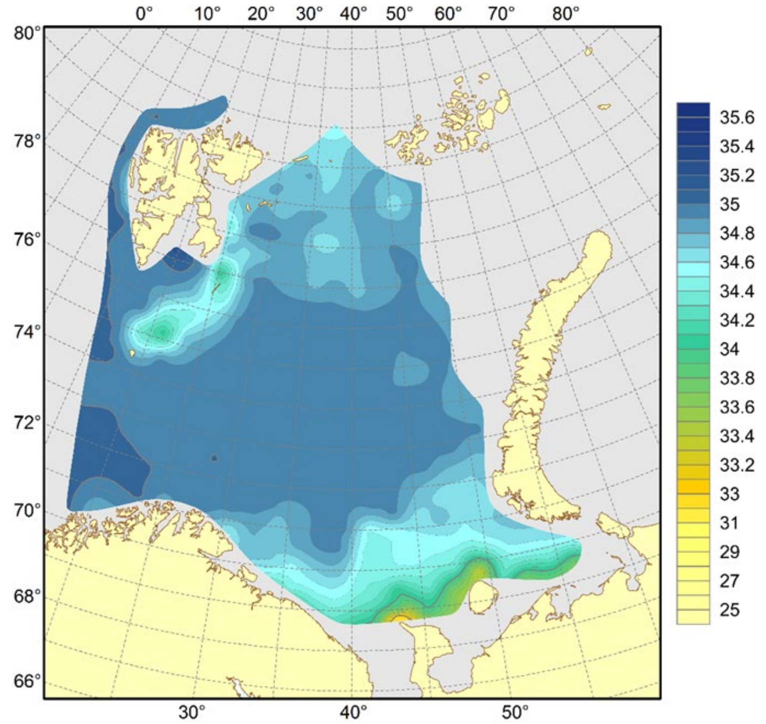

Figure 4.1.1.8. *Distribution of salinity at the bottom, August–October 2019.*

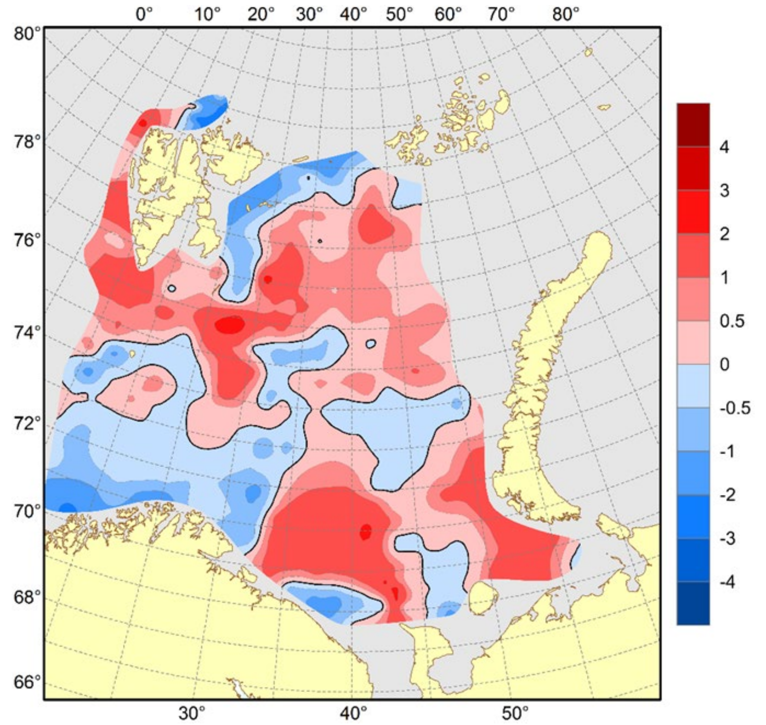

Figure 4.1.1.9. *Surface temperature anomalies (°C), August–October 2019.*

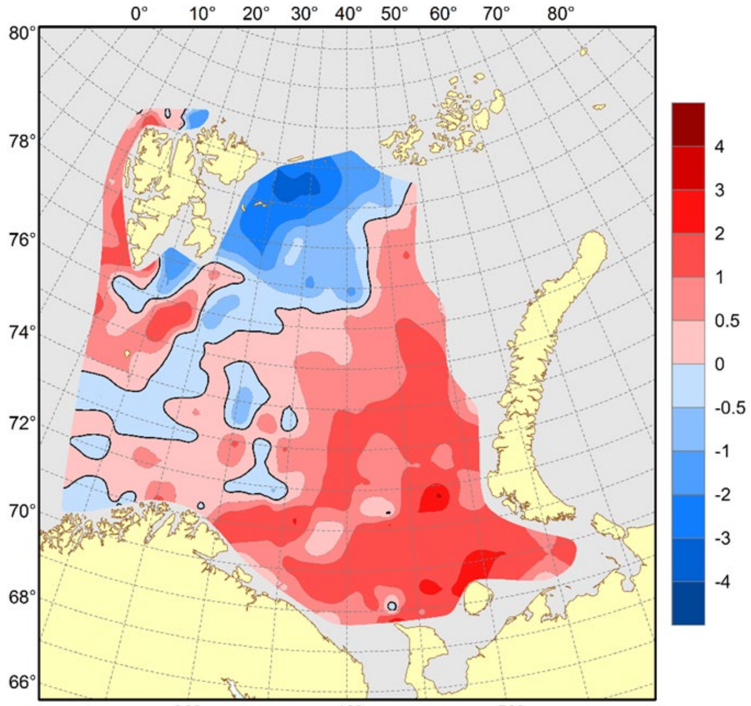

Figure 4.1.1.10. *Temperature anomalies (°C) at the bottom, August–October 2019.*

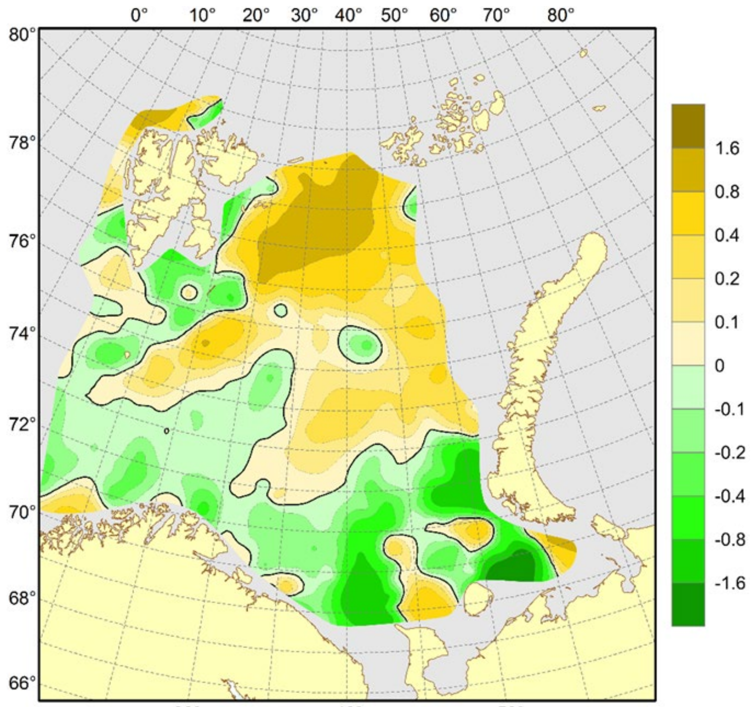

Figure 4.1.1.11. *Surface salinity anomalies, August–October 2019.*

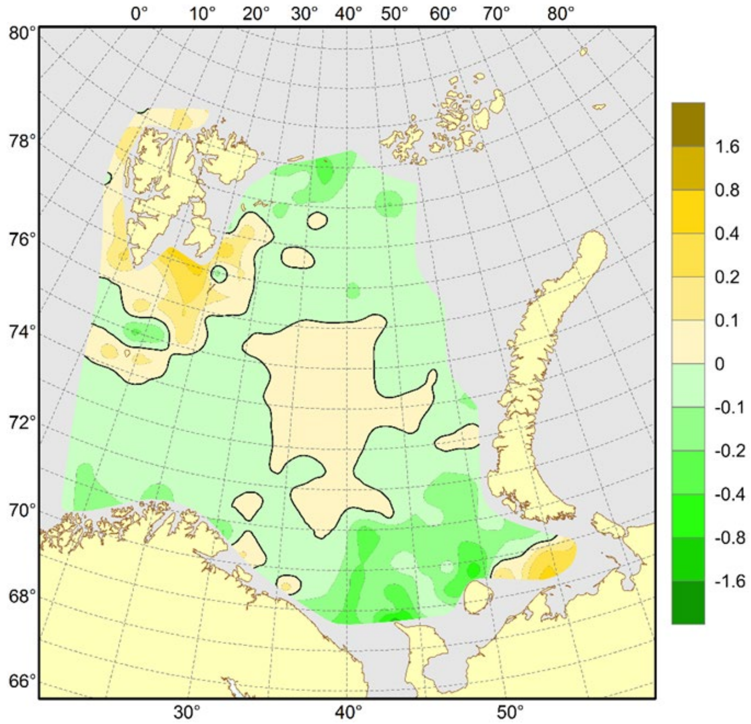

Figure 4.1.1.12. *Salinity anomalies at the bottom, August–October 2019.*

4.1.2 Standard sections

Table 4.1.2.1 shows mean temperatures in the main parts of standard oceanographic sections of the Barents Sea, along with historical data back to 1965.

The Fugløya–Bear Island and Vardø–North Sections cover the inflow of Atlantic and Coastal water masses from the Norwegian Sea to the Barents Sea. The mean Atlantic Water (50–200 m) temperature in the inflow region to the Barents Sea, i.e. at the Fugløya–Bear Island Section, was 0.1°C lower than in 2018 (Table 4.1.2.1). These temperatures have decreased by 0.7°C over the last 4 years, and are currently at the same level as in 2000–2001. The temperatures in the Atlantic Water at the Vardø–North Section also show a temperature decrease in 2019 as compared to the recent years (Table 4.1.2.1), although not as strong as at the Fugløya–Bear Island section. However, substantial changes are observed in the northern parts of the Vardø–North Section (which was sampled all the way to almost 80°N in 2019): most of the water below about 50 m depth and north 76°N is about 1°C colder than in 2018, and the Polar Front has shifted southwards from about 77°N in 2018 to 76°N in 2019.

The Kola and Kanin Sections cover the flow of Coastal and Atlantic waters in the southern Barents Sea. In August–October 2019, the Kola Section was sampled twice: the outer part in late August and the inner part in early October. The mean temperature of Coastal waters in the inner part of the Kola Section (upper, intermediate and deeper layers) was slightly (by 0.1–0.2°C) higher than the average (for the period 1951–2010) that was typical of normal years. The mean temperature of Atlantic waters in the outer part of the section (upper, intermediate and deeper layers) was 0.4–0.5°C higher than the average (for the period 1951–2010) that was typical of warm years. Compared to 2018, the active layer (0–200 m) in the outer part of the section in August 2019 was 0.9°C colder. The mean salinity of Coastal waters in the inner part of the Kola Section (0–200 m) and Atlantic waters in its outer part was lower than the long-term (1951–2010) mean by 0.08 and 0.04 respectively. In the Kanin Section, the mean temperature of the whole water column was 1.0 and 0.5°C higher than the long-term mean for the period 1965–2019 in the inner and outer parts of the section respectively (Table 4.1.2.1).

Table 4.1.2.1. *Mean water temperatures in the main parts of standard oceanographic sections in the Barents Sea and adjacent waters in August–September 1965–2019. The sections are: Kola (70º30'N – 72º30'N, 33º30'E), Kanin S (68º45'N – 70º05'N, 43º15'E), Kanin N (71º00'N – 72º00'N, 43º15'E), North Cape – Bear Island (NCBI, 71º33'N, 25º02'E – 73º35'N, 20º46'E), Bear Island – West (BIW, 74º30'N, 06º34'E – 15º55'E), Vardø – North (VN, 72º15'N – 74º15'N, 31º13'E) and Fugløya – Bear Island (FBI, 71º30'N, 19º48'E – 73º30'N, 19º20'E)*

Year	Section and layer (depth in metres)								
	Kola	Kola	Kola	Kanin S	Kanin N	NCBI	BIW	VN	FBI
	0–50	50–200	0–200	0–bot.	0–bot.	0–200	0–200	50–200	50–200
1965	6.7	3.9	4.6	4.6	3.7	5.1	-	3.8	5.2
1966	6.7	2.6	3.6	1.9	2.2	5.5	3.6	3.2	5.3
1967	7.5	4.0	4.9	6.1	3.4	5.6	4.2	4.4	6.3
1968	6.4	3.7	4.4	4.7	2.8	5.4	4.0	3.4	5.0
1969	6.7	3.1	4.0	2.6	2.0	6.0	4.2	3.8	6.3
1970	7.8	3.7	4.7	4.0	3.3	6.1	-	4.1	5.6
1971	7.1	3.2	4.2	4.0	3.2	5.7	4.2	3.8	5.6
1972	8.7	4.0	5.2	5.1	4.1	6.3	3.9	4.6	6.1
1973	7.7	4.5	5.3	5.7	4.2	5.9	5.0	4.9	5.7
1974	8.1	3.9	4.9	4.6	3.5	6.1	4.9	4.3	5.8
1975	7.0	4.6	5.2	5.6	3.6	5.7	4.9	4.5	5.7
1976	8.1	4.0	5.0	4.9	4.4	5.6	4.8	4.4	5.8
1977	6.9	3.4	4.3	4.1	2.9	4.9	4.0	3.6	4.9
1978	6.6	2.5	3.6	2.4	1.7	5.0	4.1	3.2	4.9
1979	6.5	2.9	3.8	2.0	1.4	5.3	4.4	3.6	4.7
1980	7.4	3.5	4.5	3.3	3.0	5.7	4.9	3.7	5.5
1981	6.6	2.7	3.7	2.7	2.2	5.3	4.4	3.4	5.3
1982	7.1	4.0	4.8	4.5	2.8	5.8	4.9	4.1	6.0
1983	8.1	4.8	5.6	5.1	4.2	6.3	5.1	4.8	6.1
1984	7.7	4.1	5.0	4.5	3.6	5.9	5.0	4.2	5.7
1985	7.1	3.5	4.4	3.4	3.4	5.3	4.6	3.7	5.6
1986	7.5	3.5	4.5	3.9	3.2	5.8	4.4	3.8	5.5
1987	6.2	3.3	4.0	2.7	2.5	5.2	3.9	3.5	5.1
1988	7.0	3.7	4.5	3.8	2.9	5.5	4.2	3.8	5.7
1989	8.6	4.8	5.8	6.5	4.3	6.9	4.9	5.1	6.2
1990	8.1	4.4	5.3	5.0	3.9	6.3	5.7	5.0	6.3
1991	7.7	4.5	5.3	4.8	4.2	6.0	5.4	4.8	6.2
1992	7.5	4.6	5.3	5.0	4.0	6.1	5.0	4.6	6.1
1993	7.5	4.0	4.9	4.4	3.4	5.8	5.4	4.2	5.8
1994	7.7	3.9	4.8	4.6	3.4	6.4	5.3	4.8	5.9
1995	7.6	4.9	5.6	5.9	4.3	6.1	5.2	4.6	6.1
1996	7.6	3.7	4.7	5.2	2.9	5.8	4.7	3.7	5.7
1997	7.3	3.4	4.4	4.2	2.8	5.6	4.1	4.0	5.4
1998	8.4	3.4	4.7	2.1	1.9	6.0	-	3.9	5.8
1999	7.4	3.8	4.7	3.8	3.1	6.2	5.3	4.8	6.1
2000	7.6	4.5	5.3	5.8	4.1	5.7	5.1	4.2	5.8
2001	6.9	4.0	4.7	5.6	4.0	5.7	4.9	4.2	5.9
2002	8.6	4.8	5.8	4.0	3.7	-	5.4	4.6	6.5
2003	7.2	4.0	4.8	4.2	3.3	-	-	4.7	6.2
2004	9.0	4.7	5.7	5.0	4.2	-	5.8	4.8	6.4
2005	8.0	4.4	5.3	5.2	3.8	6.7	-	5.0	6.2
2006	8.3	5.3	6.1	6.1	4.5	-	5.8	5.3	6.9
2007	8.2	4.6	5.5	4.9	4.3	6.9	5.6	4.9	6.5
2008	6.9	4.6	5.2	4.2	4.0	6.2	5.1	4.7	6.4
2009	7.2	4.3	5.0	-	4.3	-	-	5.2	6.4
2010	7.8	4.7	5.5	4.9	4.5	-	5.4	-	6.2
2011	7.6	4.0	4.9	5.0	3.8	-	-	5.1	6.4
2012	8.2	5.3	6.0	6.2	5.2	-	-	5.7	6.4
2013	8.8	4.6	5.6	5.5	4.6	-	5.6	4.9	6.3
2014	8.0	4.6	5.4	4.5	4.1	-	-	5.2	6.1
2015	8.5	4.8	5.7	6.1	4.6	-	-	5.5	6.6
2016	-	-	-	-	5.5	-	-	5.1	6.5
2017	7.9	4.8	5.6	-	-	-	-	5.2	6.4
2018	8.1	4.9	5.7	-	-	-	-	-	6.0
2019	-	-	-	5.5	4.1	-	-	4.7	5.9
Average 1965–2019	7.6	4.1	4.9	4.5	3.6	5.8	4.8	4.4	5.9

4.2 Antropogenic pollution

4.2.1 Marine litter

Text by: T. Prokhorova and B. E. Grøsvik

Figures by: D. Prozorkevich

Anthropogenic litter floating at the surface and collected in trawls in 2019 was observed onboard Russian and all Norwegian vessels.

Plastic dominated among anthropogenic pollutants on the water surface (59 % of observations) (Fig. 4.2.1.1). The maximum surface observation of plastic litter was 0.331 m^3, with the average of 0.014 m^3. Due to currents, recorded debris could be dumped directly in some areas and transported from other areas. Wood was recorded in 39 % of the observations. The maximum surface observation of wood was 2.8 m^3, with the average of 0.4 m^3. Metal, paper and rubber was observed singularly.

Fishery related litter was recorded in 15.3 % of plastic litter observations at the surface (Figure 4.2.1.2). Fishery related litter was represented by ropes (OSPAR code 31) and floats/buoys (OSPAR code 37).

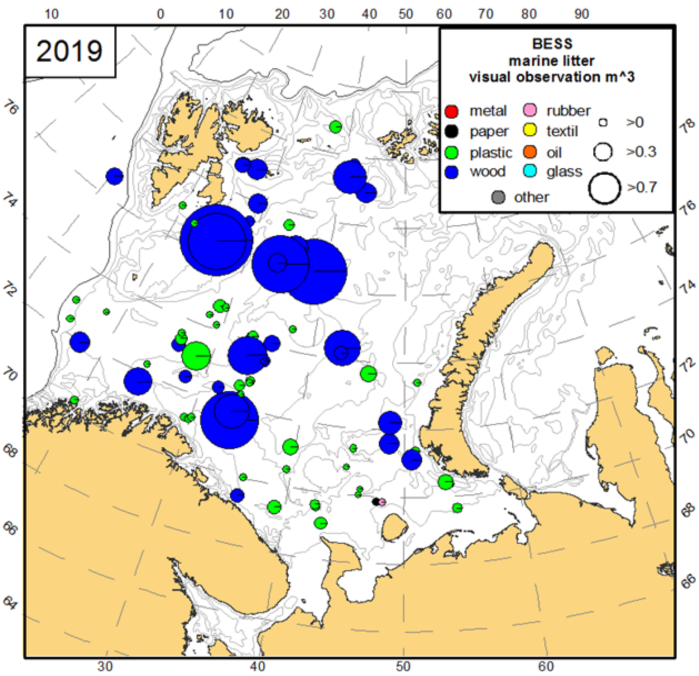

Figure 4.2.1.1 *Type of observed anthropogenic litter (m^3) at the surface in the BESS 2019.*

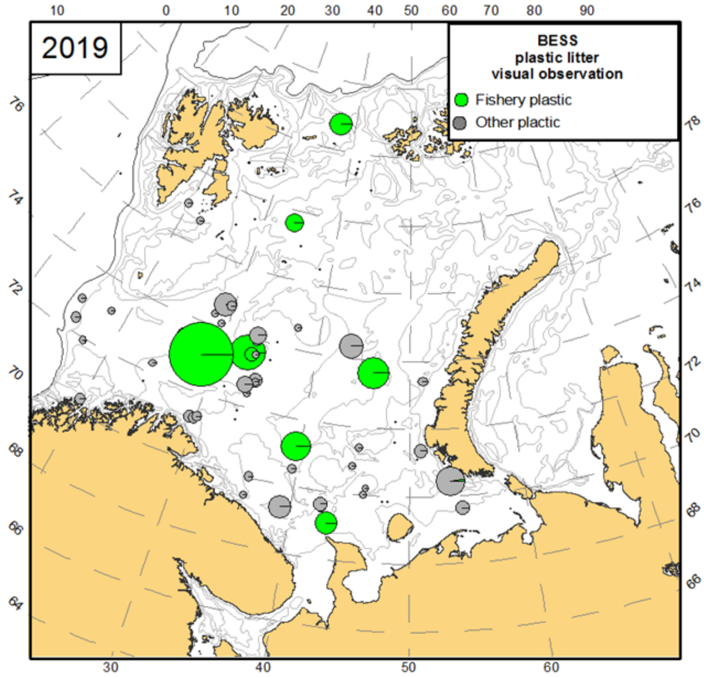

Figure 4.2.1.2 *Litter observations of plastic at the surface indicated as fishery related and other litter in the BESS 2019 (crosses – occurrences of anthropogenic litter).*

Anthropogenic litter was observed in 25.8 % of pelagic trawl stations (Fig. 4.2.1.3). As in previous years, plastic dominated from all anthropogenic matter in pelagic trawls (96.5 % of stations with observed litter). Weight of plastic litter from pelagic trawls was from 0.1 g to 23 kg with average of 0.03 kg (except the single maximum catch of 23 kg). Considering the low catchability by pelagic trawl for low-density polymers, the total amount of this matter in the Barents Sea could be much higher. Another type of litter (wood, textile, paper and metal) was observed singularly. The maximum catch of litter by pelagic trawl was 10.5 kg per n.mile, with the average of 0.037 kg per n.mile.

Litter was observed throughout the survey in the bottom trawl catches (43.8 % of the bottom trawl stations) (Fig. 4.2.1.4). Plastic also dominated the litter content from the bottom trawls (82.3 % of stations with observed litter). Weight of plastic litter in bottom trawls was from 0.1 g to 11.3 kg with average of 0.04 g (except the single maximum catch of 11.3 kg). Wood was registered in bycatch in shallow waters in the south-eastern part of the Barents Sea, also in the northern part of the survey area (24.8 % of stations with observed litter). Wood might be brought to the area by ocean currents from the eastern seas because of the timber-rafting from the Siberian rivers, as well as it might be lost from ships. Textile, paper, metal, rubber and glass was observed among the bottom trawl catches sporadically. The maximum catch of litter by bottom trawl was 21.0 kg per n.mile, with the average of 0.17 kg per n.mile.

Litter from fishery was a significant part of plastic litter both in the pelagic and bottom trawls (63.4 % and 41.1 % respectively) (Figure 4.2.1.5).

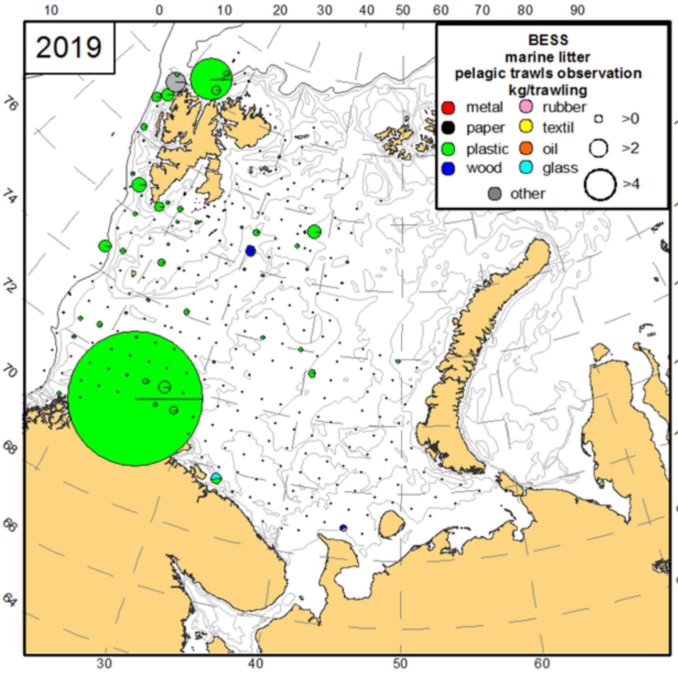

Figure 4.2.1.3 *Type of anthropogenic litter collected in the pelagic trawls (kg) in the BESS 2019 (crosses – pelagic trawl stations).*

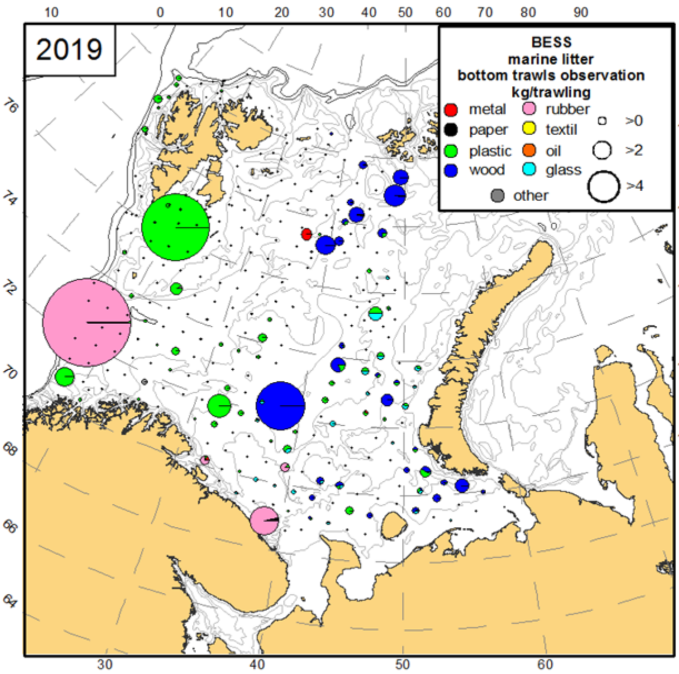

Figure 4.2.1.4 *Type of anthropogenic litter collected in the bottom trawls (kg) in the BESS 2019 (crosses – bottom trawl stations).*

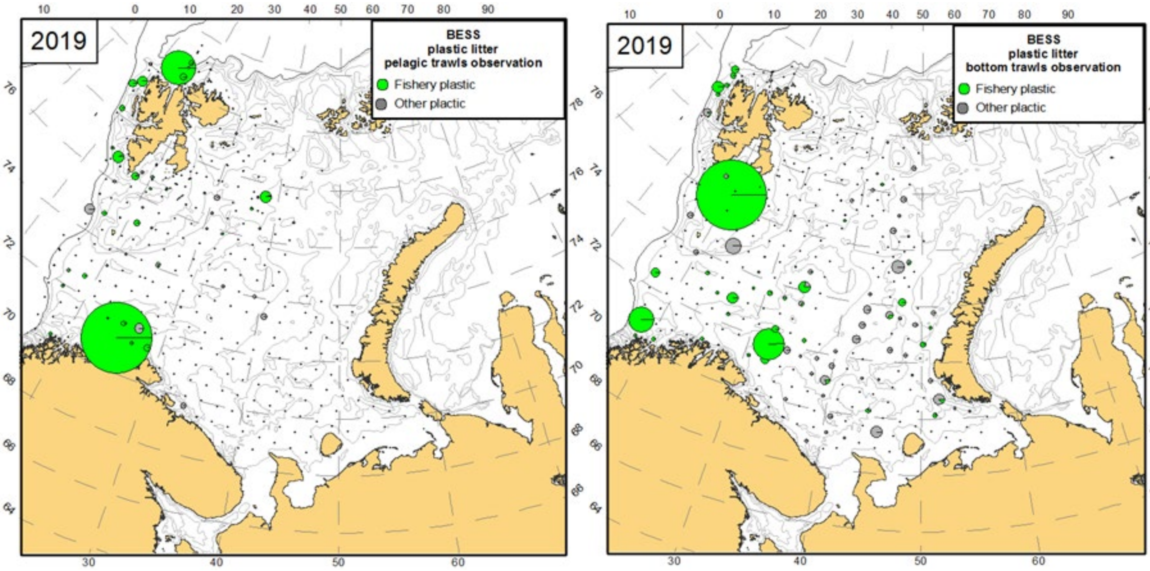

Figure 4.2.1.5 *Fishery plastic proportion among the plastic litter collected in the pelagic (to the left) and bottom trawls (to the right) in the BESS 2019 (crosses – trawl stations).*

5 PLANKTON COMMUNITY

5.1 Phytoplankton, chlorophyll a and nutrients

Text and figures by: E. Bagøien

About 20 phytoplankton samples were collected from stations dispersed within the Norwegian sector of the Barents Sea during the joint ecosystem cruise in 2019. The samples were collected from depth of 10 m using CTD-mounted water-bottles. The samples were fixed in Lugol's solution, and species abundances and composition has been analysed at IMR in Flødevigen using the Utermöhl sedimentation method for volumes of 50 ml.

Nutrient and chlorophyll samples were collected from various depths at roughly 170 CTD stations. The nutrient samples (20 ml) were preserved with chloroform (200 µl), and thereafter kept at about 4°C until subsequent chemical analysis on shore at IMR. The chlorophyll-samples were collected by filtering 263 ml of seawater through glass-fibre filters, which were then frozen at about -18°C until subsequent extraction of pigments in acetone and thereafter fluorometric analysis in the IMR laboratory on shore. Concentrations of nitrate, nitrite, silicate and phosphate, along with chlorophyll and phaeopigments, in all collected samples have now been analysed.

Data on phytoplankton species, chlorophyll or nutrient levels are not presented in the cruise-report, but the results are available at IMR.

5.2 Mesozooplankton biomass and geographic distribution

Text by: E. Bagøien, I. Prokopchuk, V. Nesterova, A. Dolgov and J. Rønning
Figure by: E. Bagøien

Mesozooplankton sampling stations during the joint Norwegian-Russian Barents Sea ecosystem cruise in 2019 are presented in Fig. 5.1. In the Norwegian sector the WP2 net (opening area ~ 0.25 m^2) was applied, while in the Russian sector the Juday net (opening area ~ 0.11 m^2) was used. Both gears were rigged with nets of mesh-size 180 µm and hauled vertically from near the bottom to the surface. A comparison study has shown that the total zooplankton biomass collected by the two gears is roughly comparable. The Norwegian biomass samples are dried before weighing, while the Russian samples are preserved in 4% formalin and their wet-weight measured. Dry-weight is then estimated by dividing the wet-weight with a factor of 5. Apart from the region just west of Novaya Zemlya, the spatial coverage was good in both the Norwegian and Russian sectors this year.

The spatial distribution of total mesozooplankton biomass shown in Figure 5.1 is based on a total of 229 samples, of which 171 were located in the Norwegian sector and 58 in the Russian sector. Within the Norwegian sector, where we have the longest time-series, the average biomass was 8.0 (± 6.2 SD) g dry-weight m^{-2}. This was a little higher than in 2018 (7.2 g dry-weight m^{-2}) and above the 20-year long-term mean for 1999-2018 (7.0 g dry-weight m^{-2}). The average zooplankton biomass within the Russian sector was 7.5 (± 6.7 SD) g dry-weight m^{-2}, which is not comparable to the 2018 value (9.1 ± 6.1 g dry-weight m^{-2}) due to markedly different spatial coverages in the easternmost regions these two years. When combining the data for the Norwegian and Russian sectors in 2019, the overall average was 7.9 (± 6.3 SD) g dry-weight m^{-2} – which is the arithmetic average for all stations shown in Figure 5.1. In 2018 the overall average for the Norwegian and Russian data combined was 7.5 g dry-weight m^{-2}. We point out that the average combined biomasses for these two years are not comparable due to differing spatial sampling in the Russian sector. It is important to note that comparing average biomasses for different years is vulnerable to differing area coverages. Challenges in covering the same area over a series of years are inherent in such large-scale monitoring programs, and interannual variation in ice-cover and logistical issues are two of several reasons for this. To optimize the regularity of the sampling grid across the survey area in 2019, most stations belonging to the Hinlopen-section north of Svalbard (Spitzbergen) and the whole Vardø-North section were omitted when calculating the average biomass (omitted stations not shown in Fig. 5.1).

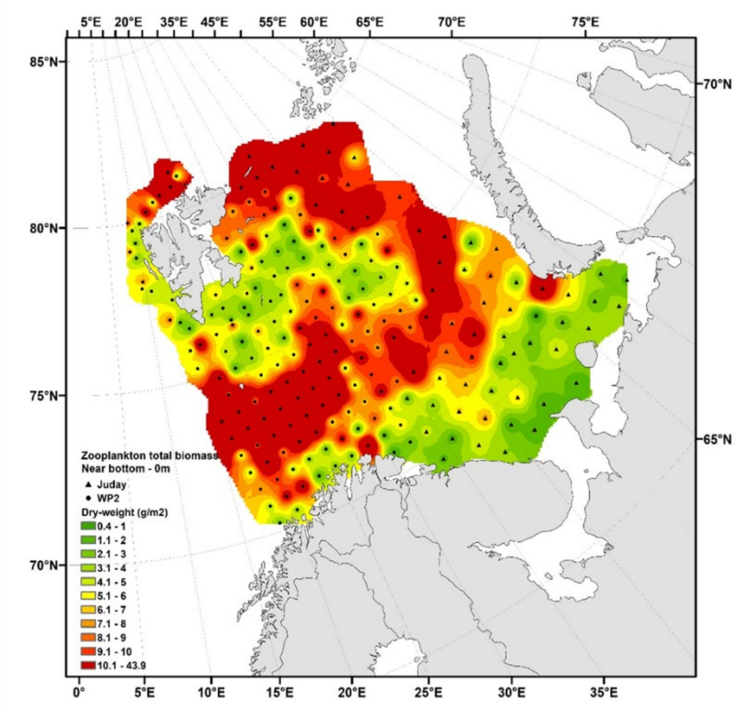

Figure 5.1. *Distribution of total zooplankton biomass (g dry-weight m^{-2}) in the near-bottom – 0 m layer in the Barents Sea during BESS 2019 - based on a total of 229 stations. The data visualized were collected by WP2 and Juday nets with mesh-size 180 µm. Interpolation was made in ArcGIS v.10.5, module Spatial Analyst, using inverse distance weighting (IDW).*

The purpose of this was to avoid weighting of areas with higher sampling density. Differences in survey coverages among years, as well as spatial variability in station density within the survey region, impact biomass estimates, and particularly so in an environment characterized by large-scale patches of biomass. Addressing such challenges is a task for the ICES Working Group on the Integrated Assessments of the Barents Sea (WGIBAR), which in addition to the estimated average for the national sectors and the whole Barents Sea, will make interannual biomass comparisons within-well defined and consistent spatial polygons.

The overall distribution patterns show similarities across years, although some interannual variability is apparent. In 2019, the familiar pattern of comparatively high biomasses (>10 g dry-weight m^{-2}) was observed in the southwestern region as well as north-northeast of Svalbard (Spitsbergen), along with relatively low biomasses in the central region as well as in the south-eastern corner of the Barents Sea (Fig. 5.1).

Several factors may impact the levels of zooplankton biomass in the Barents Sea, including;

- Advective supply of zooplankton from the Norwegian Sea – mediated by ocean currents
- Local zooplankton production rates – which are linked to temperature, nutrient conditions and primary production rates
- Predation from carnivorous zooplankters (jellyfish, krill, hyperiids, chaetognaths, etc.)
- Predation from planktivorous fish including capelin, young herring, polar cod, juveniles of cod, saithe, haddock, redfish
- Predation from marine mammals and seabirds

Spatial distributions of mesozooplankton biomass, and relationships with ecosystem components such as ocean currents, hydrography, and abundances/distributions of relevant predators will be evaluated in more detail in ICES working group (WGIBAR) report.

5.3 Macroplankton biomass and distribution

Text by: T. Prokhorova, E. Eriksen and I. Prokopchuk
Figure by: P. Krivosheya, T. Prokhorova and I. Prokopchuk

Due to limited resources the microzooplankton was not possible to estimate from the 2019 survey in time for this report. If possible, the time series will be completed and updated in next year survey report.

5.3.1 Krill

Krill (euphausiids) represent the most important group of macrozooplankton in the Barents Sea, followed by hyperiid amphipods. Krill play a significant role in the Barents Sea ecosystem, facilitating transport of energy between different trophic levels. There are mainly four species of krill in the Barents Sea; *Thysanoessa inermis* primarily associated with the Atlantic boreal western and central regions, whereas the neritic *Thysanoessa raschii* mainly occurs in the southeastern Barents Sea. These two species can reach 30 mm in length. *Meganytiphanes norvegica,* the largest species (up to 45 mm) is mainly restriced to typical Atlantic waters. The smallest of the species, the oceanic *Thysanoessa longicaudata* (up to 18 mm), is associated with the inflowing Atlantic water.

In 2019, krill (euphausiids) were caught by standard pelagic «Harstad» trawl and 39% of all samples were identified to species level. The data here reported on krill represent bycatches from trawling on the 0-group fish.

In 2019, krill were widely distributed in the BESS area (Figure 5.3.1.1). The biomass values in the report are given as grams of wet weight per square m (g m^{-2}). Larger catches (more than 50 g m^{-2}) were made around Svalbard (Spitsbergen) and in the western and southeastern Barents Sea. About one third of the stations during the survey in 2019 were sampled during night (Table 5.3.1.1). The total krill biomass was estimated on basis of night catches only. During the night, most of the krill migrate to upper layers to feed and are therefore more accessible for the trawl. Both the day and night catches in 2019 (means of 8.2 g m^{-2} and 18.5 g m^{-2} respectively) were higher than the long-term means (2.5 g m^{-2} and 8.0 g m^{-2} respectively).

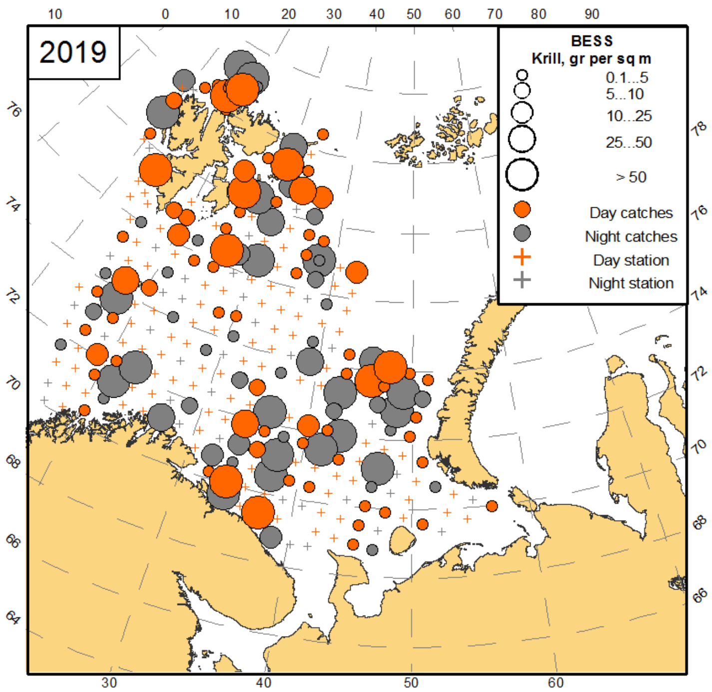

Figure 5.3.1.1. *Krill distribution (biomass, g wet-weight m^{-2}), based on pelagic trawl stations covering the upper water layers (0-60 m), in the Barents Sea in August-October 2019.*

Species identification of euphausiids took place on the Norwegian vessels only. *M. norvegica* and *T. inermis* were widely observed in the Norwegian samples, while *T. longicaudata* were mostly observed in the western areas (Figure 5.3.1.2).

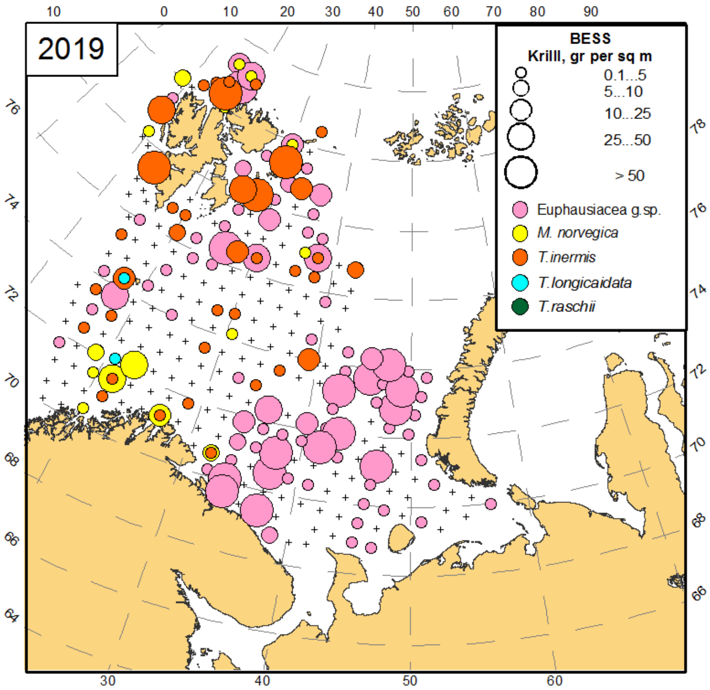

Figure 5.3.1.2. *Krill species distribution (biomass, g wet-weight m-2), based on trawl stations covering the upper water layers (0-60 m), in the Barents Sea in August-October 2019.*

During the survey, length measurements of krill onboard the Norwegian vessels were made. Length distribution of two common species (*M. norvegica* and *T. inermis*) is shown in Figure 5.3.1.3. The length of *M. norvegica* varied from 10 to 46 mm (with an average of 30.1 mm), and *T. inermis* from 13 to 33 mm (with an average of 22 mm).

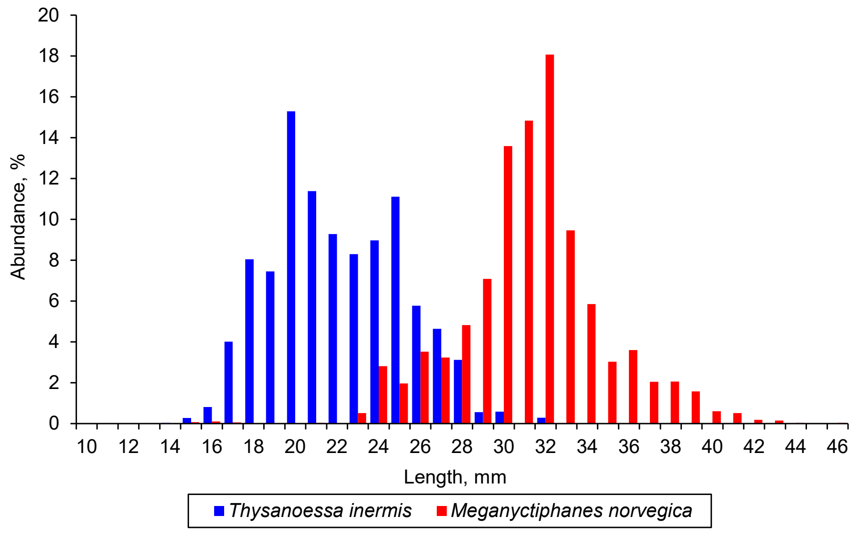

Figure 5.3.1.3 *Length distribution of T. inermis and M. norvegica from catches with standard pelagic trawl in the upper layers (0-60 m) of the Barents Sea in August-October 2019.*

In 2019, the total biomass of krill was estimated as 22.3 million tonnes for the whole Barents Sea. It is the highest biomass since 2011, and much higher than long-term mean of 9.3 million tonnes (Fig. 5.3.1.4).

Table 5.3.1.1 *Day and night total catches (g m^{-2}) of krill taken by the pelagic trawl in the upper water layers (0-60 m).*

Year	Day			Night		
	N	Mean g m^{-2}	Std Dev	N	Mean g m^{-2}	Std Dev
1980	237	1.49	11.38	90	4.86	23.96
1981	214	1.19	9.14	83	7.95	21.53
1982	192	0.18	1.19	69	6.29	22.57
1983	203	0.32	2.76	76	0.39	1.91
1984	217	0.15	1.64	66	1.72	9.17
1985	217	0.07	0.54	75	0.80	4.42
1986	229	3.03	11.70	76	11.90	37.82
1987	200	4.90	22.44	88	3.82	13.08
1988	207	2.69	30.16	81	11.84	55.84
1989	296	1.99	8.45	129	3.71	13.01
1990	283	0.11	0.76	115	1.18	6.32
1991	284	0.03	0.33	124	7.03	25.11
1992	229	0.11	1.18	77	0.92	2.92
1993	194	1.21	6.69	79	2.23	7.36
1994	175	3.01	10.23	72	7.27	18.78
1995	166	4.86	18.86	80	9.13	34.46
1996	282	4.34	26.62	118	9.32	21.53
1997	102	4.12	22.71	167	3.58	12.94
1998	176	2.24	16.00	185	5.68	23.95
1999	140	1.50	9.64	90	4.64	13.09
2000	202	1.52	9.53	67	3.54	11.49
2001	212	0.07	0.63	66	5.77	19.60
2003	203	1.26	9.54	74	2.84	11.23
2004	229	0.34	2.94	80	6.49	22.47
2005	314	3.50	30.53	86	9.02	24.78
2006	227	1.23	6.66	103	9.66	31.54
2007	192	1.79	10.93	112	9.04	39.29
2008	199	0.11	1.02	77	16.92	43.57
2009	241	0.42	2.56	131	10.29	25.02
2010	198	1.76	13.00	105	14.98	43.35
2011	212	0.13	0.69	95	19.46	77.70
2012	243	4.00	12.35	84	11.48	34.21
2013	222	0.11	0.88	83	13.23	42.16
2014	196	4.16	27.85	98	4.85	27.36
2015	199	9.70	54.43	97	14.22	44.61
2016	122	16.56	54.81	78	13.48	19.66
2017	146	0.57	2.60	85	15.35	42.54
2018*	-	-	-	-	-	-
2019	179	8.20	35.04	97	18.51	43.17
1980-2019	210	2.45		94	7.98	

*not coverage of the survey area

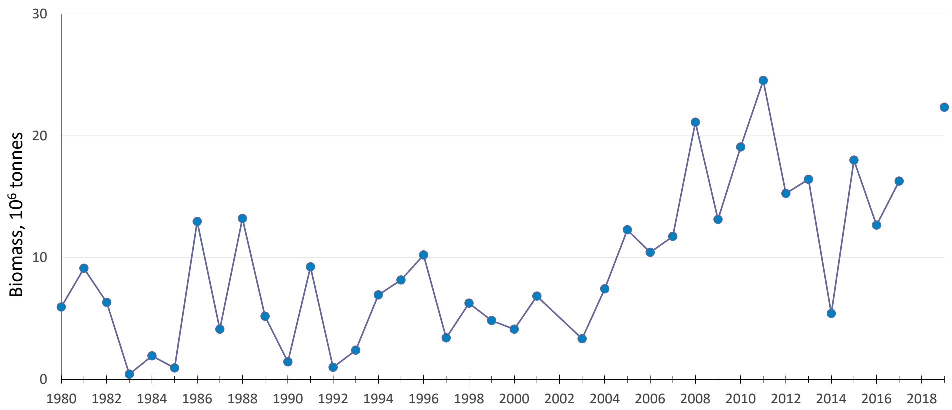

Figure 5.3.1.4. *Krill biomass (wet-weight, million tonnes) estimated for upper layers of the whole Barents Sea during 1980-2019, based on night catches with standard pelagic trawls covering the upper water layers (0-60 m)*

5.3.2 Amphipods (mainly hyperiids)

Text by: T. Prokhorova, E. Eriksen and I. Prokopchuk
Figures by: P. Krivosheya, T. Prokhorova and I. Prokopchuk

The data here reported on pelagic amphipods represent bycatches from trawling on the 0-group fish, using the standard pelagic «Harstad» trawl in th 60-0 m layer in autumn. During 2012 and 2013, amphipods were absent from pelagic trawl catches, while in 2014 some limited catches were taken north of Svalbard (Spitsbergen). Several large catches were made east and north of Svalbard (Spitsbergen) during 2015-2017. In 2018, amphipods were caught east of the Svalbard (Spitsbergen) Archipelago. In 2019, amphipods were found mainly in the northern part of surveyed area (Figure 5.3.2.1). The largest catches were dominated by Arctic *Themisto libellula*, and made north and east of Svalbard (Spitsbergen) (Figure 5.3.2.2).

In 2019, the mean day-time catches were higher than the night-time catches (1.1 g m^{-2} and 0.8 g m^{-2}, respectively), and the same was the case for the maximum catches (39.8 g m^{-2} during day and 17.0 g m^{-2} during night). This year, the estimated amphipod biomass for the upper 60 m of the whole Barents Sea was high (1.23 million tonnes), and about twice as high as in 2015-2016 (close to 570 thousand tonnes) and more than 20 times higher than in 2017. The higher biomasses in 2019 were most likely related to lower temperatures in the northern area, which was covered by Arctic water masses (close to 0°C and below).

T. libellula dominated in the catches, while only two catches of *Themisto abyssorum* were taken during the survey. In addition, to Themisto sp., low catches of *Hyperia galba*, which associates with jellyfish, were found in the northern part of the central area, where jellyfish were abundant.

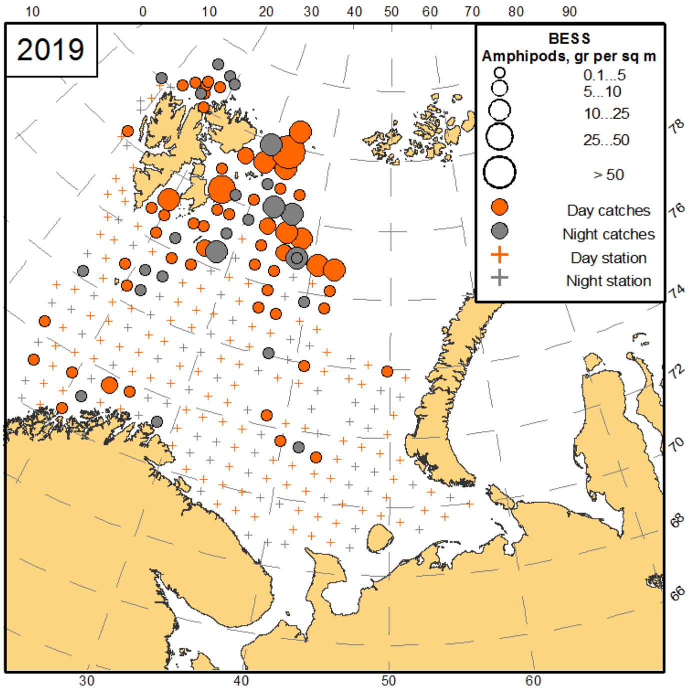

Figure 5.3.2.1 *Amphipods distribution (biomass, g wet-weight m*$^{-2}$*), based on standard pelagic trawls covering the upper layers (0-60 m) of the Barents Sea in August-October 2019.*

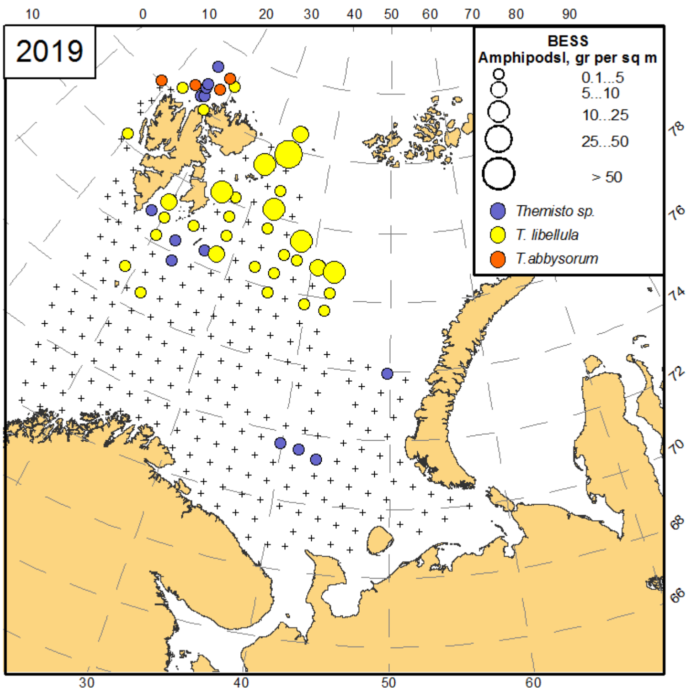

Figure 5.3.2.2. *Distribution of amphipods of genus Themisto (biomass, g wet-weight m- 2), based on standard pelagic trawls covering the upper layers (0-60 m) of the Barents Sea in August-October 2019.*

The length of the most common and abundant *T. libellula* varied from 11.0 to 39.0 mm with an average length of 20.0 mm (Figure 5.3.2.3).

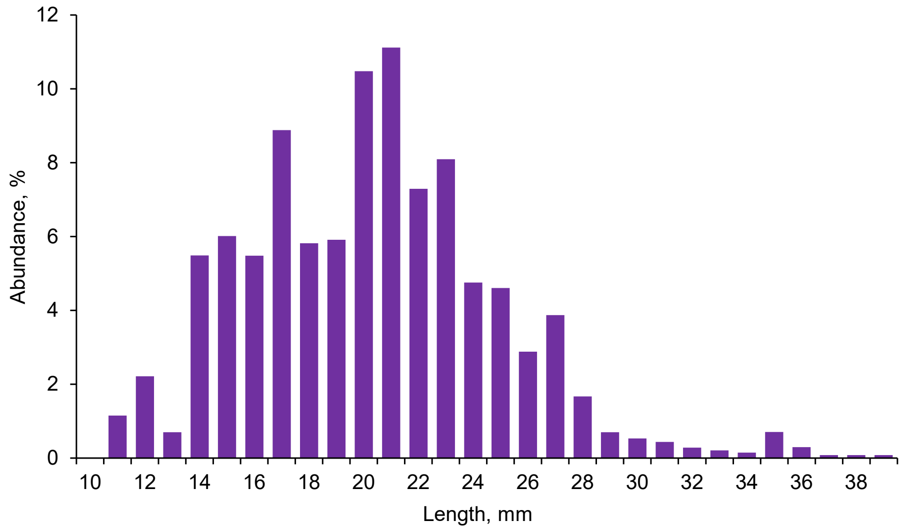

Figure 5.3.2.3 *Length distribution of T. libellula from catches with standard pelagic trawl in the upper layers (0-60 m) of the Barents Sea in August-October 2019.*

6 FISH RECRUITEMENT (YOUNG-OF-THE-YEAR)

Text by: E. Eriksen, T. Prokhorova and F. Keulder-Stenevik
Figures by: D. Prozorkevich

Abundance estimates and mean length were calculated for the new 15 subareas (Fig. 6.1) by MatLab software for period 1980-2018 and that summarized for the entire Barents Sea. This was done due to the use of new software and new strata system (ICES 2019). The «new» 0-group indices are very close to those calculated before by other software (SAS, MS Access and etc.). Abundance estimates and fish length, presented in the report, takes to according capture efficiency of the trawl (Dingsør 2005, Eriksen et al. 2009). For calculation indices in 2019 using StoX software (Johnsen et al. 2019).This indices were not checked for comparability with previous calculations. Thus, the 2019 indexes are preliminary and will be verified later.

This year, the main distribution of most of 0-group species were covered well. The 2019-year class of capelin was estimated as a strong. The 2019-year class of redfish was close to long term mean level. The 2019-year classes of cod, haddock, polar cod and herring were estimated as weak. Abundance indices of saithe, long rough dab, sandeel and Greenland halibut were not calculated. The total biomass of 0-group fishes was not estimated in 2019. A more detailed description of 0-group numbers development and spatial distribution can be found in the reports of the ICES Working Group on integrated assessment of the Barents Sea (WGIBAR).

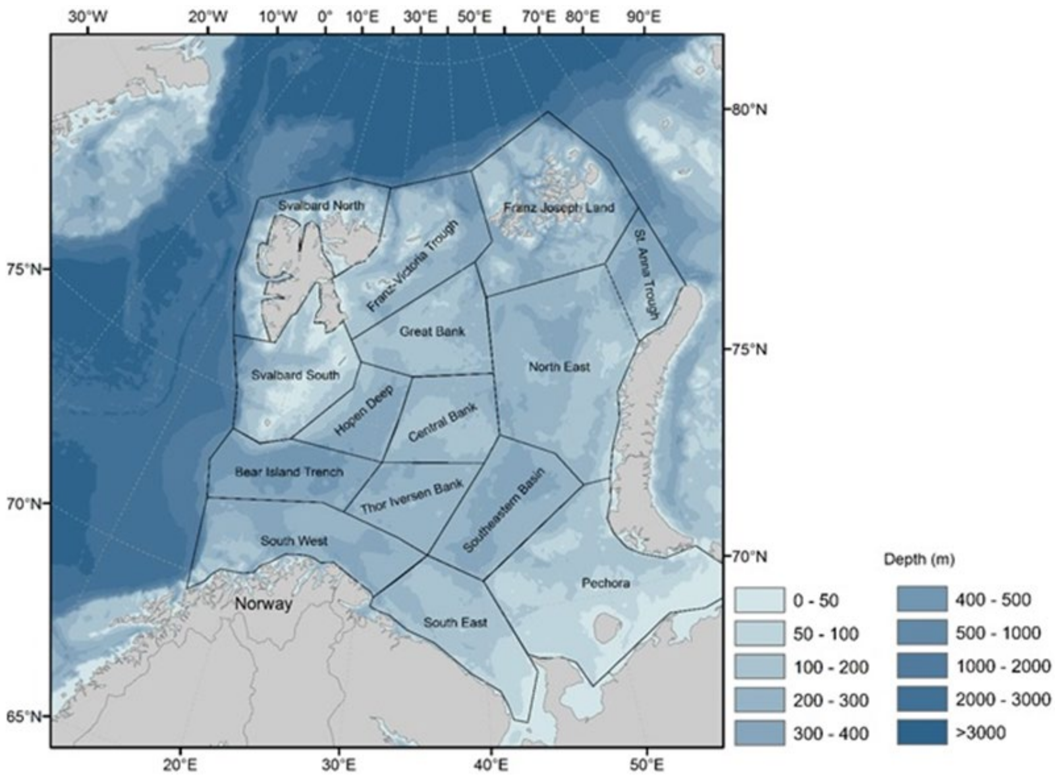

Figure 6.1. *Map showing subdivision of the Barents Sea into 15 subareas (regions) used to calculate estimates of 0-group abundance and fish length based on the BESS.*

Table 6.1. *0-group fish abundance (in millions) corrected for capture efficiency and estimated by SAS for the period 1980-2017 (Eriksen et al. 2019), new spatial abundance indices described in ICES 2018 and presented for the same period (using MatLab) and for 2019 (using Stox, preliminary data).*

Year	Capelin		Cod		Haddock		Herring		Redfish		Polar cod Tot	
	SAS estimates	Spatial indices	SAS estimates	Spatial indices	SAS estimates	Spatial indices	SAS estimates	Spatial indices	SAS estimates	Spatial indices	SAS estimates	Spatial indices
1980	740289	759631	276	576	265	1376	77	1680	277873	185589	286097	608723
1981	477260	535762	289	325	75	4006	37	7141	153279	170720	51037	82816
1982	599596	654770	3480	3633	2927	3004	2519	1368	106140	78216	12008	27959
1983	340200	421025	19299	24685	6217	6405	195446	219899	172392	146807	88518	94527
1984	275233	294986	24326	23755	5512	5625	27354	33271	83182	24952	27187	49898
1985	63771	112080	66630	64442	2457	2372	20081	11757	412777	285105	149927	289240
1986	41814	58667	10509	13457	2579	2920	93	93	91621	121773	121513	475292
1987	4032	4381	1035	1068	708	715	49	6004	23747	23799	64802	233431
1988	65127	79171	2570	2614	1661	1644	60782	71219	107027	90393	43721	65487
1989	862394	963452	2775	3194	650	696	17956	18825	16092	13505	165449	214094
1990	115636	129596	23593	26552	3122	3274	15172	18578	94790	90493	249681	400136
1991	169455	234446	40631	44323	13713	12805	267644	263390	41499	24351	1105262	1400000
1992	2337	5318	166276	202984	4739	6246	83909	109872	13782	12111	130504	182687
1993	952	2082	133046	142089	3785	4331	291468	232645	5458	4928	367416	962069
1994	13898	20053	70761	104678	4470	5514	103891	186754	52258	35479	2188460	2428460
1995	2869	16748	233885	311255	1203	1700	11018	13604	11816	7922	201	519
1996	136674	172296	280916	350231	2632	2153	549608	650298	28	33	634691	1314085
1997	189372	282067	294607	400571	1983	2690	463243	608594	132	176	359912	701511
1998	113390	146691	24951	30275	14116	18979	476065	675159	755	1032	192483	321677
1999	287760	428062	4150	6125	2740	4052	35932	49803	46	48	1178164	1574590
2000	140837	188480	108093	139029	10906	13727	469626	571836	7530	12490	1107286	1500000
2001	90181	139161	4150	5842	4649	5117	10008	17461	6	9	148110	236821
2002	67130	99597	76146	97657	4381	6700	151514	194233	130	155	1044788	1100000
2003	340877	550319	81977	87392	30792	33111	177676	173040	216	225	95313	237883
2004	53950	67223	65969	85438	39303	51074	773891	940773	862	1076	293578	457284
2005	148466	231379	72137	82011	91606	98746	125927	170091	12676	15065	70633	111737
2006	515770	819319	25061	27621	28505	34263	294649	288971	20403	19773	198678	339897
2007	480069	759603	42628	50547	8401	9456	144002	183782	156548	191145	213914	494650
2008	995101	1251469	234144	277479	9864	11627	201046	276263	9962	9438	43276	81631
2009	673027	864507	185457	210241	33339	36013	104233	109307	49939	49708	323677	403382
2010	318569	415820	135355	169309	23669	26058	117087	166224	66392	74371	279474	409415
2011	594248	767153	448005	451670	19114	19630	83051	99667	7026	8938	254193	407433
2012	988600	1140875	410757	486495	5281	5927	177189	177189	58535	78699	150332	106219
2013	316020	397913	385430	456363	16665	17218	289391	361005	928	1191	12393	16480
2014	163630	267724	464124	614774	11765	12854	136305	154881	77658	80226	22647	32800
2015	457481	592028	37474	59189	15089	23016	82749	94695	101653	97108	50380	56855
2016	778784	979640	53796	81745	5504	6596	79439	123462	12941	16350	10832	28081
2017	213787	273046	233275	275914	19484	21654	153763	232306	43561	67357	70971	6992
2019		*564080*		*23404*		*892*		*17245*		*91065*		*65902*
LTM	740289	759631	276	576	265	1376	77	1680	277873	185589	286097	608723

Note: incomplete coverage survey area in 2018

6.1 Capelin (*Mallotus villosus*)

In 2019, the highest concentrations of capelin were found in the west-central and south-central Barents Sea, and were located further south that in 2016-2018. High densities 0-group capelin were also found west and north of Svalbard (Spitsbergen) archipelago and close to Norwegian coast (6.1.1). The density legend in the figure 6.1.1 is based on the catches, measured as number of fish per square nautical mile. More intensive colouring indicates denser concentrations. Estimated total abundance of the capelin was as high as 564 x 10^9 individuals.

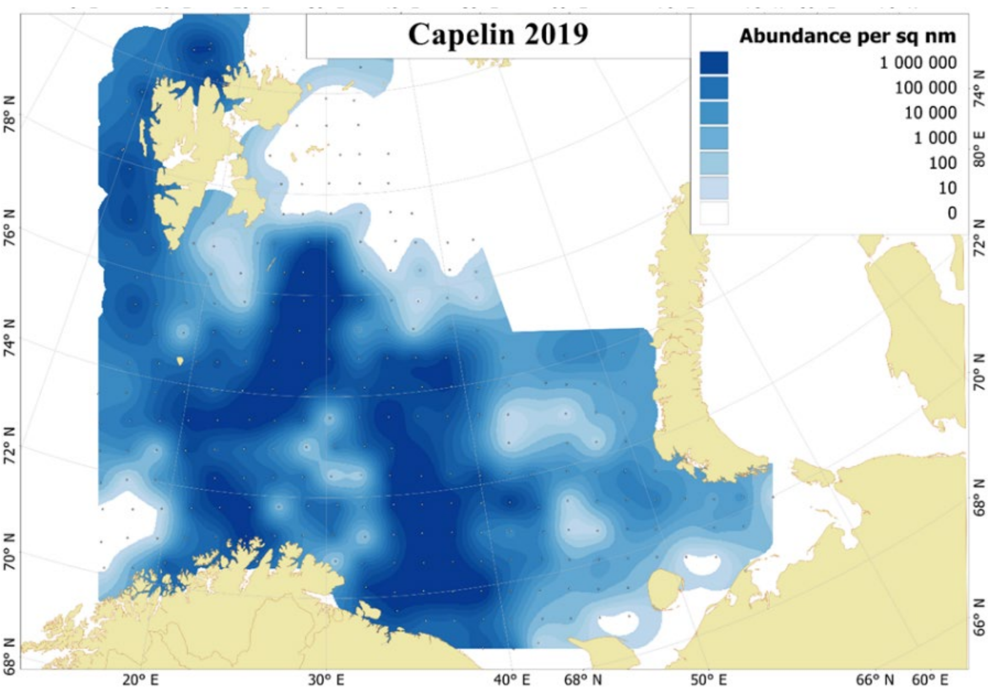

Figure 6.1.1. *Distribution of 0-group capelin, August-October 2019. Dots indicate sampling locations.*

The average length of capelin was 4.25 cm. Capelin length varied from 1 to 7 cm, while dominated by capelin of 3.5-4.5 cm. The smallest capelin with length between 2.5-3.5 cm were found in the western and west-central areas (South West and Thor Iversen bank and Bear Island Trench), and the capelin from South West and South East areas, close to the northern Norwegian and Russian coasts (with an average length of 3.9 cm) indicated outcomes from later spawning. The largest (with an average length of 6.5 cm) in Franz Victoria Trough, that indicated most likely that 0-group capelin spawned earlier and drifted further and experienced a sufficient feeding and living conditions during the first summer. The abundance index of 0-group capelin in 2019 was above the long-term mean, and therefore, can be characterized as strong.

6.2 Cod (*Gadus morhua*)

0-group cod were widely distributed on the surveyed area, except northern and south-eastern areas in 2019. The main medium-dense concentrations were found in the south-central part of the sea, while low concentrations were found along the border of their distribution (Fig. 6.2.1). Total abundance of the cod was calculated as 23 x 10^9 individuals.

The average length of cod was 6.52 cm. Cod length varied from 2.5 to 11.5 cm, while dominated by cod of 5-7.5 cm. The smallest cod (with an average length of 5.1cm) were found in North east. Cod of different size group (with an average length of 8.0 cm) were observed in the Central, Svalbard South and Svalbard North. The abundance index of 2019-year class is very low than the long-term mean, and thus may be characterized as weak.

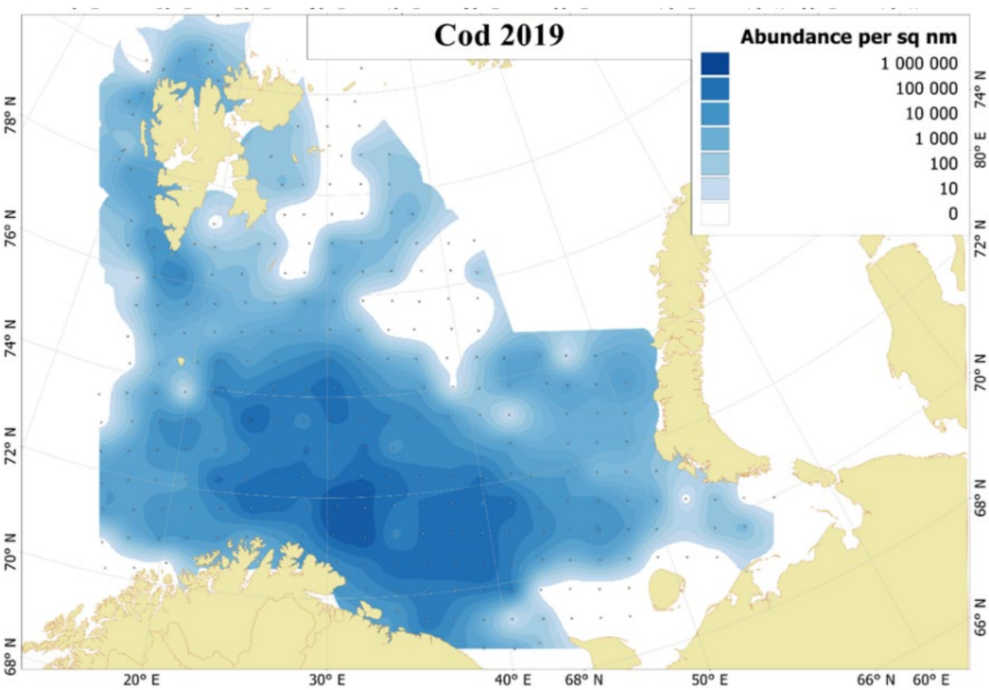

Figure 6.2.1. *Distribution of 0-group cod, August-October 2019. Dots indicate sampling locations.*

6.3 Haddock (*Melanogrammus aeglefinus*)

0-group haddock distributed widely in the western and central Barents Sea in 2019 (Figure 6.3.1). The main dense concentrations were found in the central Barents Sea. Total abundance of the haddock was calculated as 1 x 10^9 individuals.

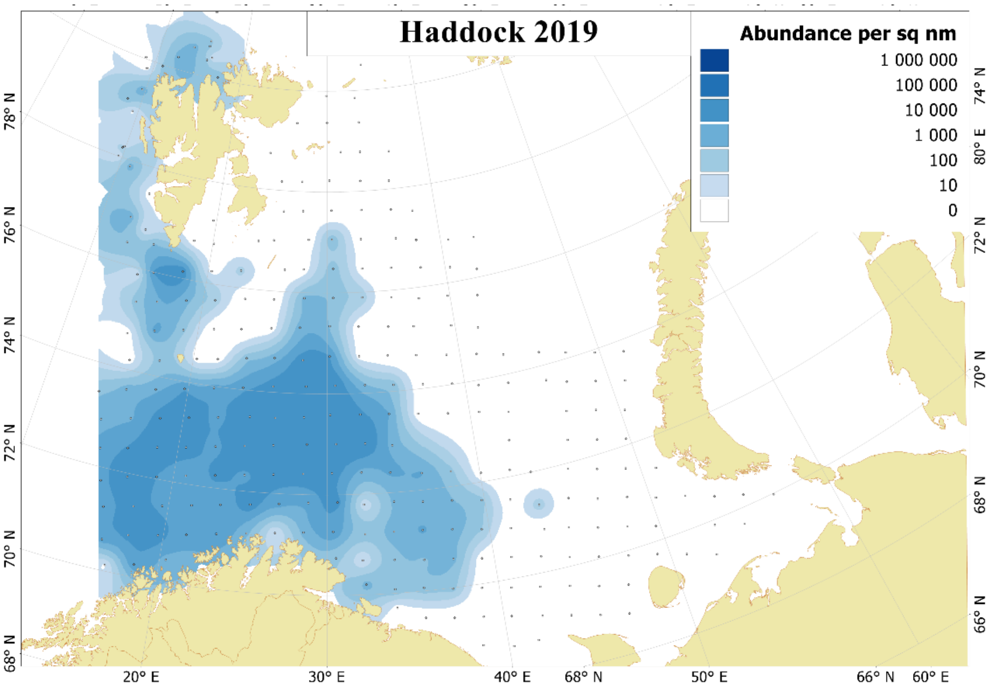

Figure 6.3.1. *Distribution of 0-group haddock, August-October 2019. Dots indicate sampling locations.*

The average length of haddock was 9.1cm. Haddock length varied from 2.5 to 13.5 cm, while dominated by haddock of 8.5-10.5 cm. The smallest haddock (with an average length of 9 cm cm) were found in South West, while the largest (with an average length of 11.4 cm) in the Great Bank area. The abundance index of 2019-year class is low than the long-term mean, and thus may be characterized as weak.

6.4 Herring (*Clupea harengus*)

In 2019, herring were distributed in the central, north western and south-central Barents Sea. The dense concentrations of herring were found central areas (Fig. 6.4.1). Total abundance of the herring was calculated as 17,2 x 10^9 individuals.

The average length of herring was 5,4 cm. Herring length varied from 2.5 to 9.5 cm, while dominated by herring of 4.5-6.5 cm. The smallest herring (with an average length of 5.0 cm) were found in South West, while largest (with an average length close to 8.0 cm) in the Franz Victoria Trough and Great Bank polygons. The abundance index of 2019-year class is low than the long-term mean, and thus may be characterized as weak.

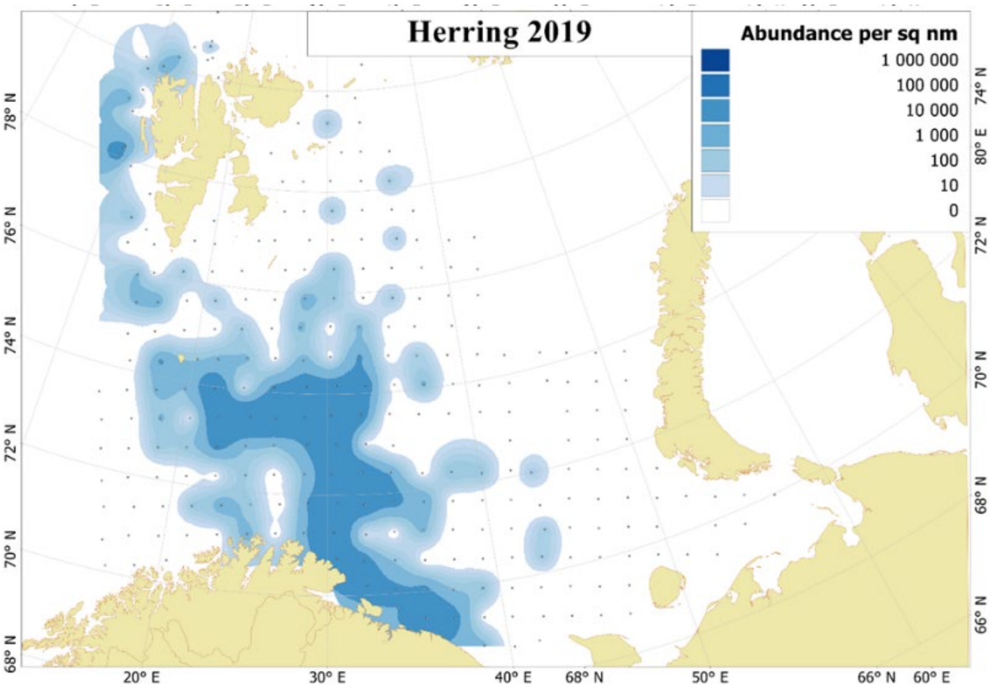

Figure 6.4.1. *Distribution of 0-group herring, August-October 2019. Dots indicate sampling locations.*

6.5 Polar cod (*Boreogadus saida*)

In 2019, the distribution area of 0-group polar cod increased significantly compared to previous years. Polar cod were widely distributed with denser concentration south of the Svalbard (Spitsbergen) and south of Novaya Zemlya (Fig.6.5.1). Total abundance of the polar cod was calculated as 65.9 x 10^9 individuals.

The average length of polar cod was 5,4 cm. Polar cod length varied from 1.5 to 8.0 cm, while dominated by polar cod of 4.0-5.5 cm. The smallest polar cod (with an average length bellow 3.7 cm) were found in Southeastern, while largest (with an average close to 4.8 cm) in the Franz Victoria Trough and Great Bank regions. The abundance index of 2019-year class is low than the long-term mean, but higher than previous six years, and thus may be characterized as weak.

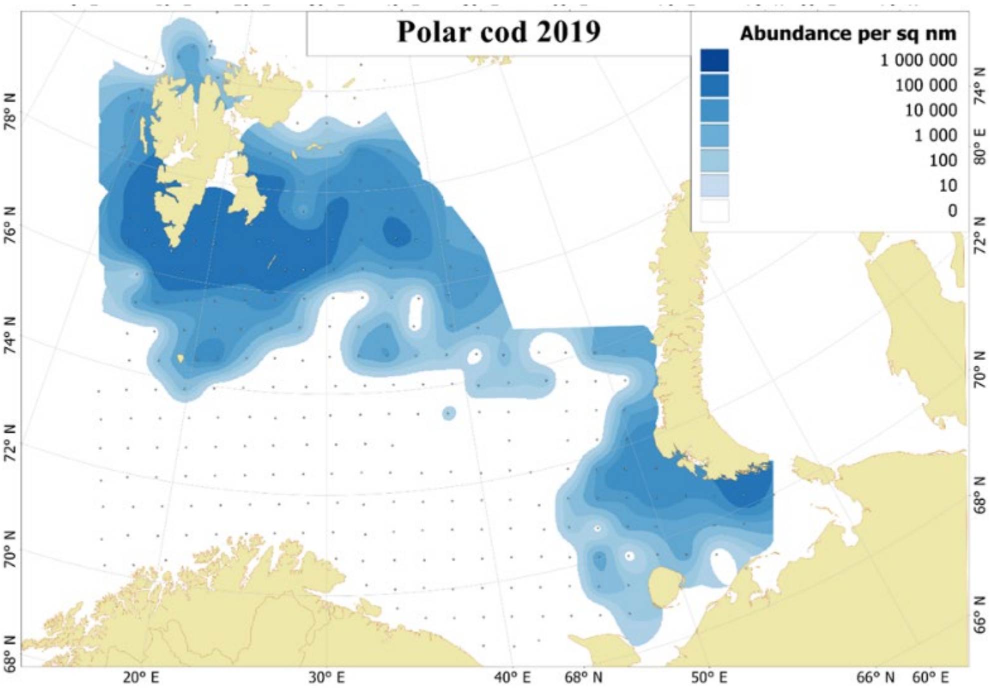

Figure 6.5.1. *Distribution of 0-group polar cod, August-October 2019. Dots indicate sampling locations.*

6.6 Saithe (*Pollachius virens*)

In 2019, saithe was observed rarely. Only a few pieces were caught in the central and coastal (northern Norwegian and Russian coast) areas.

6.7 Redfish (mostly *Sebastes mentella*)

0-group redfish was distributed north of Norwegian coast and south and west of Svalbard (Spitsbergen) in 2019 (Figure 6.7.1). The densest concentrations were found west of Svalbard (Spitsbergen) and in the western Barents Sea. Total abundance of the redfish was calculated as 91.1 x 10^9 individuals.

The average length of redfish was 5,4 cm. Redfish length varied from 0.5 to 5.5 cm, while dominated by redfish of 3.5-4.5 cm. The smallest redfish (with an average length of 2.1cm) were found in South West, while largest (with an average above 4.5 cm) in the Svalbard North and Southeastern Basin stratas. The abundance index of 2019-year class is slightly below the long-term mean and close to 2015, and thus may be characterized as average.

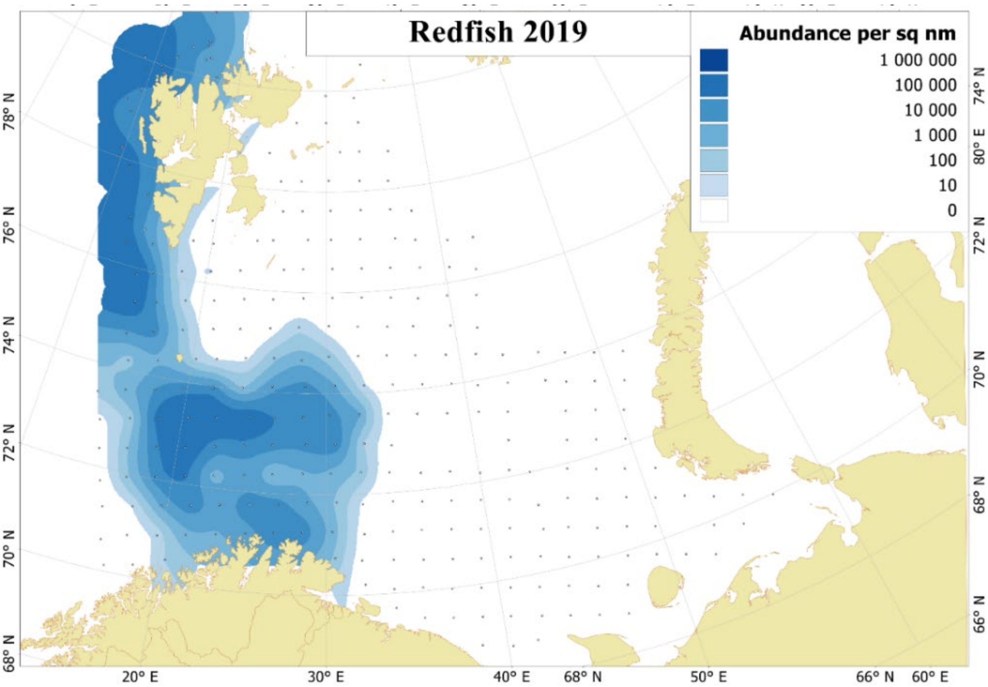

Figure 6.7.1. *Distribution of 0-group redfishes* **(***mostly Sebastes mentella***)***, August-October 2019. Dots indicate sampling locations.*

6.8 Greenland halibut (*Reinhardtius hippoglossoides*)

0-group Greenland halibut was distributed west, north and south of Svalbard (Spitsbergen) in 2019 similar to distribution in 2018 (Figure 6.8.1).

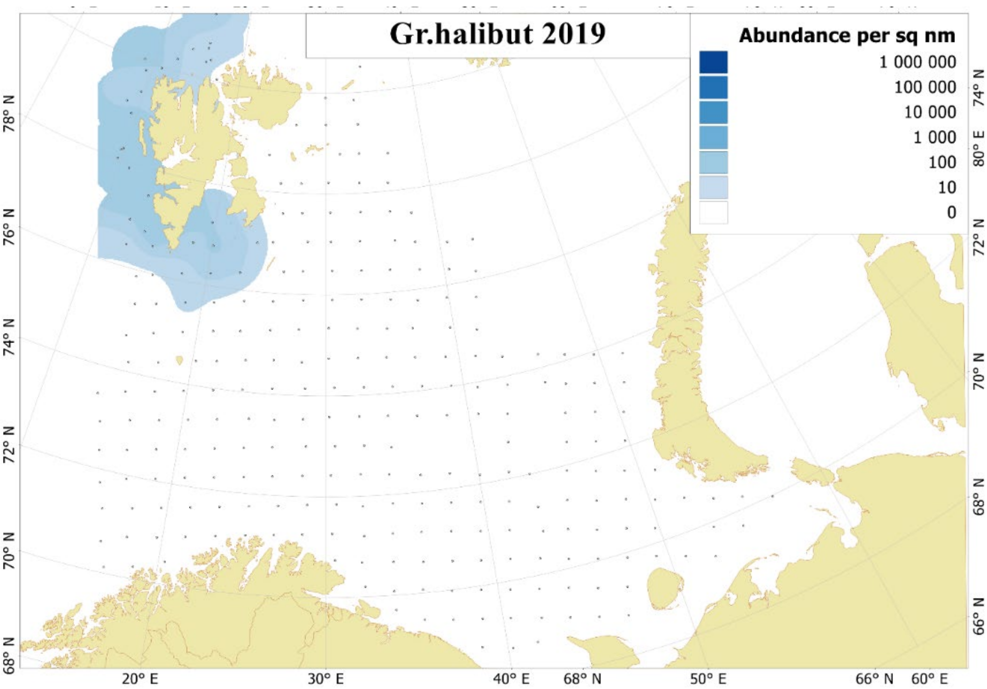

Figure 6.8.1. *Distribution of 0-group Greenland halibut, August-October 2019. Dots indicate sampling locations.*

6.9 Long rough dab (*Hippoglossoides platessoides*)

In 2019, 0-group long rough dab very widely distributed in the Barents Sea (Figure 6.9.1). In comparison to previous years, the number of LRD in catches has increased significantly. This may be due to an increase numbers, but most likely the late juvenile's settlement.

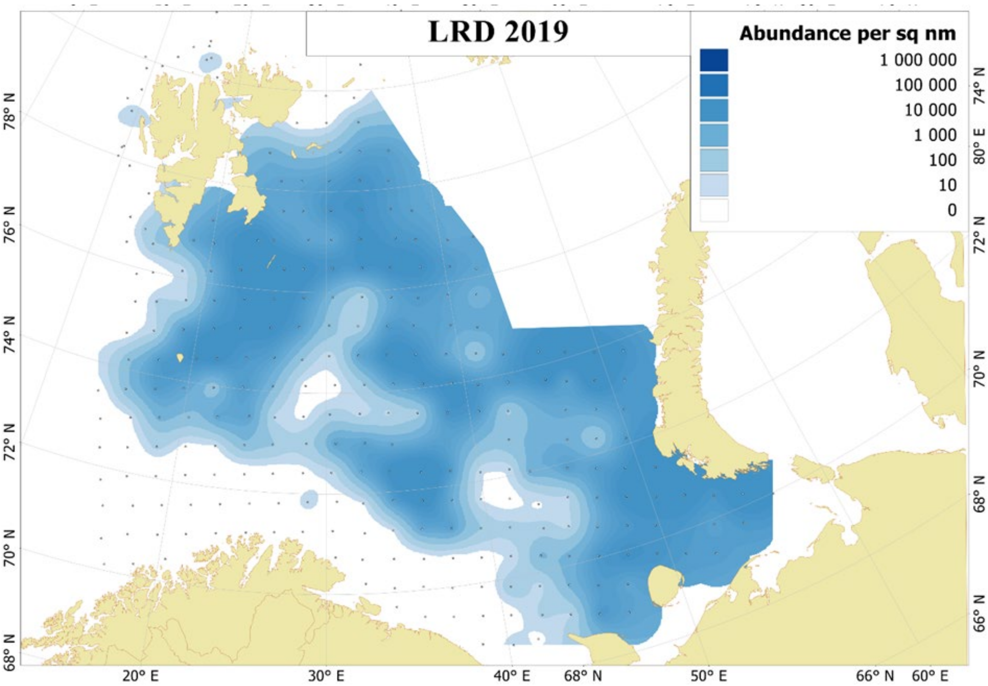

Figure 6.9.1. *Distribution of 0-group long rough dab, August-October 2019. Dots indicate sampling locations.*

6.10 Wolffishes (*Anarhichas sp.*)

There are three species of wolffish live in the Barents Sea: Atlantic wolffish (*Anarhichas lupus*), Spotted wolffish (*Anarhichas minor*) and Northern wolffish (*Anarhichas denticulatus*). 0-group of Atlantic wollfish and Spotted wolffish were widely distributed and were found the western, central and northern Barents Sea in 2019 (Fig. 6.10.1). Northern wolfish was found mainly in the southern and one specimen in the northern Barents Sea.

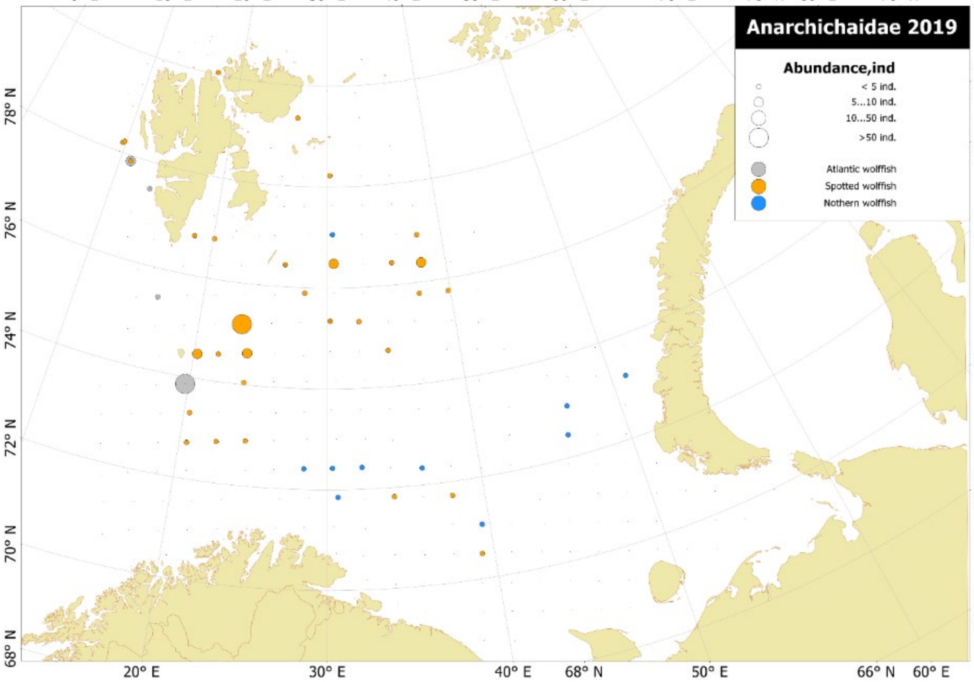

Figure 6.10.1. *Distribution of 0-group wolffishes, August-October 2019. Dots indicate sampling locations.*

6.11 Sandeel (*Ammodytes marinus*)

In 2019, 0-group sandeel were found in the western and central and some few in the southeastern Barents Sea (Figure 6.11.1).

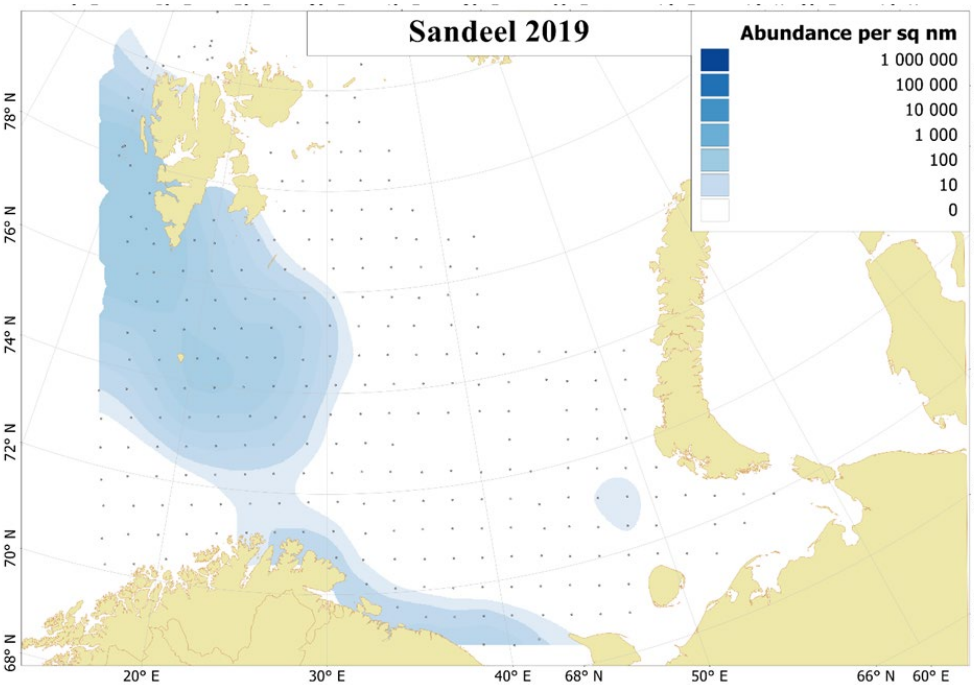

Figure 6.11.1. *Distribution of 0-group sandeel, August-October 2019. Dots indicate sampling locations.*

7 COMMERCIAL PELAGIC FISH

Text by: D. Prozorkevich, and G. Skaret
Figures by: S. Karlson, G. Skaret and D. Prozorkevich,

7.1 Capelin (*Mallotus villosus*)

7.1.1 Geographical distribution

The geographical distribution of capelin recordings is shown in Figure 7.1.1.1. The main distribution area was along the western edges of the Great Bank, and little capelin was found in east and north.

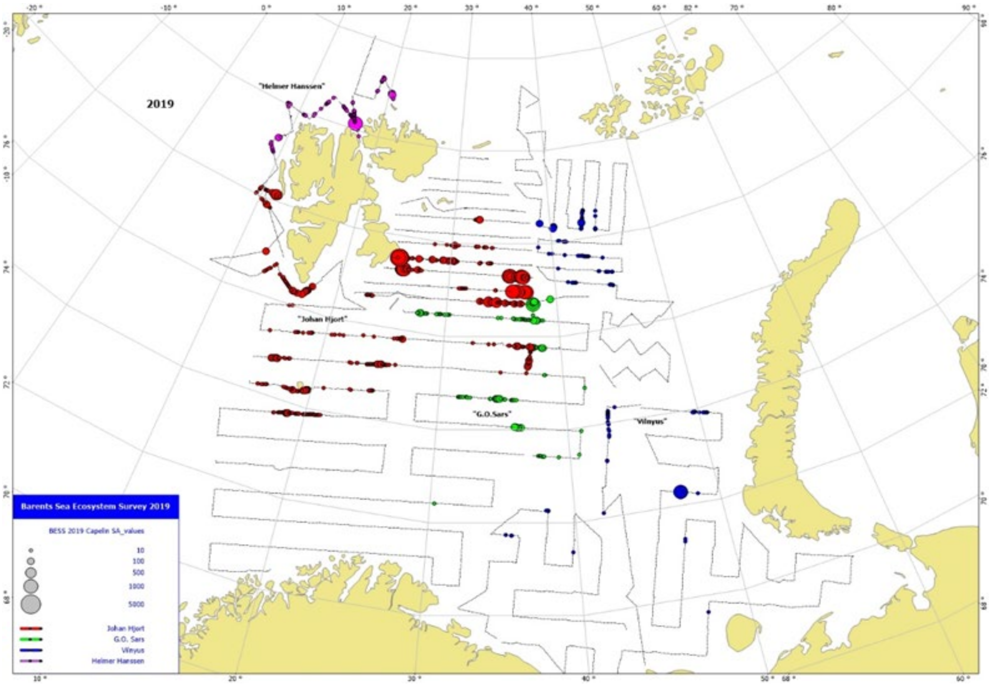

Figure. 7.1.1.1 *Estimated geographical distribution of capelin in autumn 2019. Circle sizes correspond to S_A values per nautical mile.*

7.1.2 Abundance by size and age

A detailed summary of the acoustic stock estimate is given in Table 7.1.2.1, and the time series of abundance estimates is summarized in Table 7.1.2.2. A comparison between the estimates in 2019 and 2018 is given in the table 7.1.2.3 with the 2018 estimate shown on a shaded background.

The total stock is estimated to about 0.41 million tonnes, which is far below the long term mean level (ca. 2.8 million tonnes), and a 75% decrease from 2018. About 73 % (0.30 million tonnes) of the 2019 stock has length above 14 cm and is therefore considered to be maturing. Both the average weights of age group 2+ and 3+ were similar to last year (figure 7.1.2.1).

A more detailed description of biology and stock development of the Barents Sea capelin can be found in the reports of the ICES Working Group on integrated assessment of the Barents Sea (WGIBAR). The work concerning assessment and quota advice for capelin is dealt with in a separate report that will form part of the ICES Arctic Fisheries Working Group report for 2020. Mean weight at age in 2019 was close to long term mean. It reflect capelin feeding conditions during the summer-autumn period. These conditions depends not only the stock size, but also by the state of the plankton community in the Barents Sea. It is evident that in 2019 the capelin food base (zooplankton abundance and species composition) was favorable in 2019 (Figure 7.1.2.1).

Table 7.1.2.1 *Barents Sea capelin. Summary of results from the acoustic estimate in August-October 2019.*

	Age/year class						
Length (cm)	**1**	**2**	**3**	**4**	**Sum 10^9**	**Biomass 10^3 t**	**Mean weight (g)**
	2018	**2017**	**2016**	**2015**			
7.0-7.5	1.121				1.121	1.46	1.3
7.5-8.0	1.756				1.756	2.51	1.4
8.0-8.5	0.985				0.985	2.00	2.0
8.5-9.0	1.874	0.009			1.883	4.65	2.5
9.0-9.5	1.387	0.042			1.429	4.14	2.9
9.5-10.0	1.452	0.006			1.459	5.14	3.5
10.0-10.5	1.522				1.522	6.40	4.2
10.5-11.0	1.598	0.016			1.615	7.91	4.9
11.0-11.5	0.875	0.149	0.053		1.077	6.05	5.6
11.5-12.0	1.112	0.122			1.234	7.79	6.3
12.0-12.5	0.950	0.271			1.221	9.28	7.6
12.5-13.0	0.512	0.418	0.018		0.948	8.38	8.8
13.0-13.5	0.746	0.865	0.027		1.638	16.52	10.1
13.5-14.0	0.554	1.534	0.280		2.369	27.30	11.5
14.0-14.5	0.515	1.094	0.043		1.651	21.56	13.1
14.5-15.0	0.317	1.395	0.124	0.059	1.895	27.99	14.8
15.0-15.5	0.146	1.045	0.267	0.002	1.461	24.49	16.8
15.5-16.0	0.010	1.002	1.391	0.041	2.444	46.28	18.9
16.0-16.5	0.019	0.736	1.195	0.116	2.066	43.83	21.2
16.5-17.0	0.003	0.388	1.537	0.343	2.271	52.69	23.2
17.0-17.5		0.049	0.801	0.244	1.095	28.90	26.4
17.5-18.0		0.101	0.665	0.178	0.945	28.35	30.0
18.0-18.5		0.014	0.551	0.149	0.714	23.06	32.3
18.5-19.0		0.003	0.060	0.015	0.078	2.75	35.1
19.0-19.5			0.024	0.008	0.032	1.21	37.9
19.5-20.0				0.006	0.006	0.24	38.0
20.0-20.5				0.006	0.006	0.26	41.0
20.5-21.0				+	+	+	44.0
TSN 10^9	17.455	9.260	7.036	1.169	34.92		
TSB 10^3 t	86.015	134.535	160.425	30.171		411.147	
Mean length (cm)	10.03	14.26	16.22	16.83		12.63	
Mean weight (g)	4.93	14.53	22.8	25.71			11.77
SSN 10^9	1.01	5.828	6.658	1.169	14.593	105.593	
SSB 10^3 t	14.518	100.915	156.138	30.057			301.615

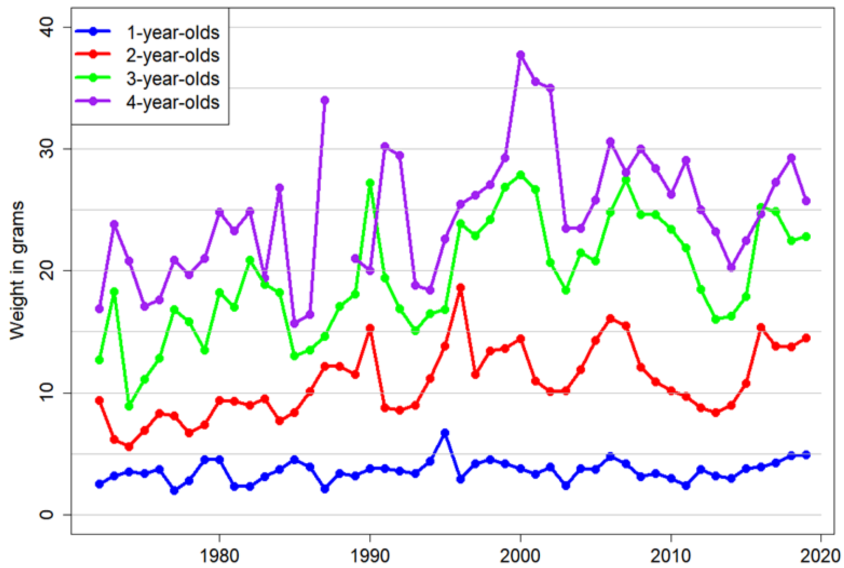

Figure 7.1.2.1. *Weight at age (grams) for capelin in August-September 1972-2019.*

Table 7.1.2.3. *Table on summary of acoustic stock size estimates for capelin in 2018-2019. A comparison between the estimates this year and the previous year (shaded background)*

Year class		Age	Numbers (10^9)		Mean weight (g)		Biomass (10^3 t)	
2018	2017	1	17.5	58.6	4.93	4.86	90	290
2017	2016	2	9.3	59.6	14.53	13.79	130	800
2016	2015	3	7.0	21.4	22.80	22.45	160	480
2015	2014	4	1.2	0.3	25.71	29.28	30	9
Total stock in:								
2019	2018	1-4	34.9	139.9	11.77	11.54	411	1597

Table 7.1.2.2. *Barents Sea capelin. Acoustic estimates of the stock by age in autumn 1973- 2019. Biomass (B) in 10^6 tonnes and average weight (AW) in grams. All estimates based on TS = 19.1 log (L) - 74.0 dB*

	Age										
Year	1		2		3		4		5		Sum
	B	AW	B	AW	B	AW	B	AW	B	AW	B
1973	1.69	3.2	2.32	6.2	0.73	18.3	0.41	23.8	0.01	30.1	5.14
1974	1.06	3.5	3.06	5.6	1.53	8.9	0.07	20.8	+	25.0	5.73
1975	0.65	3.4	2.39	6.9	3.27	11.1	1.48	17.1	0.01	31.0	7.81
1976	0.78	3.7	1.92	8.3	2.09	12.8	1.35	17.6	0.27	21.7	6.42
1977	0.72	2.0	1.41	8.1	1.66	16.8	0.84	20.9	0.17	22.9	4.80
1978	0.24	2.8	2.62	6.7	1.20	15.8	0.17	19.7	0.02	25.0	4.25
1979	0.05	4.5	2.47	7.4	1.53	13.5	0.10	21.0	+	27.0	4.16
1980	1.21	4.5	1.85	9.4	2.83	18.2	0.82	24.8	0.01	19.7	6.71
1981	0.92	2.3	1.83	9.3	0.82	17.0	0.32	23.3	0.01	28.7	3.90
1982	1.22	2.3	1.33	9.0	1.18	20.9	0.05	24.9			3.78
1983	1.61	3.1	1.90	9.5	0.72	18.9	0.01	19.4			4.23
1984	0.57	3.7	1.43	7.7	0.88	18.2	0.08	26.8			2.96
1985	0.17	4.5	0.40	8.4	0.27	13.0	0.01	15.7			0.86
1986	0.02	3.9	0.05	10.1	0.05	13.5	+	16.4			0.12
1987	0.08	2.1	0.02	12.2	+	14.6	+	34.0			0.10
1988	0.07	3.4	0.35	12.2	+	17.1					0.43
1989	0.61	3.2	0.20	11.5	0.05	18.1	+	21.0			0.86
1990	2.66	3.8	2.72	15.3	0.44	27.2	+	20.0			5.83
1991	1.52	3.8	5.10	8.8	0.64	19.4	0.04	30.2			7.29
1992	1.25	3.6	1.69	8.6	2.17	16.9	0.04	29.5			5.15
1993	0.01	3.4	0.48	9.0	0.26	15.1	0.05	18.8			0.80
1994	0.09	4.4	0.04	11.2	0.07	16.5	+	18.4			0.20
1995	0.05	6.7	0.11	13.8	0.03	16.8	0.01	22.6			0.19
1996	0.24	2.9	0.22	18.6	0.05	23.9	+	25.5			0.50
1997	0.42	4.2	0.45	11.5	0.04	22.9	+	26.2			0.91
1998	0.81	4.5	0.98	13.4	0.25	24.2	0.02	27.1	+	29.4	2.06
1999	0.65	4.2	1.38	13.6	0.71	26.9	0.03	29.3			2.77
2000	1.70	3.8	1.59	14.4	0.95	27.9	0.08	37.7			4.27
2001	0.37	3.3	2.40	11.0	0.81	26.7	0.04	35.5	+	41.4	3.63
2002	0.23	3.9	0.92	10.1	1.04	20.7	0.02	35.0			2.21
2003	0.20	2.4	0.10	10.2	0.20	18.4	0.03	23.5			0.53
2004	0.20	3.8	0.29	11.9	0.12	21.5	0.02	23.5	+	26.3	0.63
2005	0.10	3.7	0.19	14.3	0.04	20.8	+	25.8			0.32
2006	0.29	4.8	0.35	16.1	0.14	24.8	0.01	30.6	+	36.5	0.79
2007	0.93	4.2	0.85	15.5	0.10	27.5	+	28.1			2.12
2008	0.97	3.1	2.80	12.1	0.61	24.6	0.05	30.0			4.43
2009	0.42	3.4	1.82	10.9	1.51	24.6	0.01	28.4			3.77
2010	0.74	3.0	1.30	10.2	1.43	23.4	0.02	26.3			3.50
2011	0.50	2.4	1.76	9.7	1.21	21.9	0.23	29.1			3.71
2012	0.54	3.7	1.37	8.8	1.62	18.5	0.06	25.0			3.59
2013	1.04	3.2	1.81	8.4	0.94	16.0	0.16	23.2	+	29.1	3.96
2014	0.32	3.0	0.95	9.0	0.64	16.3	0.04	20.3			1.95
2015	0.14	3.8	0.40	10.8	0.20	17.9	0.09	22.5	+	28.1	0.84
2016	0.12	3.9	0.12	15.3	0.08	25.2	0.00	24.7			0.33
2017	0.37	4.3	1.70	13.8	0.42	24.9	0.01	27.3			2.51
2018	0.29	4.9	0.80	13.8	0.48	22.4	0.01	29.3			1.60
2019	0.09	4.9	0.13	14.5	0.16	22.8	0.03	25.7			0.41
Average	0.62	3.6	1.28	10.9	0.80	19.6	0.18	24.9	0.07	28.1	2.83

7.2 Polar cod (*Boreogadus saida*)

7.2.1 Geographical distribution

In 2019, polar cod were found mainly in the northeastern part of the survey area. Single concentrations were also recorded to south and to north of Svalbard (Spitsbergen). The BESS survey area has been regularly decreasing in recent years, especially in the north-eastern part. In 2019 the northeastern part of the survey was not fully surveyed also (Fig.7.2.1.1). There is a high probability that part of the polar cod stock distributed outside survey area.

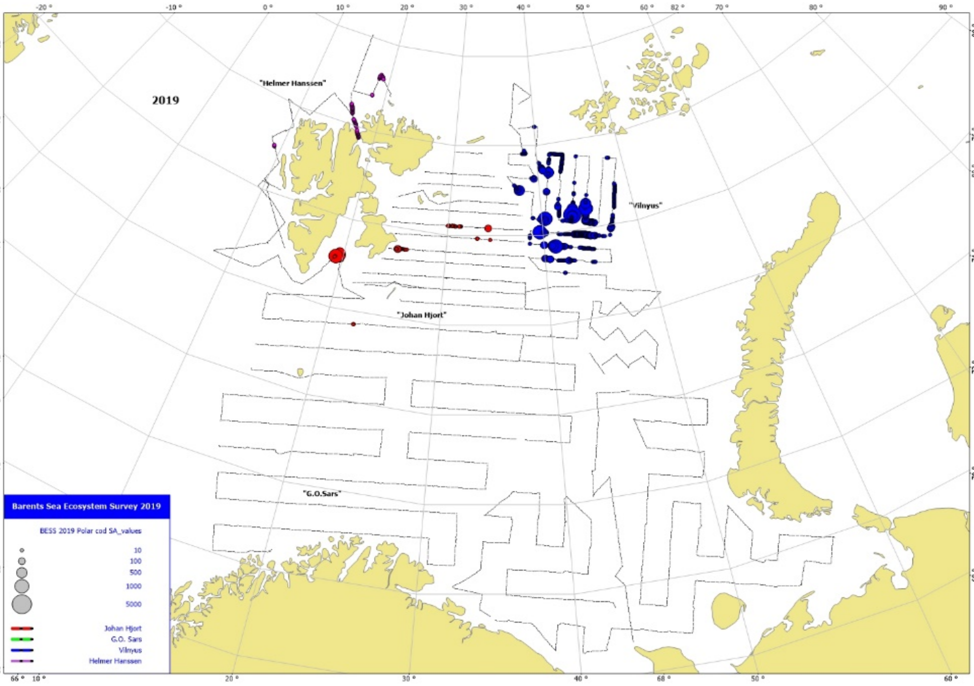

Figure 7.2.1.1 *Estimated geographical distribution of polar cod in autumn 2019. Circle sizes correspond to S_A values per nautical mile.*

7.2.2 Abundance estimation

Reducing the survey area, together with the changing hydrological conditions in the Barents Sea does not allow to perform correct estimates of the polar cod stock. For this reason, stock size estimations are highly uncertain.

The stock abundance estimate by age number and weight in 2019 is given in Table 7.2.2.1 and the time series of abundance estimates is summarized in Table 7.2.2.2.

In 2019, the polar cod stock inside surveyed area decrease and close to the minimum level in the history of observations. For all age groups number and biomass in 2019 significant below long term level. The 1-year-olds dominated the total numbers (81 %) which was estimated at 6.11 bill.ind.

Table 7.2.2.1 *Barents Sea polar cod. Acoustic estimate in the Barents Sea in August-October 2019.*

Length (cm)	Age group / year class				Sum	Biomass	Mean,
	1	2	3	4+	(10^9)	(10^3 t)	weight (g)
	2018	2017	2016	2015+			
7.0 - 7.9	0.1336				0.1336	0.35	2.63
8.0 - 8.9	0.6855	0.0003			0.6858	2.70	3.94
9.0 - 9.9	1.5577	0.0079			1.5656	9.23	5.89
10.0 - 10.9	1.8727	0.0191	0.0004		1.8922	14.97	7.91
11.0 - 11.9	0.9982	0.0179	0.0025		1.0187	10.70	10.51
12.0 - 12.9	0.6751	0.0377	0.0408		0.7536	10.27	13.62
13.0 - 13.9	0.1765	0.2032	0.0074		0.3870	6.53	16.87
14.0 - 14.9	0.0046	0.3208	0.0088	0.0001	0.3343	7.61	22.75
15.0 - 15.9	0.0047	0.2808	0.0384	0.0011	0.3250	8.68	26.72
16.0 - 16.9		0.2220	0.0588	0.0007	0.2814	8.60	30.57
17.0 - 17.9		0.0646	0.0329	0.0014	0.0988	3.66	37.03
18.0 - 18.9		0.0313	0.0147	0.0005	0.0465	1.89	40.62
19.0 - 19.9		0.0116	0.0005	0.0063	0.0184	0.99	54.03
20.0 - 20.9		0.0001	0.0037	0.0001	0.0040	0.24	60.2
21.0 - 21.9			0.0034	0.0003	0.0037	0.27	72.98
22.0 - 22.9			0.0010	0.0018	0.0028	0.21	76.79
23.0 - 23.9				0.0023	0.0023	0.22	94.0
24.0 - 24.9			0.0008		0.0008	0.08	101.0
TSN (10^9)	6.109	1.217	0.214	0.014	7.555		
TSB (10^3 t)	49.75	30.302	6.307	0.846		87.201	
Mean length (cm)	10.19	14.75	15.53	19.84		11.34	
Mean weight (g)	8.14	24.89	29.48	58.1			11.54

Table 7.2.2.2 *Barents Sea polar cod. Summary of acoustic estimates by age in August-October. TSN and TSB are total stock numbers (10^9) and total stock biomass (10^3 tonnes) respectively*

Year	Age 1		Age 2		Age 3		Age 4+		Total	
	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB
1986	24.038	169.6	6.263	104.3	1.058	31.5	0.082	3.4	31.441	308.8
1987	15.041	125.1	10.142	184.2	3.111	72.2	0.039	1.2	28.333	382.8
1988	4.314	37.1	1.469	27.1	0.727	20.1	0.052	1.7	6.562	86.0
1989	13.54	154.9	1.777	41.7	0.236	8.6	0.06	2.6	15.613	207.8
1990	3.834	39.3	2.221	56.8	0.65	25.3	0.094	6.9	6.799	127.3
1991	23.67	214.2	4.159	93.8	1.922	67	0.152	6.4	29.903	381.5
1992	22.902	194.4	13.992	376.5	0.832	20.9	0.064	2.9	37.79	594.9
1993	16.269	131.6	18.919	367.1	2.965	103.3	0.147	7.7	38.3	609.7
1994	27.466	189.7	9.297	161	5.044	154	0.79	35.8	42.597	540.5
1995	30.697	249.6	6.493	127.8	1.61	41	0.175	7.9	38.975	426.2
1996	19.438	144.9	10.056	230.6	3.287	103.1	0.212	8	33.012	487.4
1997	15.848	136.7	7.755	124.5	3.139	86.4	0.992	39.3	28.012	400.7
1998	89.947	505.5	7.634	174.5	3.965	119.3	0.598	23	102.435	839.5
1999	59.434	399.6	22.76	426	8.803	286.8	0.435	25.9	91.463	1141.9
2000	33.825	269.4	19.999	432.4	14.598	597.6	0.84	48.4	69.262	1347.8
2001	77.144	709	15.694	434.5	12.499	589.3	2.271	132.1	107.713	1869.6
2002	8.431	56.8	34.824	875.9	6.35	282.2	2.322	143.2	52.218	1377.2
2003*	32.804	242.7	3.255	59.9	15.374	481.2	1.739	87.6	53.172	871.4
2004	99.404	627.1	22.777	404.9	2.627	82.2	0.51	32.7	125.319	1143.8
2005	71.675	626.6	57.053	1028.2	3.703	120.2	0.407	28.3	132.859	1803.3
2006	16.19	180.8	45.063	1277.4	12.083	445.9	0.698	37.2	74.033	1941.2
2007	29.483	321.2	25.778	743.4	3.23	145.8	0.315	19.8	58.807	1230.1
2008	41.693	421.8	18.114	522	5.905	247.8	0.415	27.8	66.127	1219.4
2009	13.276	100.2	22.213	492.5	8.265	280	0.336	16.6	44.09	889.3
2010	27.285	234.2	18.257	543.1	12.982	594.6	1.253	58.6	59.777	1430.5
2011	34.46	282.3	14.455	304.4	4.728	237.1	0.514	36.7	54.158	860.5
2012	13.521	113.6	4.696	104.3	2.121	93	0.119	8	20.457	318.9
2013	2.216	18.1	4.317	102.2	5.243	210.3	0.18	9.9	11.956	340.5
2014	0.687	6.5	4.439	110	3.196	121	0.08	5.3	8.402	243.2
2015	10.866	97.1	1.995	45.1	0.167	5.3	0.008	0.5	13.036	148.0
2016	95.919	792.7	6.38	139.1	0.207	6.9	0.023	0.7	102.529	939.4
2017	13.81	121.82	8.269	200.8	1.112	34.29	0.0032	0.14	23.195	357.05
2018**	1.90	16.45	0.98	23.104	0.24	9.434	0.014	0.605	3.124	49.60
2019**	6.109	49.75	1.217	30.302	0.214	6.307	0.014	0.846	7.555	87.201
Average	30.16	241.33	13.69	313.52	4.60	173.35	0.48	26.28	48.97	756.16

*- data partly recovered by VPA.

**- incomplete coverage survey area

7.3 Herring (*Clupea harengus*)

7.3.1 Geographical distribution

Compared to 2018 year, the geographic distribution of young Norwegian spring spawning herring (NSSH) was well covered. Herring was distributed separately in two large areas - in the eastern part of the Barents Sea, between the Kanin Peninsula and Novaya Zemlya and along the coast of northern Norway (Figure 7.3.1.1). In the eastern part of the Barents Sea herring at the age of 1 year prevailed. To west of 20 ° mostly older age groups were recorded.

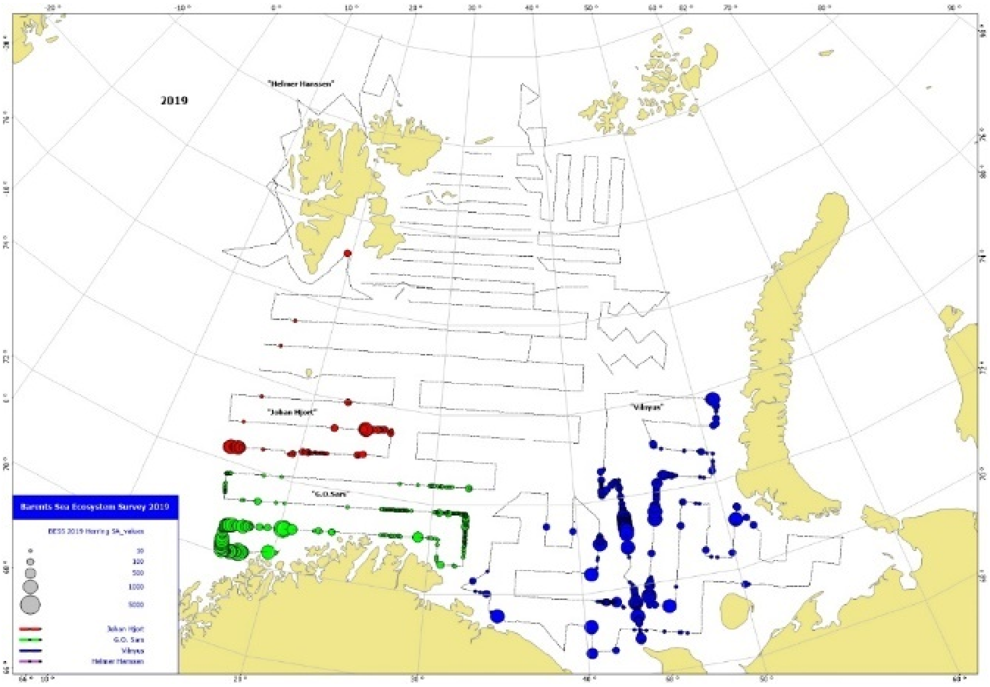

Figure 7.3.1.1 *Estimated geographical distribution of herring in autumn 2019. Circle sizes correspond to S_A values per nautical mile.*

7.3.2 Abundance estimation

The total number and biomass of NSSH in the Barents Sea in the autumn 2019 shown in table 7.3.2.1. Total numbers for ages 1-4+ in 2019 was estimated at 21.5 billion individuals. It is little lower than the long term level (Table 7.3.2.2). Number of 1-year-olds was estimated at 13.65 billion individuals. It is below the long-term average (15.93 billion individuals) but second largest value in recent 12 years. There was an estimated 6 billion 3+ which is well above the long-term level and this confirms the numerous of the 2016 year class. The abundance older age groups (4 years and more) was also estimated at a relative high level (1.6 billons ind).

Two surveys for juvenile NSSH assessment currently being carried out in the Barents Sea. The first survey in May-June (IESNS) and the second in August-October (BESS). IESNS covered more larger area in western parth of Barents sea, thus, it is difficult to compare surveys results directly.

Comparison the results of two surveys by ages showed different stock structure. BESS shows more abundant ages 1 + and 4+, less 2+ and 3+ years. However, both surveys estimate the 2016 year class as numerous. Herring numbers (bill.ind) by age groups from the BESS and IESNS (in brackets) are shown below.

Age 1+:**13.65** (0.11), age 2+: **0.21** (2.31), age 3+: **6.0** (17.31), age 4+:**0.4** (0.23), total: **21.46** (19.75).

Table 7.3.2.1 *Norwegian spring spawning herring. Acoustic estimate in the Barents Sea in August-October 2019*

			Age/year class						
Length,	2018	2017	2016	2015	2014	2013+	Sum	Biomass	Mean
(cm)	1	2	3	4	5	6+	(10^9)	(10^3 t)	weight (g)
10-11	0.9184						0.918	5.97	6.5
11-12	4.4595						4.460	42.50	9.53
12-13	4.2417						4.242	50.12	11.82
13-14	3.0587						3.059	43.38	14.18
14-15	0.0098						0.010	0.21	21.4
15-16	0.7567						0.757	22.02	29.11
16-17	0.1215						0.122	4.23	34.79
17-18	0.0770	0.0478					0.125	4.91	39.36
18-19	0.0022	0.0486					0.051	2.38	46.87
19-20		0.0127					0.013	0.71	56.33
20-21	0.0006		0.0003				0.001	0.06	64.67
21-22		0.0014	0.0036				0.005	0.37	74.55
22-23		0.0045	0.0341				0.039	3.21	83.33
23-24		0.0642	2.8244				2.889	274.46	95.01
24-25		0.0109	0.1154				0.126	13.47	106.68
25-26		0.0195	1.2139				1.233	155.35	125.95
26-27			0.6048				0.605	90.61	149.81
27-28			0.6336				0.634	108.81	171.75
28-29			0.2814	0.0156			0.297	56.63	190.62
29-30			0.2104	0.0271			0.238	51.19	215.51
30-31			0.0824	0.0741		0.0824	0.239	60.82	254.66
31-32				0.2011	0.1532	0.0383	0.393	114.10	290.66
32-33				0.0842	0.1515	0.4040	0.640	197.66	308.97
33-34					0.0214	0.2887	0.310	106.00	341.86
34-35						0.0367	0.037	12.66	344.6
35-36						0.0210	0.021	8.20	391.33
TSN (10^9)	13.646	0.209	6.004	0.402	0.326	0.871	21.459		
TSB (10^3t)	171.62	15.06	756.07	112.16	98.65	276.50		1430.05	
Mean length (cm)	12.5	20.9	25.2	31.3	32.1	32.8			
Mean weight (g)	12.6	71.9	125.9	278.9	302.5	317.4			66.64

Table 7.3.2.2 *Norwegian spring spawning herring. Summary of acoustic estimates by age in autumn 1999-2019. TSN and TSB are total stock numbers (10^9) and total stock biomass (10^3 tonnes) respectively*

Year	Age 1		Age 2		Age 3		Age 4+		Total	
	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB
1999	48.759	716	0.986	31	0.051	2	0	0	49.795	749
2000	14.731	383	11.499	560	0	0	0	0	26.230	943
2001	0.525	12	10.544	604	1.714	160	0	0	12.783	776
2002	**No data**	–	–	–	–	–	–	–	–	–
2003	99.786	3090	4.336	220	2.476	326	0	0	106.597	3636
2004	14.265	406	36.495	2725	0.901	107	0	0	51.717	3252
2005	46.38	984	16.167	1055	6.973	795	0	0	69.520	2833
2006	1.618	34	5.535	398	1.620	211	0	0	8.773	643
2007	3.941	148	2.595	218	6.378	810	0.25	46	13.164	1221
2008	0.03	1	1.626	77	3.987**	287**	3.223**	373**	8.866**	738**
2009	0.002	48	0.433	52	1.807	287	1.686	393	5.577	815
2010	1.047	35	0.215	34	0.234	37	0.428	104	2.025	207
2011	0.095	3	1.504	106	0.006	1	0	0	1.605	109
2012	2.031	36	1.078	66	1.285	195	0	0	4.394	296
2013	7.657	202	5.029	322	0.092	13	0.057	9	12.835	546
2014	4.188	62	1.822	126	6.825	842	0.162	25	13.011	1058
2015	1.183	6	9.023	530	3.214	285	0.149	24	13.569	845
2016	7.760	131	1.573	126	3.089	389	0.029	6	12.452	652
2017	34.95	820	2.138	141	3.465	412	0.982	210	41.537	1583
2018	**No data**	–	–	–	–	–	–	–	–	–
2019	13.65	172	0.209	15.06	6.00	756	1.6	487	21.46	1430
Average	15.93	384	5.94	390	2.64	311	0.45	88	25.05	1175

** including several Kanin herring (mix concentration in south-east area)

7.4 Blue whiting (*Micromesistius poutassou*)

7.4.1 Geographical distribution

Blue whiting is an important component of the Barents Sea ecosystem, and changes in the stock of blue whiting in the Norwegian Sea are also observed in the Barents Sea.

As in previous years, blue whiting was observed in the western part of the Barents Sea, in particular along the continental shelf slope (Figure 7.4.1.1).

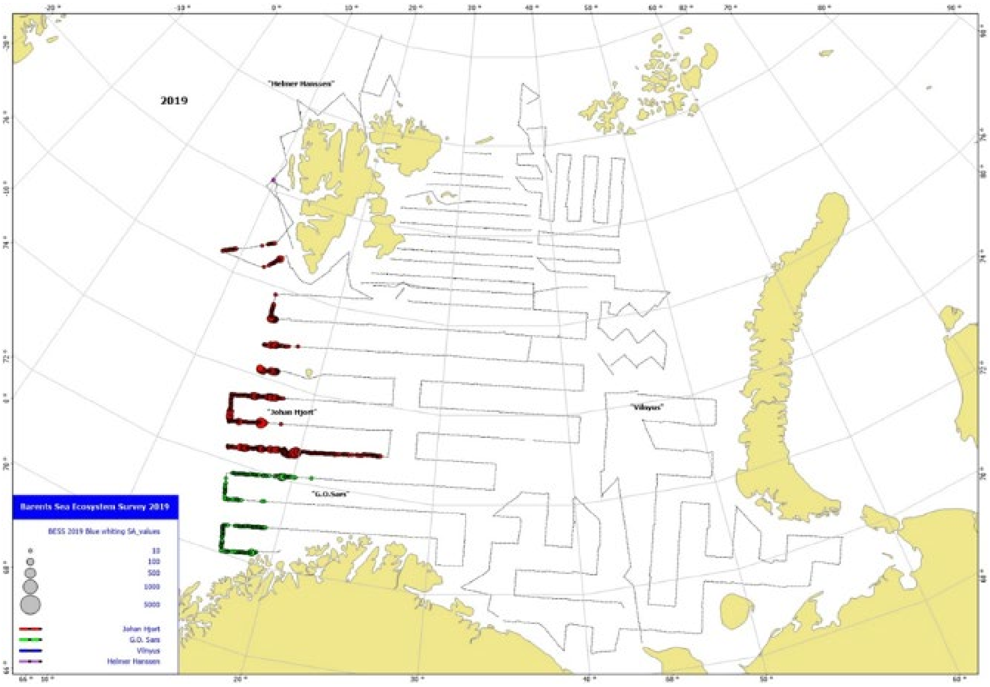

Figure 7.4.1.1. *Estimated geographical distribution of blue whiting in autumn 2019. Circle sizes correspond to S_A values per nautical mile.*

7.4.2 Abundance by size and age

From 2004-2007 estimated biomass of blue whiting in the Barents Sea was between 200 000 and 350 000 tonnes (Table 7.4.2.1). In 2008 the estimated biomass dropped abruptly to only about 18% of the estimated biomass in the previous year, and it stayed low until 2012. From 2012 onwards it has been variable, and this year the biomass was low, at a similar level as last year and clearly below the long term average.

The 5-year olds (2014 year class) still dominate in terms of both number and biomass as expected based on the high abundance of the 2014 year class in previous years (Table 7.4.2.2 and 7.4.2.3).

Table 7.4.2.1 *Blue whiting. Acoustic estimate in the Barents Sea in August-October 2019*

	Age/year class														
Length (cm)	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2005	Sum (10^6)	Biomass (10^3 t)	Mean weight (g)
	1	2	3	4	5	6	7	8	9	10	11	14			
15-16	0.3												0.3	8.0	24.0
16-17	4.0												4.0	0.1	24.0
17-18		23.1											23.1	0.7	30.0
18-19	14.3	10.9											25.3	0.8	30.1
19-20	19.2												19.2	0.8	41.0
20-21		6.8											6.8	0.3	39.8
21-22	7.3												7.3	0.4	48.3
22-23	4.4	1.3											5.8	0.3	52.4
23-24	4.5	0.2											4.7	0.3	62.0
24-25				3.1	2.0								5.1	0.4	85.8
25-26					12.0								12.0	1.2	101.3
26-27			21.1										21.1	2.2	104.9
27-28		6.0	23.6										29.6	3.9	131.9
28-29		2.1	19.9	4.5	16.2								42.7	6.1	142.7
29-30				30.6	9.0	2.8		6.3					48.7	7.5	153.6
30-31		13.9	1.4		22.2	3.2							40.7	6.9	169.5
31-32			0.2	3.0	11.1	4.5	2.4						21.2	4.2	197.7
32-33				0.4	8.2	0.3							8.9	2.0	222.7
33-34				4.0		0.3	3.7						8.0	1.7	210.0
34-35							2.2				1.6		3.7	0.9	238.6
35-36					1.7				2.3				4.0	1.1	277.6
36-37				0.4		1.6		0.2			0.2		2.4	0.7	271.0
37-38					0.9							0.9	1.8	0.5	279.4
38-39												0.1	0.1	33.1	309.5
39-40								0.1		0.1	0.1		0.4	0.1	339.6
TSN (10^6)	54.0	64.4	66.3	46.1	83.2	12.5	8.4	6.6	2.3	0.1	1.9	1.0	346.9		
TSB (10^3 t)	2.2	4.9	8.4	7.0	13.6	2.5	1.7	1.2	0.6	0.0	0.5	0.3		42.9	
Mean length (cm)	19.6	22.0	27.3	29.4	29.4	31.1	32.8	29.7	35.2	39.5	34.7	37.4			
Mean weight (g)	40.0	76.5	127.0	152.3	163.1	198.0	205.5	182.1	276.2	340.0	258.5	293.0			124.0

Table 7.4.2.2 *Blue whiting. Summary of acoustic estimates by age in August-October. TSN and TSB are total stock numbers (10^6) and total stock biomass (10^3 tonnes) respectively*

Year	Age 1		Age 2		Age 3		Age 4+		Total	
	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB	TSN	TSB
2004	669	26	439	33	1056	98	1211	159	3575	327
2005	649	20	523	36	1051	86	809	102	3039	244
2006	47	2	478	34	730	70	922	129	2177	235
2007			116	11	892	92	743	107	1757	210
2008					10	1	238	36	247	37
2009	1				6	1	359	637	366	65
2010			2		5	1	155	31	163	33
2011	2		2		13	2	93	22	109	25
2012	583	27	64	8	58	9	321	77	1025	121
2013	1	0	349	28	135	13	175	42	664	84
2014	111	5	19	2	185	20	127	28	443	55
2015	1768	71	340	29	134	15	286	44	2529	159
2016	277	13	1224	82	588	48	216	36	2351	188
2017	43	2	253	22	503	49	269	38	1143	115
2018			18	1	74	8	215	29	332	40
2019	54	2	64	5	66	8	162	27	347	43
Average	263	11	243	18	344	33	394	97	1267	124

Target strength estimation based on formula: TS = 20 log (L) - 65.2 (Recalculation by Åge Høines, IMR 2017)

Table 7.4.2.3 *Summary of stock size estimates for Blue whiting in 2018-2019*

Year class		Age	Numbers (10^9)		Mean weight (g)		Biomass (10^3 t)	
2018	2017	1	17.5	58.6	4.93	4.86	86.0	285
2017	2016	2	9.3	59.6	14.53	13.79	134.5	821.9
2016	2015	3	7.0	21.4	22.80	22.45	160.4	480.3
2015	2014	4	1.2	0.3	25.71	29.28	30.2	9.3
Total stock in:								
2019	2018	1-4	34.9	139.9	11.77	11.54	411.1	1598

8 COMMERCIAL DEMERSAL FISH

Text by: E. Johannesen, A. Russkikh, B. Bogstad, E. H. Hallfredsson, H. Höffle, and D. Prozorkevitch
Figures by: P. Krivosheya

This section provides data on the distribution for the main commercial fish species.
In 2019 the area covered was larger than in 2018, but data was lacking in northeast and in most of the Loop hole (international waters). Indices based on the 2019 ecosystem survey data used in assessment for cod, haddock, the redfishes and Greenland halibut (chapter 8.1-8.2, 8.4-8.6) will be presented in the Arctic Fisheries Working Group report in 2020. Preliminary estimates are presented in the table 8.1.

8.1 Cod (*Gadus morhua*)

At the time of survey cod usually reaches the northern and eastern limits of its feeding area. In general, the cod was distributed almost over the entire area surveyed (Fig. 8.1), but cod was practically absent in the area between the northeastern part of Svalbard (Spitsbergen) and Franz Josef Land, where large concentrations have been found in previous years. There was no coverage in the northeast, probably some cod were distributed northeast of the covered areas.

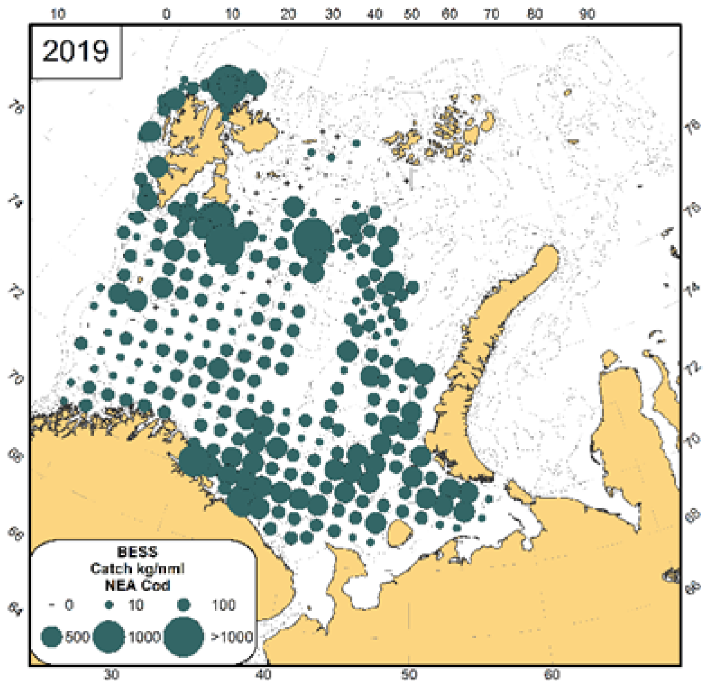

Figure 8.1.1 *Distribution of cod (Gadus morhua), August-October 2019.*

8.2 Haddock (*Melanogrammus aeglefinus*)

Within the area surveyed, the haddock distribution in 2019 was similar to that found in 2017 but a larger proportion appears to be distributed further east compared to 2017. Main concentrations of haddock in 2019 observed on shallow waters along Murman Rise and Kanin bank (Fig.8.2). There was no coverage here in 2018, so we cannot compare.

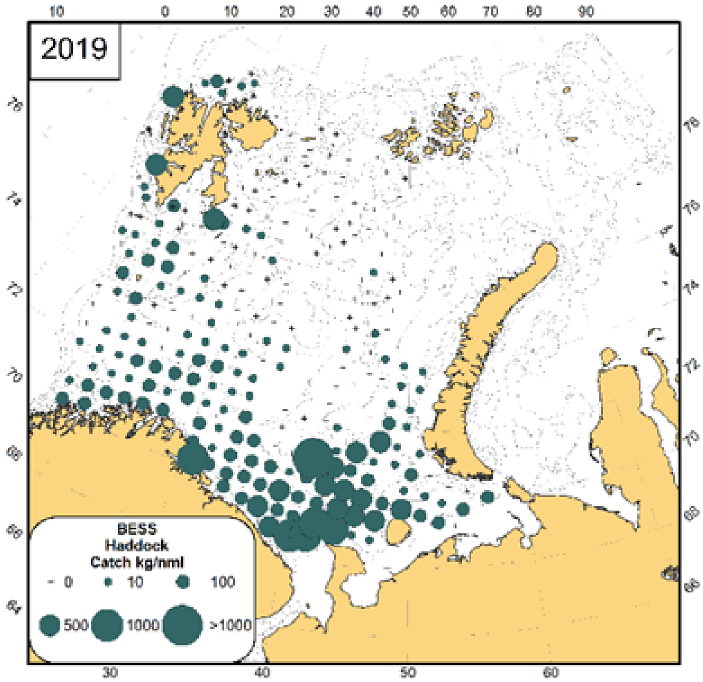

Figure 8.2.1 *Distribution of haddock (Melanogrammus aeglefinus), August-October 2019.*

8.3 Saithe (*Pollachius virens*)

This survey covers only a minor part of the total Northeast arctic saithe stock distribution. As in previous years, the main concentrations of saithe were distributed along the Norwegian coast (Fig. 8.3). High catch rates were apparent in the southwest.

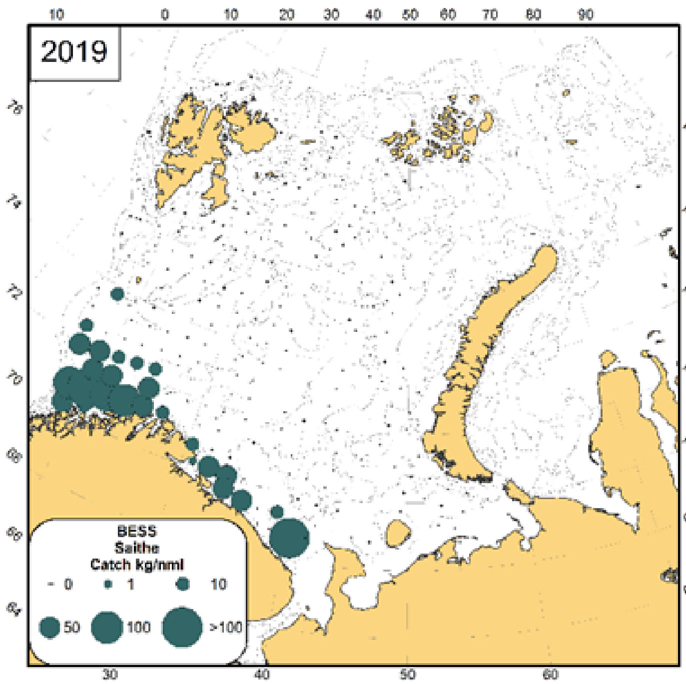

Figure 8.3.1 *Distribution of saithe (Pollachius virens), August-October 2019.*

8.4 Greenland halibut (*Reinhardtius hippoglossoides*)

BESS covers mainly an area where young Greenland halibut is found, including nursery area in the northern most part. However, in recent years larger Greenland halibut has increasingly been registered in the deep-water central parts of Barents Sea. This affects the stock indices when expressed in biomass.
G. halibut indices that are used in the assessment in ICES AFWG are calculated in a different way than here (Table 8.1). The BESS registrations are divided into northern (nursery) area and southern part. Thus, two indices are estimated, each of them additionally divided by sex, based on BESS. Moreover two trawl indices from surveys that cover deeper waters than BESS, at the continental slope, are also used.

As in previous years, the Greenland halibut was observed in almost all catches in the deep areas of the Barents Sea (Fig. 8.4.1). Compared to last year the distribution pattern has not changed, but the catches decreased in the northern part of the area surveyed. The main concentrations of G. halibut were observed around Svalbard (Spitsbergen), to the west of Franz Josef Land, and in the Bear Island Trench.

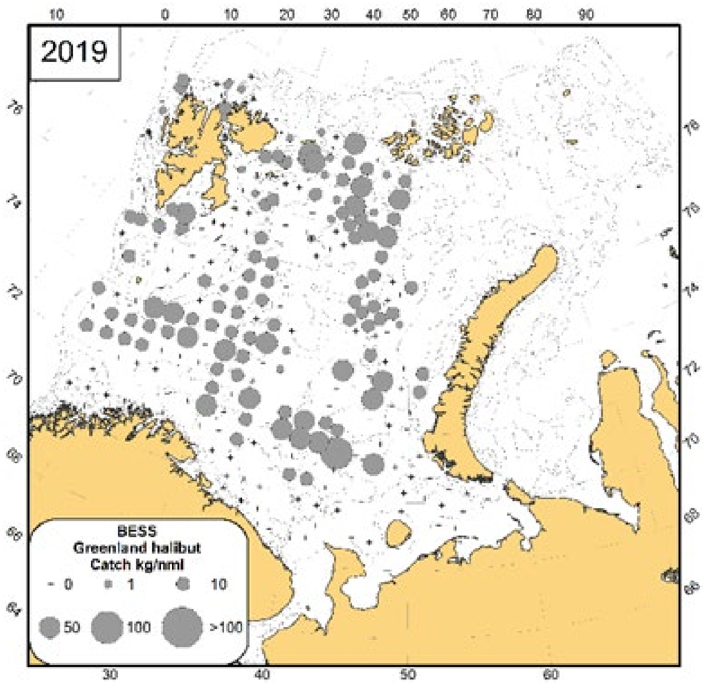

Figure 8.4.1 *Distribution of Greenland halibut (Reinhardtius hippoglossoides), August-October 2019.*

8.5 Golden redfish (*Sebastes norvegicus*)

In 2019, centers of abundance for golden redfish were observed along the coast of the Troms region in Norway, off the North Cape, northwest of Svalbard (Spitsbergen) and along the Murman coast (Fig. 8.5.1). Off Svalbard (Spitsbergen) the highest abundances were found further north and were fewer observations than in 2018. Out in the open Barents Sea and west of Bear Island abundances were no more than 5 kg/nml. The abundance along the Murman coast was more similar to 2017 than to 2018 or earlier years. Observations in the eastern Barents Sea, the area not covered in 2018, were few and of low abundance.

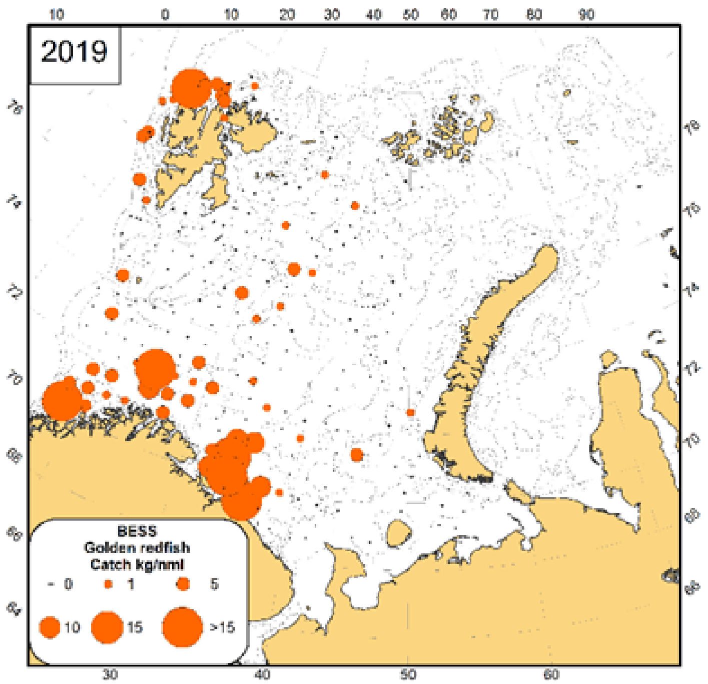

Figure 8.5.1 *Distribution of golden redfish (Sebastes norvegicus), August-October 2019.*

8.6 Deep-water redfish (*Sebastes mentella*)

Like in 2018, deep-water redfish was observed almost everywhere except for the easternmost stations of the survey and north of Bear Island, which is consistent with earlier observations. The distribution and abundance in 2019 did not differ much from earlier years (Fig. 8.6.1).

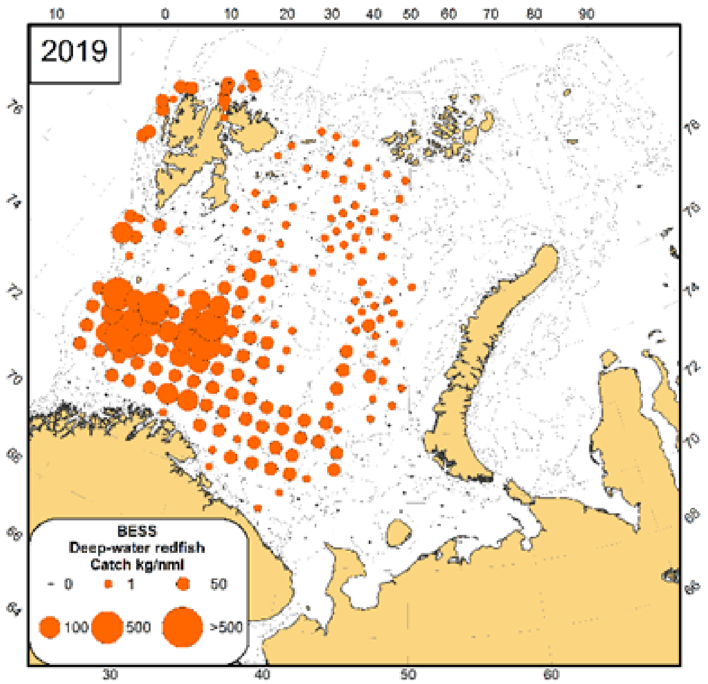

Figure 8.6.1 *Distribution of golden redfish (Sebastes mentella), August-October 2019.*

Highest catches of deep-water redfish were concentrated in the area south and southeast of Bear Island, particularly along the Bear Island Trench. Peak abundances were observed further west in this general area than in 2018.

8.7 Long rough dab (*Hippoglossoides platessoides*)

As usual, long rough dab were found in the entire area surveyed (Fig. 8.7.1). The distribution and abundance in 2019 is not comparable with 2018 due to incomplete coverage last year survey, but was similar to that in 2017. The abundance and biomass indices increased somewhat (Table 8.1) but larger catches in 2019 were obtained in the southwestern part of the sea, while in previous years – in central part of Sea – near the Hope Trench.

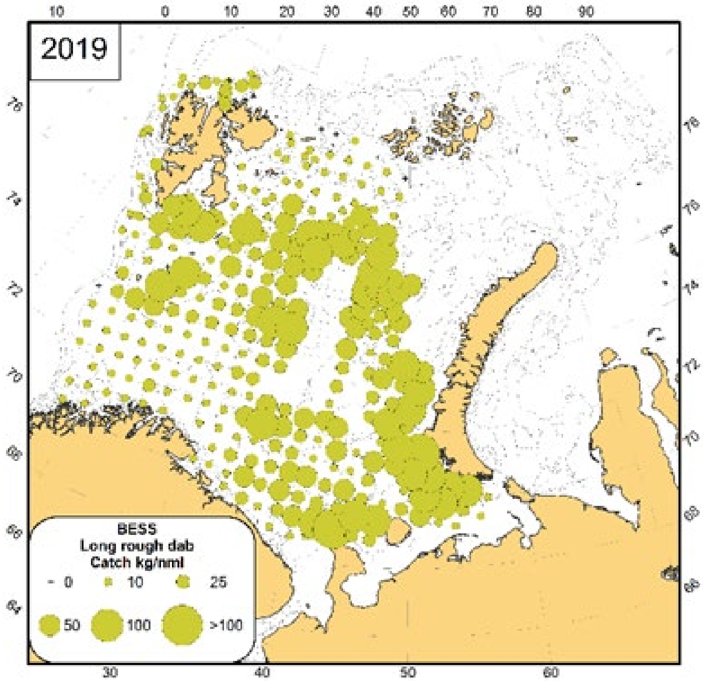

Figure 8.7.1 *Distribution of long rough dab (Hippoglossoides platessoides), August-October 2019.*

8.8 Plaice (*Pleuronectes platessa*)

Almost the entire distribution area of plaice was covered in 2019 except coastal water in Russian Economic Zone. (Fig. 8.8.1). Abundance and biomass indices in 2019 was almost as high as in 2014, when the highest abundance of the entire time series of the survey was estimated (Table 8.1).

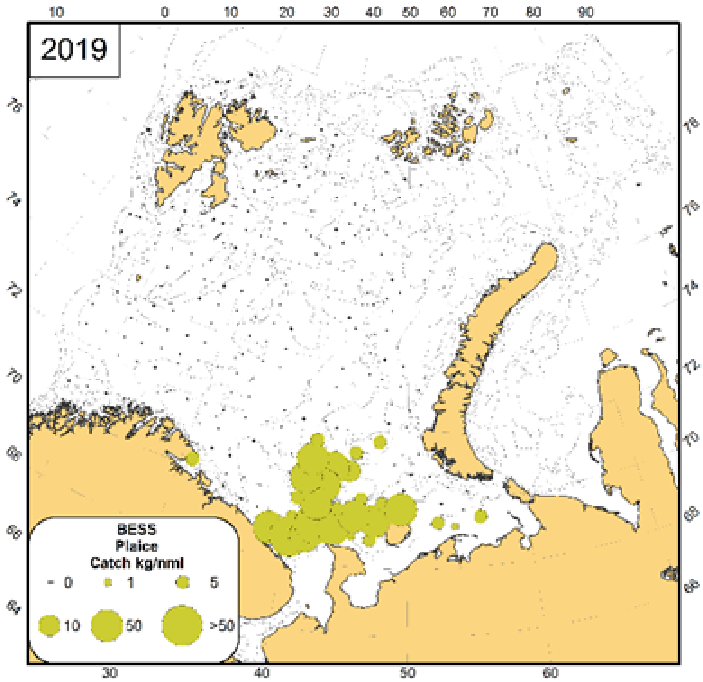

Figure 8.8.1 *Distribution of plaice (Pleuronectes platessa), August-October 2019.*

8.9 Atlantic wolffish (*Anarhichas lupus*)

Atlantic wolffish is the most numerous of the three species of wolffishes inhabiting the Barents Sea, while it due to its smaller size has the lowest biomass of the three species. Abundance and distribution of Atlantic wolffish in 2019 (Fig 8.9.1) was generally similar to 2017

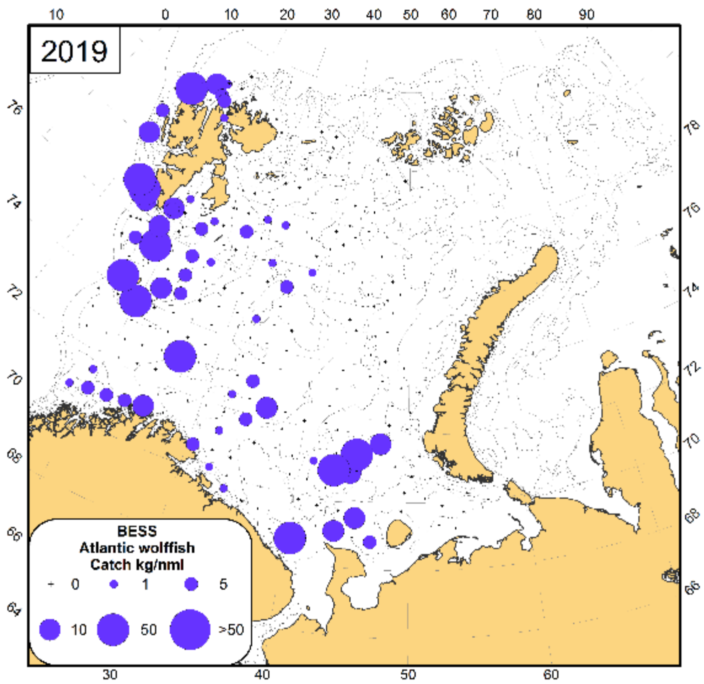

Figure 8.9.1 *Distribution of Atlantic wolffish (Anarhichas lupus), August-October 2019.*

8.10 Spotted wolffish (*Anarhichas minor*)

Spotted wolffish is the most valuable commercial wolffish species. In 2019 the abundance and distribution of spotted wolffish was almost the same as in previous years (Fig. 8.10, Table 8.10.1).

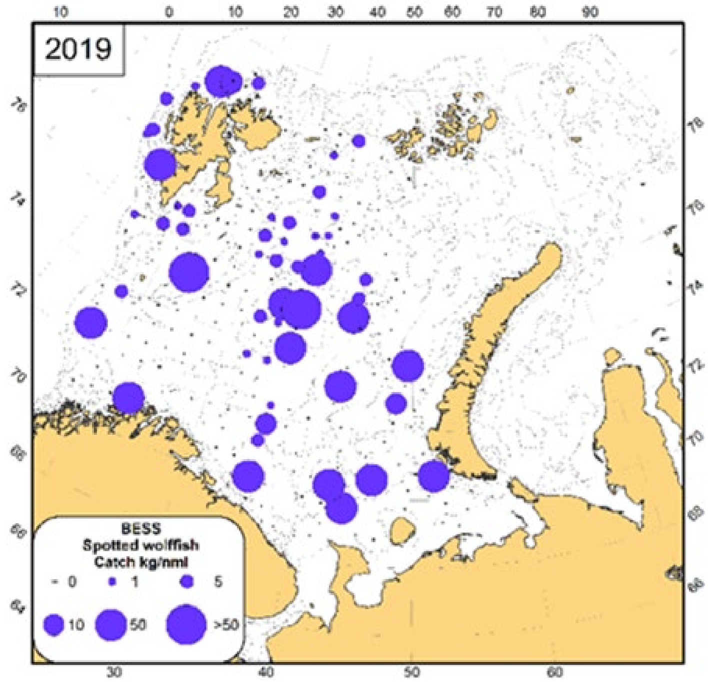

Figure 8.10.1 *Distribution of spotted wolffish (Anarhichas minor), August-October 2019.*

8.11 Northern wolffish (*Anarhichas denticulatus*)

In 2019 the distribution of spotted wolffish was almost the same as in previous years (Fig. 8.11.1). The abundance and biomass was the highest recorded during BESS (Table 8.1).

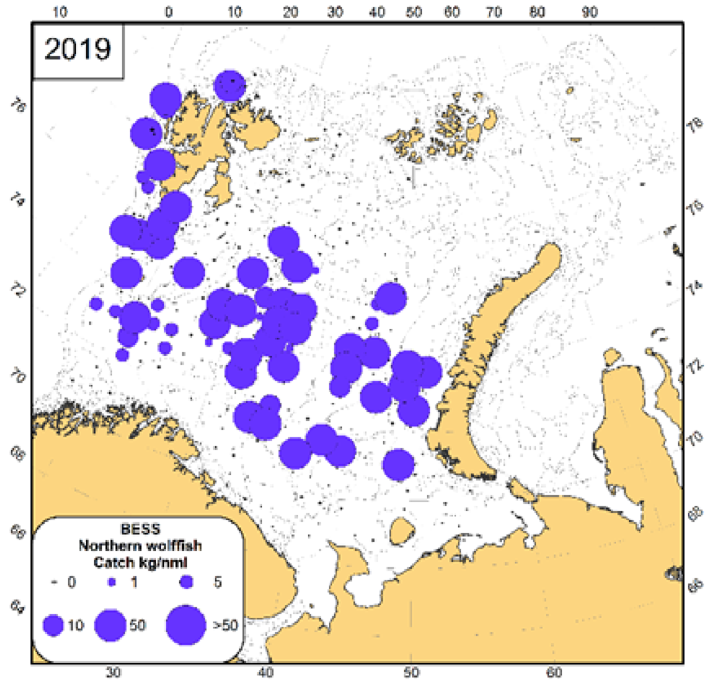

Figure 8.11.1 *Distribution of northern wolffish (Anarhichas denticulatus), August-October 2019.*

Table 8.1. *Abundance (N, 10^6 individuals) and biomass (B, 10^3 tonnes) of the main demersal fish species in the Barents Sea (not including 0-group)*

Species		Year															
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*	2017	2018*	2019
Atlantic wolffish	N	15	16	26	42	25	20	17	20	22	27	12	33	40	30		37
	B	7	6	11	11	14	8	17	13	9	30	12	37	24	29		20
Spotted wolffish	N	12	11	12	12	13	9	7	9	13	13	8	12	13	14		15
	B	31	26	46	42	51	47	37	47	83	84	51	86	40	63		51
Northern wolffish	N	3	3	2	3	3	3	3	6	8	12	6	9	8	8		13
	B	26	26	19	25	22	31	25	42	45	52	34	63	51	63		76
Long rough dab	N	2951	2753	3705	5327	3942	2600	2520	2507	4563	4932	3046	3624	3369	4604		3627
	B	306	272	378	505	477	299	356	322	584	565	413	438	402	538		472
Plaice	N	53	19	36	120	57	21	34	36	21	36	170	107	37	17		146
	B	43	11	19	55	29	13	21	26	13	29	121	79	29	19		101
Golden redfish	N	13	23	16	20	42	12	22	14	32	75	45	9	34	34	73	27
	B	9	11	16	11	17	11	4	5	8	20	13	5	24	18	21	21
Deep-water redfish	N	263	330	526	796	864	1003	1076	1271	1587	1608	927	894	1527	1705	1298	1126
	B	104	137	219	183	96	213	112	105	196	256	208	214	319	212	260	313
Greenland halibut	N	182	335	430	296	153	191	186	175	209	160	43	79	82	134		166
	B	39	56	77	86	76	90	150	88	86	94	53	52	40	74		61
Haddock	N	757	1211	3518	4307	3263	1883	2222	1068	1193	734	1110	1135	1604	1321		2213
	B	261	342	659	1156	1246	1075	1457	890	697	570	630	505	836	303		678
Saithe	N	36	31	28	70	3	33	5	9	14	18	3	105	58	282	30	58
	B	40	26	49	98	7	29	9	10	13	33	6	153	54	193	24	80
Cod	N	1513	1012	1539	1724	1857	1593	1651	1658	2576	2379	1373	1694	1767	1880		2068
	B	1074	499	810	882	1536	1345	2801	2205	1837	2132	1146	1425	1087	1397		1477

*survey coverage was incomplete in the central part of the Barents Sea.

*not full coverage of the survey area

9 FISH BIODIVERSITY

9.1 Fish biodiversity in the pelagic compartment

Due to limited resources the fish biodiversity in the pelagic compartment was not possible to estimate from the 2019 survey in time for this report. If possible, the time series will be continued in next year survey report.

9.2 Fish biodiversity in the demersal compartment

Text by: T. Prokhorova, E. Johannesen, A. Dolgov and R. Wienerroither
Figures by: D. Prozorkevich

Norway pout (*Trisopterus esmarkii*). The distribution of Norway pout in 2019 was similar to last year, except new occurrence eastwards to the south-western part of the Novaya Zemlya (Fig. 9.2.1). Main concentrations of this species were found in the south-western part of the Barents Sea along the Norwegian coast. The maximum catch and the average catch of Norway pout (192.4 kg/nautical mile and 1.8 kg/nautical mile respectively) in 2019 were less than in 2018 (303.2 kg/nautical mile and 3.57 kg/nautical mile respectively). Total abundance (1949.2 million individuals) and biomass (51.13 thousand tonnes) of Norway pout were higher in 2019 than in 2018 (50.8 thousand tonnes and 1687.2 million individuals respectively) (Table 9.2.1).

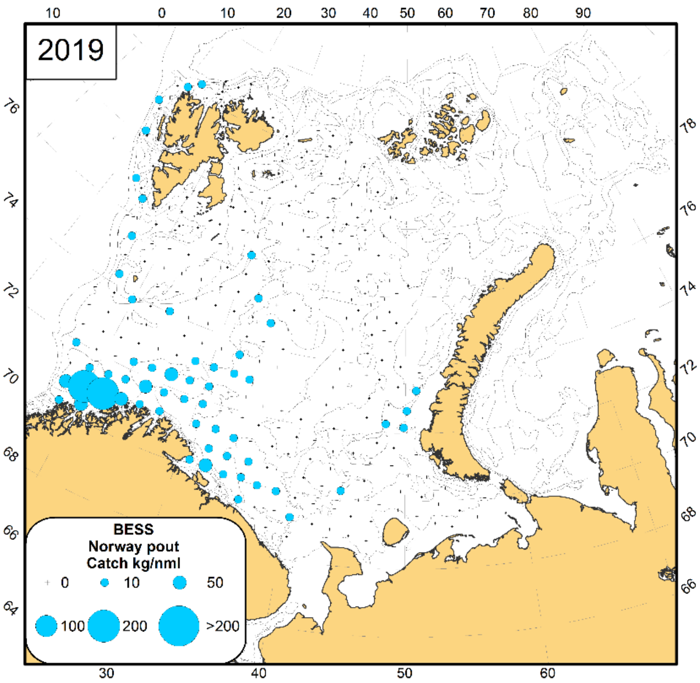

Figure 9.2.1 *Distribution of Norway pout (Trisopterus esmarkii), August-October 2019.*

Norway redfish (*Sebastes viviparus*). In 2019 Norway redfish was mainly distributed in the south-western area of the survey along the Norwegian coast, similar to 2018 (Fig. 9.2.2). Several redfish individuals were also caught in the south-western part of Svalbard (Spitsbergen). The maximum catch of Norway redfish in 2019 was 153.7 kg/nautical mile with average of 0.8

kg/nautical mile, and it is less than in 2018 (481.9 kg/nautical mile and 3.3 kg/nautical mile respectively). Total abundance and biomass indices of this species in 2019 (142.5 million individuals and 15.5 thousand tonnes) were less than in 2018 (202.9 million individuals and 25.3 thousand tonnes) (Table 9.2.1).

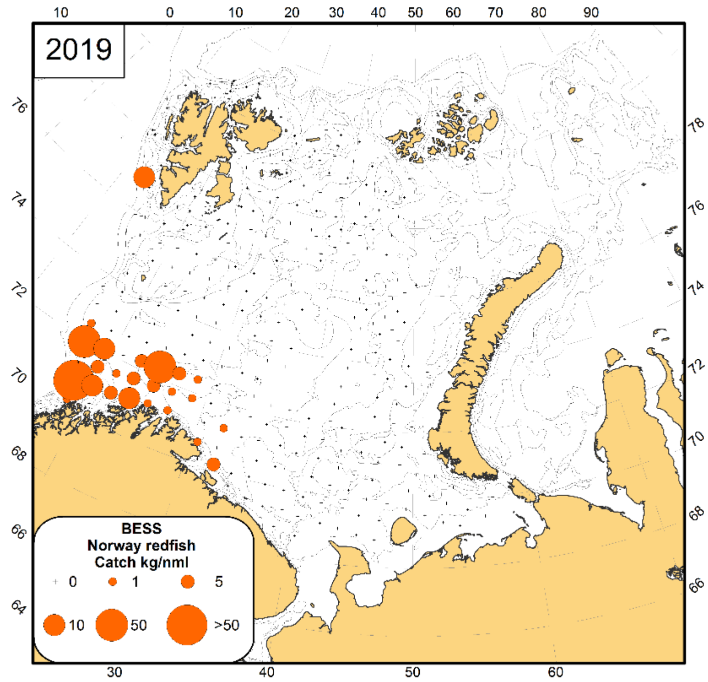

Figure 9.2.2 *Distribution of Norway redfish (Sebastes viviparus), August-October 2019.*

Table 9.2.1 *Total abundance (N, million individuals) and biomass (B, thousand tonnes) of Norway pout and Norway redfish in the Barents Sea in August-October 2006-2019 (not including 0-group).*

Year	Species			
	Norway pout		Norway redfish	
	N	B	N	B
2006	1838	32	219	19
2007	2065	61	64	10
2008	3579	97	24	4
2009	3841	131	17	2
2010	3530	103	26	2
2011	5976	68	83	9
2012	3089	105	114	12
2013	2267	40	233	25
2014	1254	37	105	6
2015	943	33	168	20
2016	797	28	125	13
2017	1260.6	21.6	133.7	14.3
2018	1687.2	50.8	202.9	25.3
2019	1949.2 ↑	51.1 ↑	142.5 ↓	15.5 ↓

Thorny skate (*Amblyraja radiata*) and **Arctic skate (*Amblyraja hyperborea*)** were selected as indicator species to study how ecologically similar fishes from different zoogeographic groups respond to changes of their environment. Thorny skate belongs to the mainly boreal zoogeographic group and widely distributes in the Barents Sea except the most north- eastern areas, while Arctic skate belongs to the Arctic zoogeographic group and distributes in the cold waters of the northern area.

Thorny skate was distributed in the wide area from the northwest to the southwest and southeast Barents Sea where warm Atlantic and Coastal Waters dominates (Figure 9.2.3). Thorny skate was observed in 48.0 % of the bottom stations. Thorny skate was distributed within a depth of 48-469 m, and the highest biomass occurred at depth 50-300 m (75.4 % of total biomass). The mean CPUE in 2019 was higher than in 2014-2017 (Table 9.2.2). The estimated total biomass and abundance of thorny skate in 2019 was also higher compared to the previous years (Table 9.2.2).

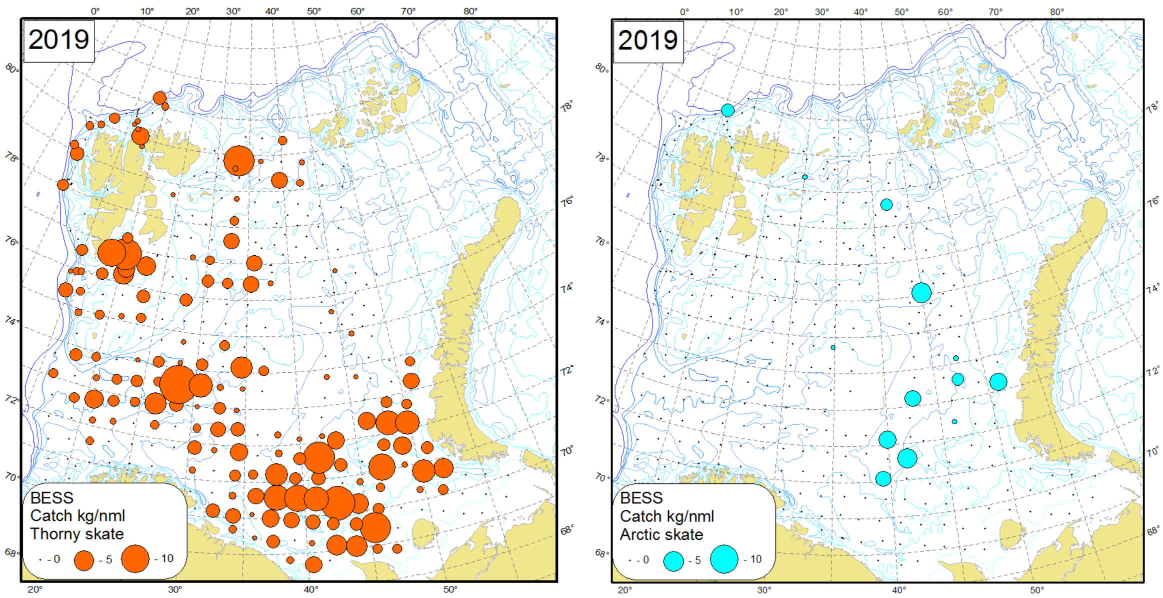

Figure 9.2.3 *Distribution of thorny skate (Amblyraja radiata) and Arctic skate (Amblyraja hyperborea), August-October 2019.*

Table 9.2.2 *Mean CPUE (N, individuals per nautical mile and B, kg per nautical male) and stock index (N – abundance, 10^6 individuals and B – biomass, 10^3 tonnes) of thorny skate during BESS 2019*

год	Mean CPUE		Stock index	
	N	B	N	B
2014	1.4	1.2	34.4	30.0
2015	1.1	1.0	31.8	30.5
2016	1.0	0.9	30.7	28.2
2017	1.8	1.3	52.0	39.7
2019*	2.0 ↑	1.4 ↑	57.0 ↑	41.3 ↑

* – 2018 is not included due to the poor coverage

Arctic skate was mainly found in deep trenches in the central Barents Sea (Figure 9.2.3). Several individuals were caught to the north off Svalbard (Spitsbergen). Arctic skate was found only in the 4.0 % of the bottom stations, and it was distributed at larger depth of 207-969 m. The highest biomass of this species was observed at 200-350 m (93.9 %). The mean CPUE of Arctic skate in 2019 was less than in 2016-2017, but the same as in 2015 (Table 9.2.3). The estimated total biomass and abundance of Arctic skate in 2019 was also less than in 2014 and 2016-2017, but higher than in 2015 (Table 9.2.3).

Table 9.2.3 *Mean CPUE (N, individuals per nautical mile and B, kg per nautical male) and stock index (N – abundance, 10^6 individuals and B – biomass, 10^3 tonnes) of Arctic skate during BESS 2019*

год	Mean CPUE		Stock index	
	N	B	N	B
2014	0.2	0.3	3.7	6.7
2015	0.07	0.1	1.6	1.9
2016	0.2	0.2	8.6	4.0
2017	0.3	0.3	4.9	4.4
2019	0.07 ↓	0.09 ↓	2.0 ↓	2.3 ↓

* – 2018 was not included due to the poor area coverage

9.3 Uncommon or rare species

Text by: T. Prokhorova, E. Johannesen, A. Dolgov and R. Wienerroither

Figures by: P. Krivosheya

Rare or uncommon species are either species that are not caught at the Barents Sea ecosystem survey every year, or caught most years but in low numbers and with limited occurrence. Most of these species usually occur in areas adjacent to the Barents Sea and were therefore found mainly along the border of the surveyed area.

Some uncommon species were observed in the Barents Sea during the ecosystem survey in 2019 (Figure 9.3.1). E.g., sea lamprey *Petromyzon marinus* is an anadromous species and parasite on different species of fish, accidentally caught in the North Atlantic Ocean. Hooknose *Agonus cataphractus* and rainbow smelt *Osmerus mordax dentex* were caught in the southeast of the survey area. Roughhead grenadier *Macrourus berglax* and scalebelly eelpout *Lycodes squamiventer* were found in deeper, Atlantic Water. Megrim *Lepidorhombus whiffiagonis* is known from the Atlantic coasts off northern Africa to Norway, was caught on the south-western border of the survey area.

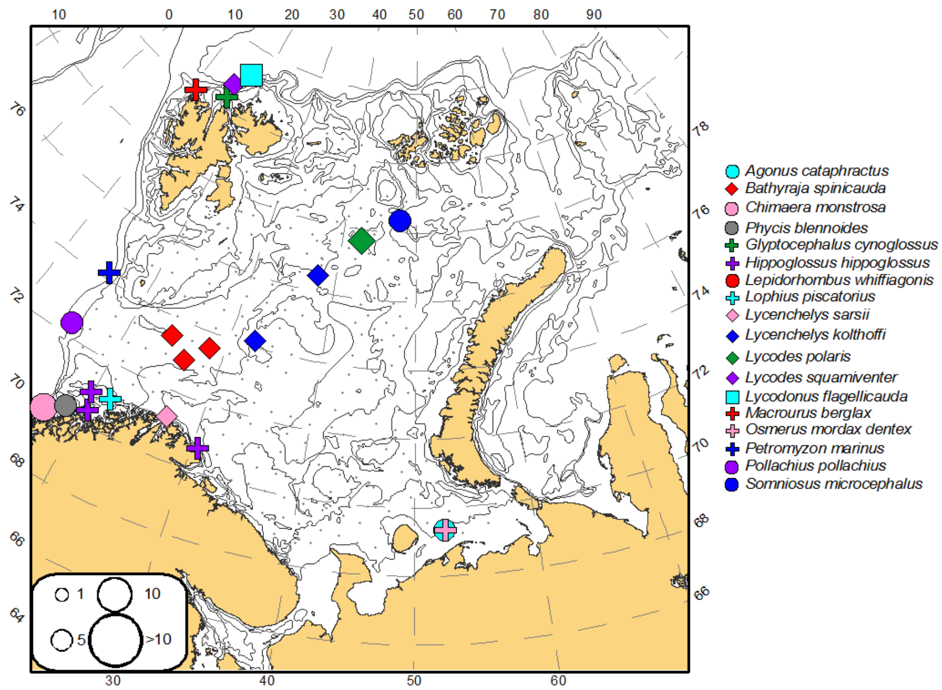

Figure 9.3.1 *Distribution of species which are rare in the Barents Sea and which were found in the survey area in 2019. Size of symbol corresponds to abundance catch (individuals per nautical mile, both bottom and pelagic trawls were used).*

9.4 Zoogeographic groups

Text by: T. Prokhorova, E. Johannesen, A. Dolgov and R. Wienerroither

Figures by: P. Krivosheya

During the 2019 ecosystem survey totally 90 fish species from 28 families were recorded in the catches, and some taxa were only recorded at genus or family level. We observed more number of species compared to the last year due to poor coverage of the REEZ in 2018. All recorded species belonged to the 7 zoogeographic groups: **widely distributed**, **south boreal, boreal**, **mainly boreal**, **Arctic-boreal**, **mainly Arctic** and **Arctic** as defined by Andriashev and Chernova (1994). Mecklenburg et al. (2018) in the recent "Marine Fishes of the Arctic Region" reclassified some of the species and geographical categorisation comprises six groups: **widely distributed, boreal, mainly boreal, Arctic- boreal, mainly Arctic and Arctic**. We use Andriashev and Chernova classification here due to the lack of comparative studies of the old and new classification applied to the Barents Sea. Only bottom trawl data were used, and only non-commercial species were included into the analysis, both demersal (including bentho-pelagic) and pelagic (neritopelagic, epipelagic, bathypelagic) species were included (Andriashev and Chernova, 1994, Parin, 1968, 1988).

Mean and maximum CPUE (normalized catch per distance) for each zoogeographic group species are not compared to 2018 due to poor coverage of the Russian Zone by BESS in 2018. The median and maximum CPUE of non-commercial fish from different zoogeographic groups are shown in Table 9.4.1.

Widely distributed (only ribbon barracudina *Arctozenus risso* represents this group), **south**

boreal (e.g. grey gurnard *Eutrigla gurnardus*, silvery pout *Gadiculus argenteus*, angler *Lophius piscatorius*) and **boreal** (e.g. round skate *Rajella fyllae*, Sars' wolf eel *Lycenchelys sarsii*, silvery lightfish *Maurolicus muelleri*) species were mostly found over the southwestern and western part of the survey area where warm Atlantic and Coastal Water dominate (Figure 9.4.1).

Mainly boreal species (e.g. lesser sandeel *Ammodytes marinus*, tusk *Brosme brosme*, greater eelpout *Lycodes esmarkii*) were widely found throughout the survey area (Figure 4.2.1).

Arctic-boreal species (e.g. Atlantic poacher *Leptagonus decagonus*, ribbed sculpin *Triglops pingelii*) were found in the central part of the Barents Sea and on the northern part between Svalbard (Spitsbergen) and Franz-Josef Land (Figure 9.4.1).

Mainly Arctic (e.g. twohorn sculpin *Icelus bicornis*, Atlantic spiny lumpsucker *Eumicrotremus spinosus*, variegated snailfish *Liparis bathyarcticus*) and **Arctic** (e.g. gelatinous snailfish *Liparis fabricii*, pale eelpout *Lycodes pallidus*, leatherfin lumpsucker *Eumicrotremus derjugini*) species were widely found on the northern and southeastern part of the Barents Sea (Figure 9.4.1). Species of these groups mostly occur in areas influenced by cold Arctic Water, Spitsbergen Bank Water, Novaya Zemlya Coastal Water and Pechora Coastal Water. Median and maximum CPUE of mainly arctic and Arctic species in 2019 were the highest from 2014 (Table 9.4.1).

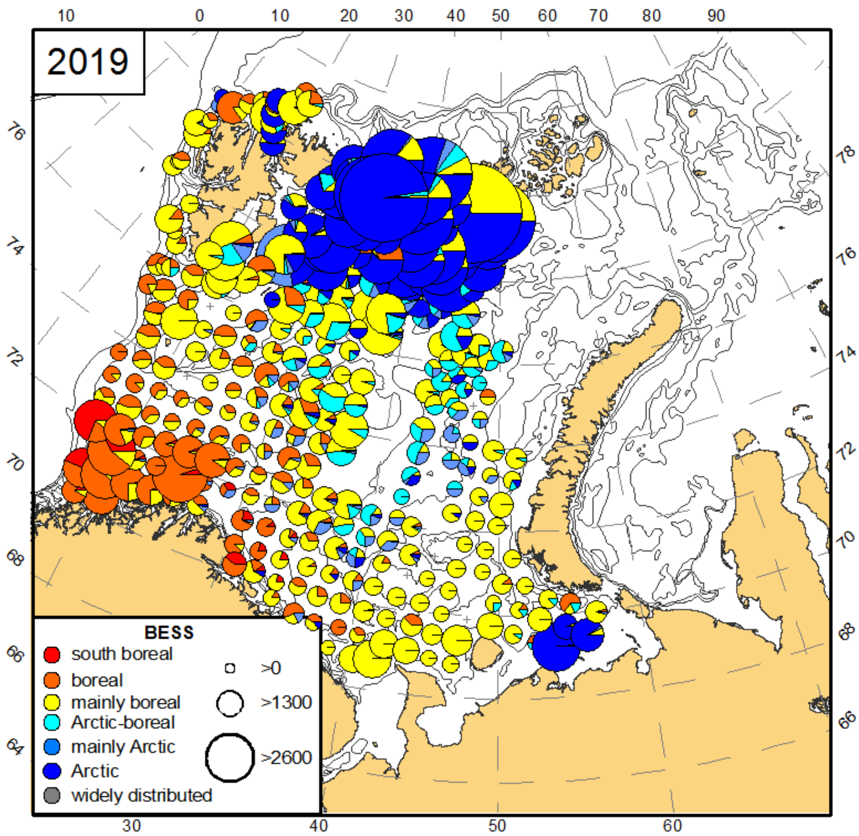

Figure 9.4.1 *Distribution of non-commercial fish species from different zoogeographic groups during the ecosystem survey 2019. The size of circles corresponds to abundance (individuals per nautical mile, only bottom trawl stations were used, both pelagic and demersal species are included).*

Table 9.4.1 *Mean and maximum CPUE (individuals per nautical mile) of non-commercial fish from different zoogeographic groups (only bottom trawl data were used, both pelagic and demersal species are included)*

Zoogeographic group	Mean CPUE						Maximum CPUE					
	2013	2014[1]	2015	2016[2]	2017	2019[3]	2013	2014[1]	2015	2016[2]	2017	2019[3]
Widely distributed	0.2	0.1	0.09	0.5	0.2	0.02↓	17.1	14.3	10.0	36.7	7.5	1.3↓
South boreal	0.8	0.9	1.2	1.4	3.2	2.6↓	171.4	105.7	216.3	135.0	372.9	312.0↓
Boreal	7.1	8.7	8.7	18.3	15.0	17.1↑	230.0	478.6	660.0	743.8	792.9	864.3↑
Mainly boreal	48.9	36.4	71.4	55.3	53.7	51.4↓	982.5	3841.4	1587.1	2962.5	2945.0	1406.1↓
Arctic-boreal	25.4	8.6	14.0	8.8	19.3	15.0↓	3326.9	371.6	1502.4	283.8	571.3	297.5↓
Mainly Arctic	10.2	1.7	1.9	3.3	4.9	7.8↑	656.3	60.9	53.8	123.2	282.5	828.8↑
Arctic	70.8	7.4	31.5	29.1	78.5	107.9↑	3013.8	386.4	832.2	808.6	2731.1	2968.8↑

[1] – Coverage in the northern Barents Sea was highly restricted
[2] – The survey started from the north
[3] – 2018 are not included due to the poor coverage of the Russian Zone

10 COMMERCIAL SHELLFISH

10.1 Northern shrimp (*Pandalus borealis*)

Text and figures by: D. Zakharov

During the survey in 2019 323 trawls were made. Northern shrimp was found in the catches of 254 trawls. The biomass of shrimp varied from several grams to 201.2 kg/nml with an average catch of 9.1±0.2 kg nml (Table 10.1.1).

Table 10.1.1 *The mean catch of shrimp (include SEM) during BESS in 2005-2019*

Year	Total number of station	Number of station with shrimp	Mean catch, ind./nml	Mean catch, kg/nml
2005	224	169	856.3±12.1	12.1±4.3
2006	637	480	3460.8±21.4	15.0±0.9
2007	551	426	2875.5±19.7	13.2±0.9
2008	431	329	1846.6±17.7	9.2±0.7
2009	378	310	1673.0±17.4	7.9±0.9
2010	319	238	2625.5±15.3	12.0±1.2
2011	391	304	2165.2±17.2	10.4±0.9
2012	443	325	2351.2±18.0	12.0±1.0
2013	487	388	1838.2±19.1.0	9.5±0.6
2014	165	101	1676.0±10.1.0	8.4±1.0
2015	334	247	1371.0±15.6	7.1±0.6
2016	317	187	1457.9±13.1.0	7.0±0.6
2017	339	281	2021.4±16.3	13.8±1.9
2018	217	160	1759.0±11.9	10.2±1.4
2019	323	254	1577.5±3.1	9.1±0.2
Total	**5556**	**4199**	**1970.3±167.9**	**10.4±0.6**

In 2019 the densest concentrations of the shrimp were registered in central part of the Barents Sea, around Spitsbergen and in the Franz Victoria Trough, as in previous years bulk concentration has been found in the same areas (Figure 10.1.1).

Biological analysis of the northern shrimp was conducted in 2019 by Russian scientists in the eastern part of the survey area. Likewise in the previous years the bulk of population of the Barents Sea shrimp was made up of individuals of smaller age groups – males with carapace length of 10-27 mm and females with carapace length of 17-30 mm (Figure 10.1.2). Length distribution and demographic information on shrimps in the western part of the Barents Sea is as yet not available.

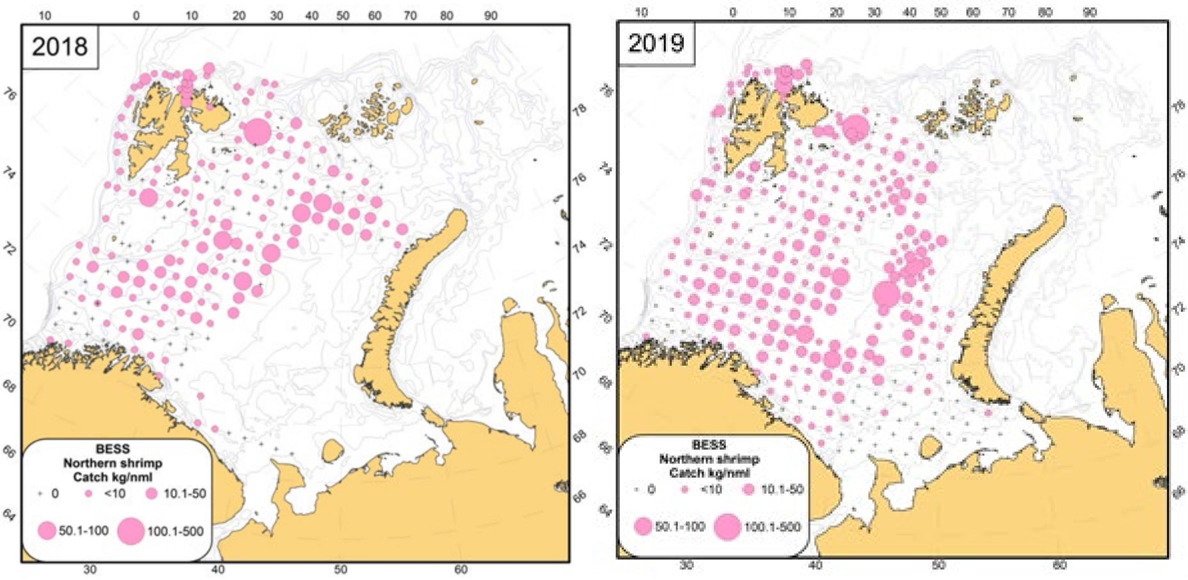

Figure 10.1.1. *Distribution of Northern shrimp (Pandalus borealis) in the Barents Sea, August-October 2018-2019.*

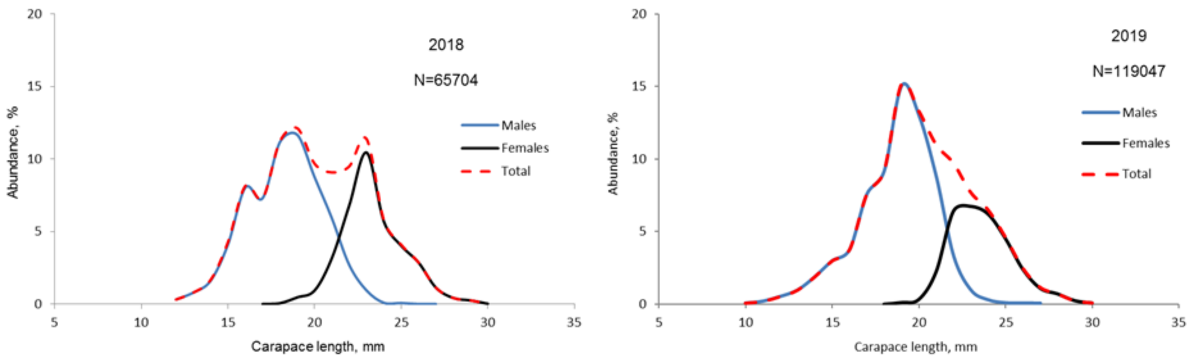

Figure 10.1.2. *Size and sex structure of catches of Northern shrimp (Pandalus borealis) in the north-eastern Barents Sea 2018 and in the eastern Barents Sea 2019.*

10.2 Red king crab (*Paralithodes camtschaticus*)

Text by: D. Zakharov, N. Strelkova

Figures by: D. Zakharov

During survey the red king crab was recorded in 32 of 323 trawl catches (Table 10.2.1).

According to the data of 2019 the most dance concentration of the crab was covered by BESS 2019 (Fig. 10.2.1). As in the previous year, the crab was not registered in the Norwegian open sea waters. In 2019 the crab was recorded more northern that in 2017-2018 from 70.5 to on 71.3° N. The most eastern catch was made in the Pechora Sea in 2017 55.6 E (Figure 10.2.1).

Table 10.2.1. *The total catches of red king crab during BESS 2005-2018.*

Year	Total number of station	Number of station with red king crab	Total catch, ind.	Total catch, kg
2005	649	8	106	309
2006	550	66	1243	3350
2007	608	30	1521	3869
2008	452	10	127	93
2009	387	7	15	25
2010	331	6	12	25
2011	401	4	40	22
2012	455	8	126	308
2013	493	3	272	437
2014	304	11	168	403
2015	335	14	255	517
2016	317	11	202	552
2017	376	13	299	687
2018	217	5	73	175
2019	323	32	1635	2897

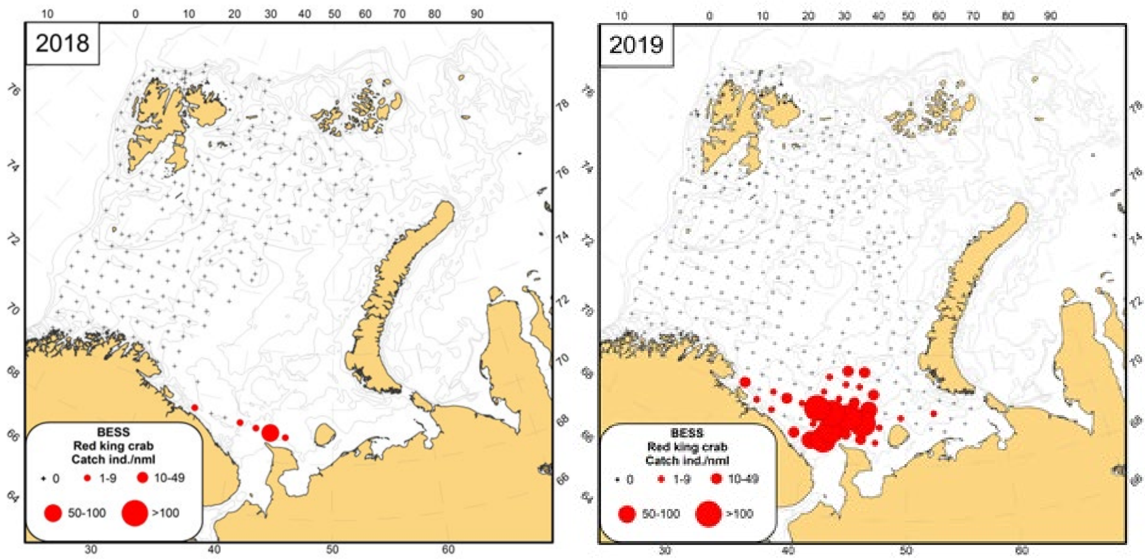

Figure 10.2.1 *Distribution of red king crab (Paralithodes camtschaticus) in the Barents Sea, August-October 2018 and 2019*

The biomass of red king crab catches in 2019 varied from 1.4 to 189.8 kg/haul (2.1-382.1 kg/nml) compared with 14.1 to 112.5 kg/haul (16.5-135.1 kg/nml) in 2017. The average biomass was 53.7±8.0 kg/haul (93.4±14.7 kg/nml) compared with 34.9±19.4 kg/haul (41.9±23.3 kg/nml) in 2017.

The abundance of crab ranged from 1 to 251 ind./haul (1.1-504.0 ind./nml) given an average crab abundance of 30.9±6.2 ind./haul (52.7±11.3 ind./nml) compared with 4-50 ind./haul (5.0-60.1 ind./nml) and 14.6±8.9 ind./haul (17.5±10.7 ind./nml) in 2017. A simultaneous increase of abundance and decrease of biomass can be caused by a rejuvenation of the crab population. This is confirmed by the size structure of the population. The size structure of the red king crab population in 2019 characterized domination of crab with 100-140 mm carapace width, this group on 65% formed by males and 35% females (Fig. 10.2.2).

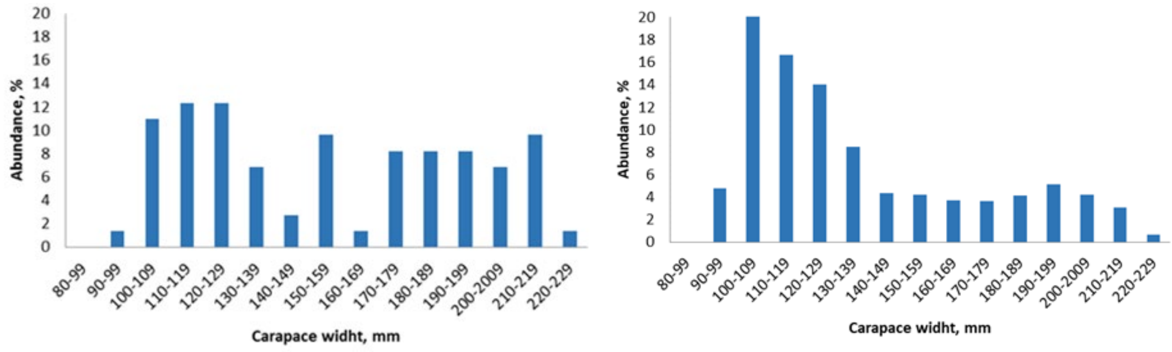

Figure 10.2.2 *Size structure of red king crab population in the Barents Sea in August-October 2018 (left) and 2019 (right)*

10.3 Snow crab (Chionoecetes opilio)

Text by: D. Zakharov, N. Strelkova

Figures by: D. Zakharov

In 2019 the snow crab were recorded in 87 out of 323 trawl catches (Table 10.3.1).

Table 10.3.1 *The total catch of snow crab during BESS in 2005-2019*

Year	Total number of station	Number of station with snow crab	Total catch, ind.	Total catch, kg
2005	649	10	14	2.5
2006	550	28	68	11
2007	608	55	133	18
2008	452	76	668	69
2009	387	61	276	36
2010	331	56	437	22
2011	401	78	6219	154
2012	455	116	37072	1169
2013	493	131	20357	1205
2014	304	78	12871	658
2015	335	89	4245	378
2016	317	84	2156	137
2017	376	159	25878	1422
2018	217	61	19494	846
2019	323	87	15523	608

In 2017 the snow crab was for the first time recorded in the water of Svalbard (Spitsbergen). In 2018 one young male with carapace wide 34 mm and weight 12 g was caught to south-west of South Cap of Spitsbergen in the depth 350 m (Fig. 10.3.1). In general, in 2018, the border recordings of the snow crabs were made further to the southwest boreal part of the Barents Sea shelf compared to previous years. Due to lack coverage of survey area, the comparison of data for 2018 and 2019 is possible only for part of the crab area. In the Barents Sea the biomass of snow crab in 2019 varied from 0.002 to 60.4 kg/haul with an average of 4.9±1.0 kg/haul compared with 0.005-268.0 kg/haul and 16.7±6.4 kg/haul in 2018.

The abundance in 2019 ranged from 1 to 1402 ind./haul with an average of 113±42 ind./haul compared with 1-4496 ind./haul and 393.6±129.7 ind./haul in 2018. The size structure of the snow crab population in 2019 characterized domination of juvenile crab with 10-40 mm carapace width (Fig. 10.3.2).

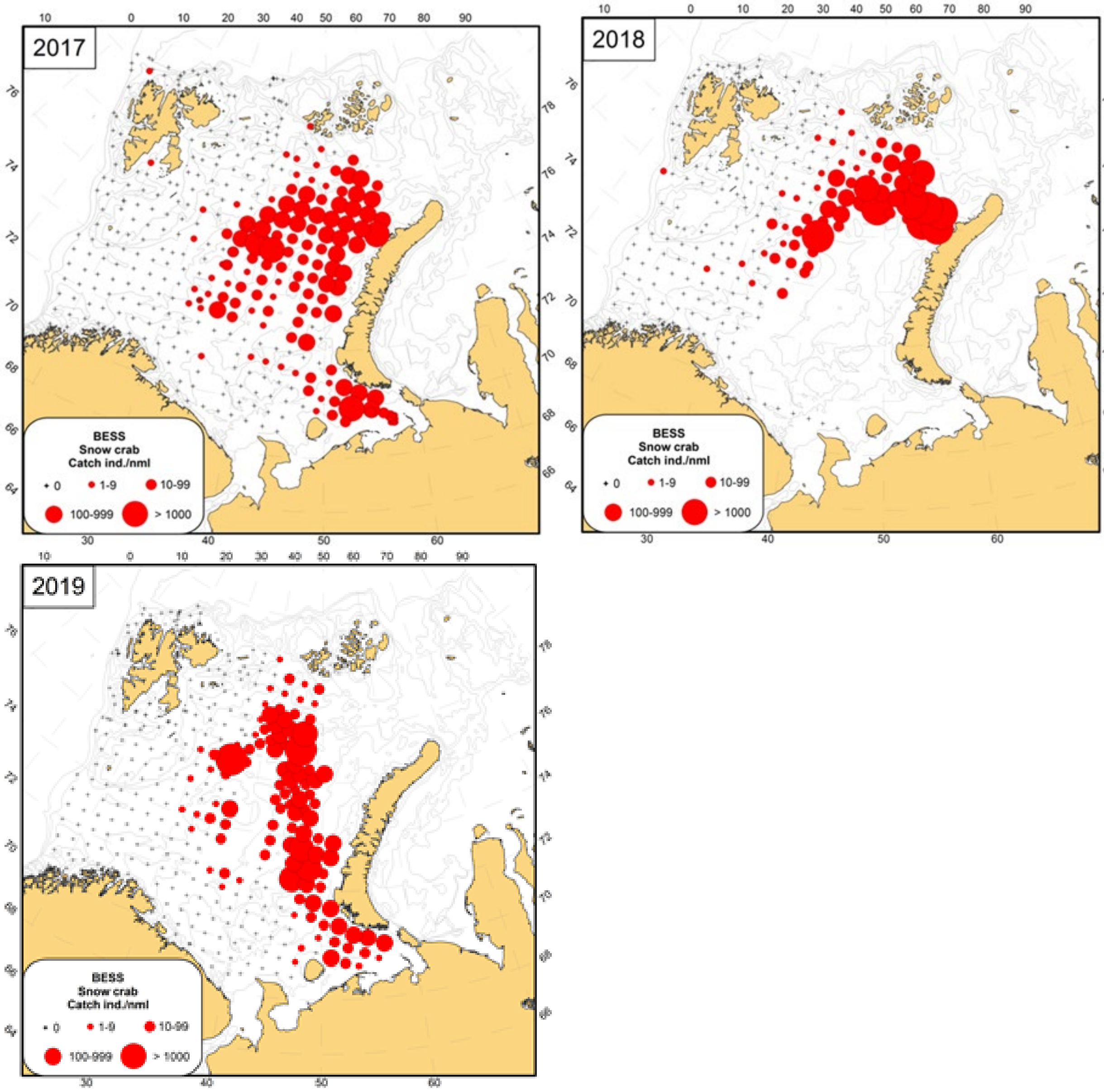

Figure 10.3.1. *Distribution of snow crab (Chionoecetes opilio) in the Barents Sea, August-October 2017- 2019.*

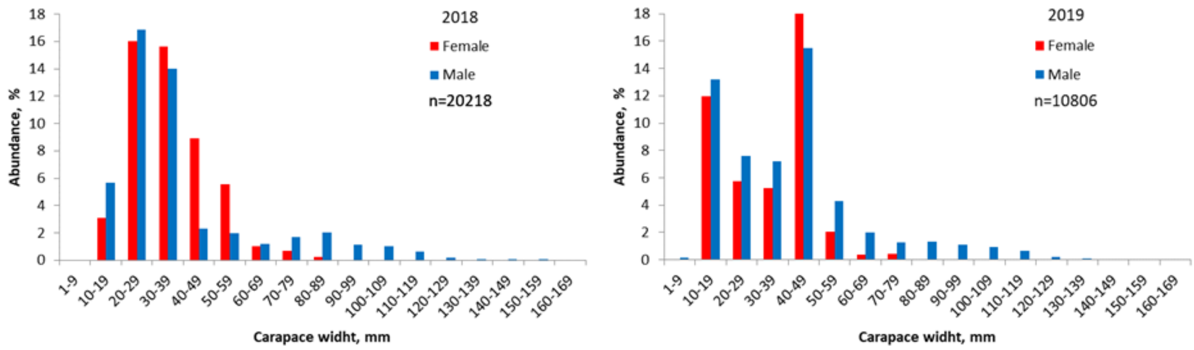

Figure 10.3.2 *Size structure of snow crab population in the Barents Sea in 2018 in the north part of the sea and in 2019.*

10.4 Iceland scallop (*Chlamys islandica*)

Text by: I. Manushin, L.L. Jørgensen
Figures by: I. Manushin,

The Iceland scallop was recorded in 112 of 323 trawl catches in 2019. The survey showed a wide distribution of scallops in the Barents Sea. The deepest record in 2019 was at 974 m, but the most abundant catches were recorded in the shallow banks and elevations of the bottom: Spitsbergen Bank, Central Bank, Great Bank, Kanin Bank, Goose Bank (Figure 10.4.1).

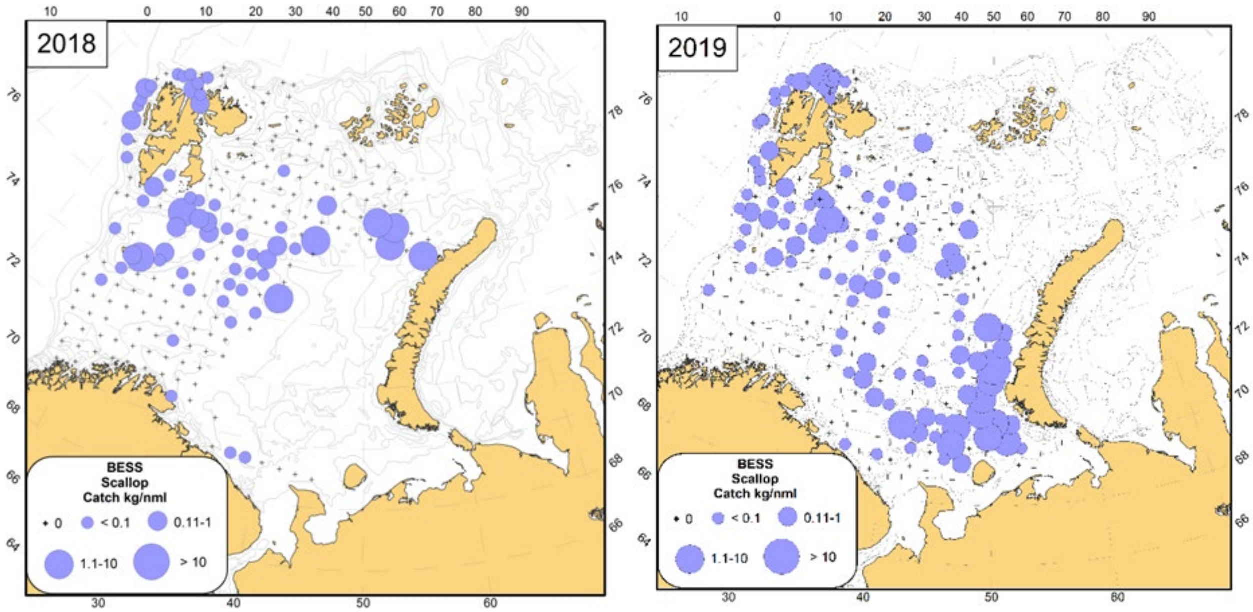

Figure 10.4.1 *Distribution of Iceland scallop (Chlamys islandica) in the Barents Sea, August-October 2018-2019.*

The biomass of scallops in 2019 varied from 1 g/haul to 29.9 kg/haul (0.001-35.1 kg/nml). The average biomass is 868±283 g/haul (1039±334 g/nml) (table 10.4). The abundance ranged from 1 to 933 ind./haul (1-1098 ind./nml). The average abundance of scallops is 35±9 ind./haul (42±11 ind./nml).

Table 10.4 *The mean catch of Iceland scallop (include SEM) during BESS in 2011-2019*

Year	Number of station with scallop (% of total)	Mean catch, ind./nml	Mean catch, g/nml
2011	101 (26)	35±5	1294±235
2012	146 (33)	62±7	1580±195
2013	131 (27)	115±17	8378±1359
2014*	50 (36)	29±4	812±121
2015	103 (31)	13±1	264±32
2016*	76 (24)	18±2	268±38
2017	125 (33)	82±11	1486±198
2018*	65 (30)	31±4	537±91
2019*	112 (35)	42±11	1039±334

* - not full coverage of the survey area

11 BENTHIC INVERTEBRATE COMMUNITY

Text by: N. Strelkova, D. Zakharov, L. L. Jørgensen, and I. Manushin
Figures by: D. Zakharov

In 2019, bycatch records of megabenthos was made from 305 bottom trawl hauls across all four research vessels of the ecosystem survey. The megabenthos was processed to closest possible taxon with abundance and biomass recorded.

This was done in Russian "Vilnyus" by two experts (Uglova T., Uzbekova O.) and in three Norwegian vessels by 8 experts (Juravleva N., Zimina O., Golikov A., *Jørgensen* L.L., Voronkov A., Plotkin A., Keulder-Stenevik F., Bałazy P.).

The total number of taxa identified from the caught invertebrates is presented in table 11.1 and more detailed information about taxonomic processing in the different vessels – in the table 11.2.

Table 11.1 *The analyzed data in BESS 2005-2019 and its main characteristics.*

Year	Number stations	Total		Average abundance, ind./nm	Average biomass, kg/nm	Number	
		Abundance, ind.	Biomass, t			species	taxa
2005	224	83077	2.1	522.5	12.7	142	218
2006	637	779454	20.7	1576.0	42.1	261	388
2007	551	526263	18.2	1240.2	44.6	222	351
2008	431	757334	12.2	2183.7	35.7	157	244
2009	378	653918	12.3	2056.4	42.2	283	391
2010	319	239282	6.8	900.0	27.3	273	360
2011	391	1089586	10.8	3411.4	34.3	282	442
2012	443	3521820	42.6	9832.1	125.5	354	513
2013	487	1573121	27.6	3885.0	71.7	362	538
2014	165	390444	5.3	2806.7	36.7	220	333
2015	334	481602	5.3	1815.1	19.9	398	599
2016	317	1116405	6.8	4230.1	36.3	266	423
2017	339	1073697	16.2	3769.4	58.6	319	500
2018	217	852613	15.4	4887.8	89.2	404	574
2019	305	1292902	19.0	4239.0	62.5	427	621
Total	5321	13138616	202.2	3157.0*	43.3*	291*	433*

* The average long-term value.

Table 11.2 *Statistics of megabenthos bycatch processing and assessment of the quality of taxonomic processing of invertebrates in the BESS 2019*

Research vessels	"G.O. Sars"	"Helmer Hansen"	"Johan Hjort"	"Vilnyus"	**Total**
Number of processed hauls	57	28	82	138	**305**
Phyllum	12	13	12	12	**13**
Class	25	25	25	24	**28**
Order	67	66	71	60	**81**
Family	154	144	184	126	**224**
Species	**231**	**190**	**320**	**211**	**427**
Total number of taxa	320	281	435	289	621
Percentage of species identification*	72.1	67.6	73.5	73.0	68.7

* calculated as quotient from division of total number of identifications till species to total number of identifications, %

11.1 Species diversity

A total of 622 invertebrate taxa (427 identified to species level) have been recorded in 2019. Compared with 2017 and 2018, the total number of recorded species increases by 25 % and 5.3% respectively, resulting in 2019 being record high in identifications to species level (Table 11.1). The reason for this high species-level number is not clear, but the participation of many high-qualified experts in groups such as Porifera, Cnidaria, Arthropoda and Mollusca on the vessels might have added to this. Effort has been made to standardize taxa and species identification among years, ships and experts. This includes:

- Database and post-data quality check of species and taxa names.
- In 2019 the first Benthic-course were held for the Ecosystem benthos participants in Tromsø in June before the Ecosystem Survey with introduction to standardized processing and species identification.
- Common literature developed for the cruise are used ("Atlas of megabenthic organisms in the Barents Sea and adjacent waters" (Zakharov et al., 2018) and Photo compendium (Jørgensen et al, being updated each year).
- Voucher species collection
- The use of standardized written procedures for benthos processing.

Despite of different coverage between years, the total taxonomic structure of bycatches is practically similar in 2018 and 2019 (Figure 11.1.1). The most diversity groups in the trawl catches in 2019 were Mollusca (149 taxa), Arthropoda (108 taxa) and Cnidaria (72 taxa) (Figure 11.1.1). Among mollusks, 53 % of taxa belong to the Gastropoda (79 taxa), 37 % – to the Bivalvia (56 taxa) and the remaining 10 % are distributed among Cephalopoda, Polyplacophora and Caudofoveata groups. The taxa of Artropoda phylum in the main were presented by Malacostraca and Pycnogonida, and Cnidaria taxa – by hydroids and anthozoans.

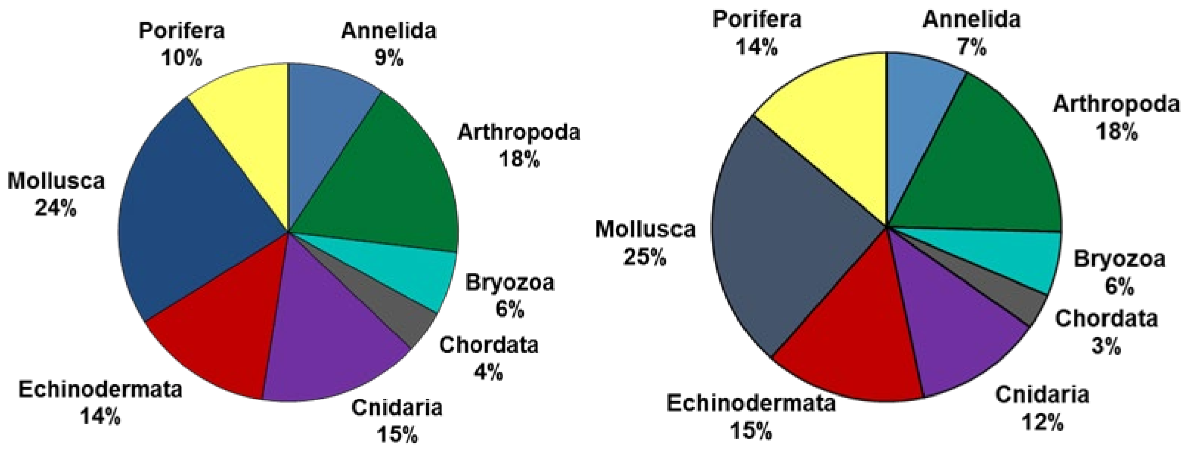

Figure 11.1.1 *The number of main taxa per megabenthic groups (%) in the Barents Sea, August-October 2018 (left) and 2019 (right)*

The species density in the terms of the number of taxa in standard trawl catches ranged from 7 to 99 with average of 35.0±1.0 taxa per trawl-catch. The low level of diversity in the Russian part of the survey area may be due to lack of skill benthos experts onboard of the "Vilnyus" in 2019 (Figure 11.1.2). The most common species and taxon's in the catches in 2019 were the following: *Ctenodiscus crispatus* (recorded at 79 % of the stations), *Pontaster tenuispinus* (61 %), *Ophiura sarsi* (61 %), *Sabinea septemcarinata* (57 %), *Ophiopholis aculeata* (55 %), Polynoidae g. spp. (53 %), *Henricia* spp. (49 %) and Porifera (46 %).

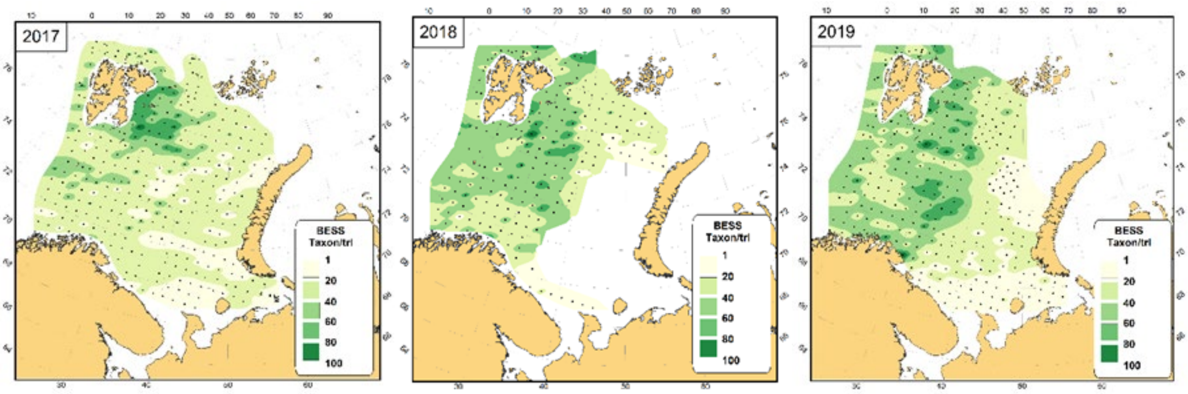

Figure 11.1.2 *The number of megabenthic taxa per trawl-catch in the Barents Sea, August-October 2017-2019.*

11.2 Abundance (number of individuals)

The number of invertebrates individuals in the trawl catches (excluding the pelagobenthic species *Pandalus borealis*) ranged from 5 to 78760 (7-121169 ind./n.ml) with an average of 3296±379 ind. per trawl-catch (4239±515 ind./n.ml).

The most abundant catches (about fifty thousand ind.) were recorded in the western part of the Barents Sea on Spitsbergen bank (Figure 11.2.1). In the area of this hot-spot the trawl-catches in the terms of abundance principally dominated by the small and densely packed sea-squirt *Molgula* sp. Abundance hot-spot in the area close to the Frantz Josef Land is dominated by the brittle stars *Ophiopholis aculeata* and *Ophiacantha bidentata*.

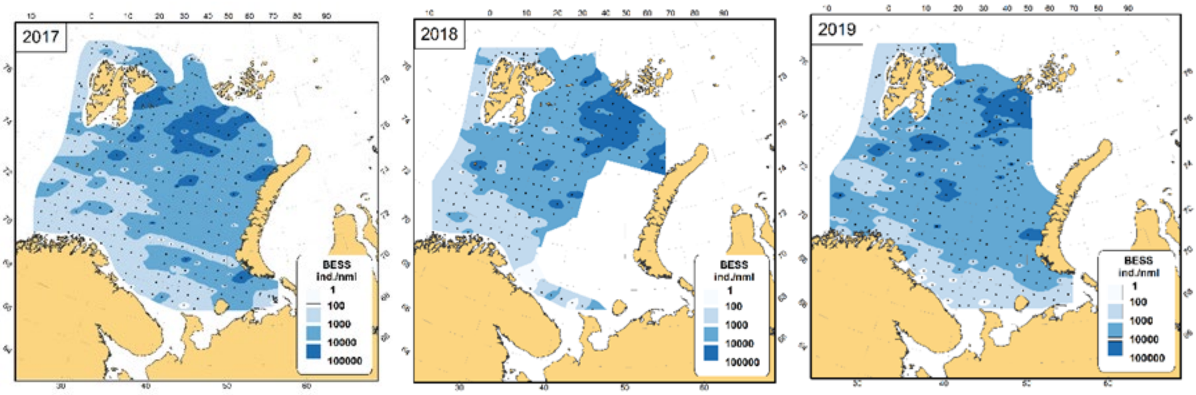

Figure 11.2.1 *The number of individuals of megabenthos (excluding Pandalus borealis) in the Barents Sea, August-October 2017-2019*

11.3 **Biomass**

Like in previous years, the biggest part of the total biomass of the by-catches was made up by Sponges, Echinoderms, and Crustaceans (total 95 %) in 2019 (Figure 11.3.1). The increase in the proportion of arthropods compared to 2018 resulted by difference of the sea area coverage on the southeastern part of the Barents Sea.

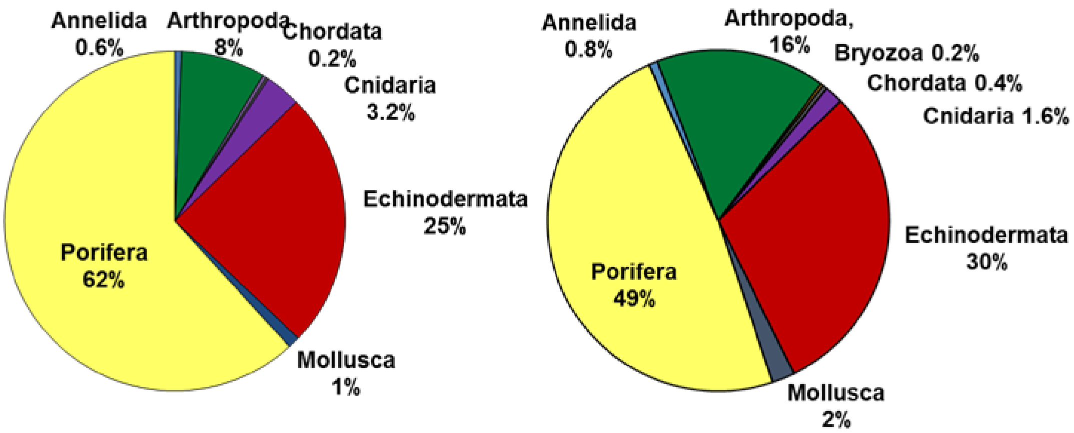

Figure 11.3.1 *Distribution of biomass (excluding Pandalus borealis) across the main megabenthic groups (%) in the Barents Sea, August-October 2018 (left) and 2019 (right)*

The invertebrate's biomass taken by the trawl (excluding semipelagic species *Pandalus borealis*) ranged from 137 g to 1,9 t (0.18-3877 kg/nml) with an average of 44.2±7.7 kg per trawl-catch (62.5±14.6 kg/nml).

The maximum bycatch of megabenthos, as in previous year, was observed in the southwestern part of the Barents Sea in the depth of 317 m (Figure 11.3.2) and dominated by two species of *Geodia* sponges (*G. barretti* and *G. macandrewii*).

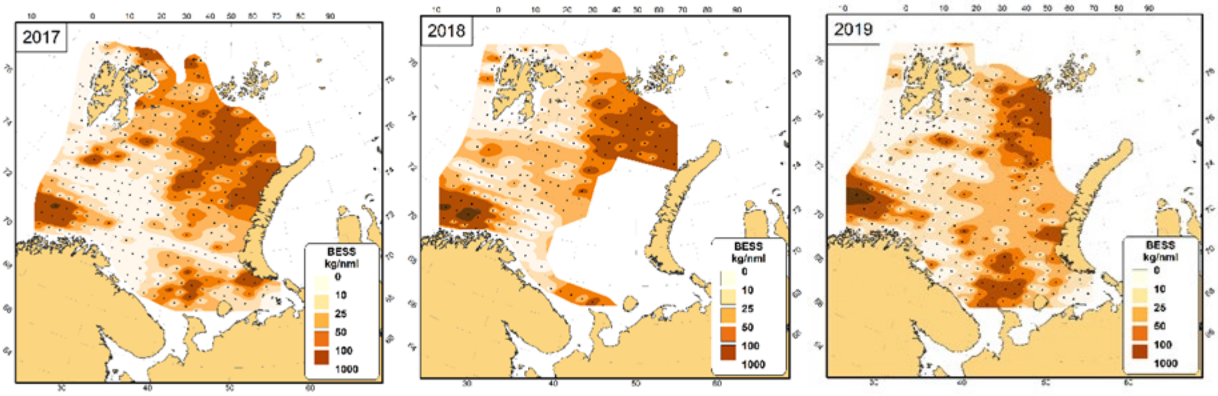

Figure 11.3.2 *Biomass distribution of megabenthos (excluding Pandalus borealis) in the Barents Sea, August-October 2017-2019.*

As in previous years, the north-eastern part of the sea was dominated by the echinoderms (*Urasterias linki, Ophioscolex glacialis, Heliometra glacialis, Ophiopleura borealis*) (Figure 11.3.3). In the southern part of the sea, near Kanin Nos peninsula, a big aggregation of the red king crab were recorded. High biomass catches near Hopen Bank were dominated by sea urchins *Strongylocentrotus* spp. and the sea star *Ctenodiscus crispatus*. High biomass of the non-*Geodia* sponges were recorded near middle part of Novaya Zemlya coast.

The most dominant species in the terms of biomass observed in the trawl catches were the *Geodia* sponges (36.0 % of the total biomass), *Paralithodes camtschaticus* (12.5%), *Ophiopleura borealis* (4.0 %), *Gorgonocephalus arcticus* (2.1 %).

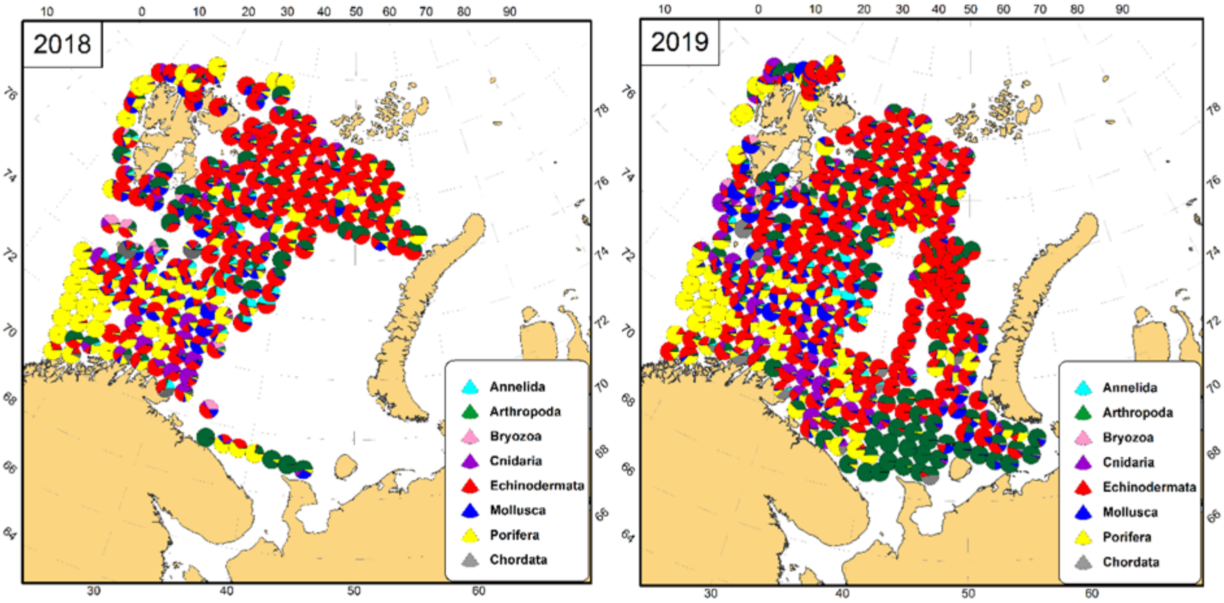

Figure 11.3.3 *Biomass distribution of main taxonomic groups per station in the Barents Sea (excluding Pandalus borealis), August-October 2018-2019.*

12 MARINE MAMMALES AND SEABIRDS

12.1 Marine mammals

Text by: R. Klepikovsky and N. Øien
Figures by: R. Klepikovsky

In total, 2750 individuals of 10 species of marine mammals were observed and 64 individuals were not identified to species during the survey in August-October 2019. The distributions of observations are given by numbers in Table 12.1.1 and locations in Figs 12.1.1-12.1.2.

As in previous years, the white-beaked dolphin (*Lagenorhynchus albirostris*) was the most abundant marine mammal species with more than 50% of all registrations. This species was widely distributed in the survey area. Apparently, most records of this species coincide with the distributions of herring, capelin, polar cod, juvenile cod and other fishes in the research area. The largest group of white-beaked dolphin included an estimated 70 individuals.

Table 12.1.1. *Number of marine mammal individuals observed during the ecosystem survey in 2019.*

Name of species	Total	%
Fin Whale	205	7.5
Humpback Whale	266	9.7
Minke Whale	241	8.8
Unidentified whale	51	1.9
White-beaked dolphin	1593	57.9
Harbour Porpoise	15	0.5
Killer Whale	10	0.4
Sperm Whale	13	0.5
Unidentified dolphins	8	0.3
Harp Seal	338	12.3
Walrus	3	0.1
Bearded seal	2	0.1
Unidentified seal	5	0.2
Total sum	2750	100

Besides the white-beaked dolphins, sperm whales (*Physeter macrocephalus*), harbour porpoises (*Phocoena phocoena*) and killer whales (*Orcinus orca*) were represented among the toothed whales. Sperm whales were observed in deep waters along the continental slope but also within the Barents Sea proper west of 29° E. The harbor porpoises were observed in the southern parts of the research area. A notable observation was made of a group of 6 killer whales in the northern Barents Sea at 79°45'N-41°33'E.

The baleen whale species minke (*Balaenoptera acutorostrata*), humpback (*Megaptera novaeangliae*) and fin (*Balaenoptera physalus*) whale were abundant in the Barents Sea, and 25% of all the animals belonged to them. These species were often found together in aggregations. In

2019, unlike in previous years, baleen whales were observed mainly south of 78°N due to low concentrations of capelin in the north.

Minke whales were widely distributed over the survey area. The densest concentrations of minke whales in northern and eastern areas overlapped with capelin, polar cod and herring aggregations. Compared with previous years, the number of encounters with this species were like that recorded in 2017.

In 2019 the humpback whales were recorded in considerable numbers in the area around Bear Island, west of Hopen Island and in the northern Barents Sea. This change in distribution compared to that in 2018 when the humpbacks were concentrated in the northern area, may be due to the low concentrations of capelin in the north.

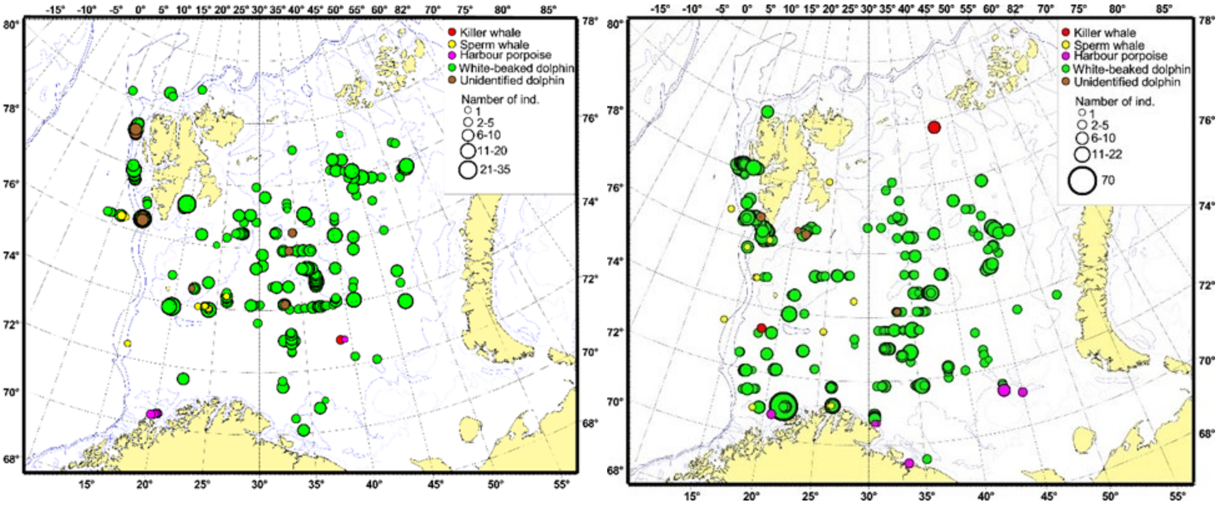

Figure 12.1.1. *Distribution of toothed whales in August-October: 2018 (left) and 2019 (right).*

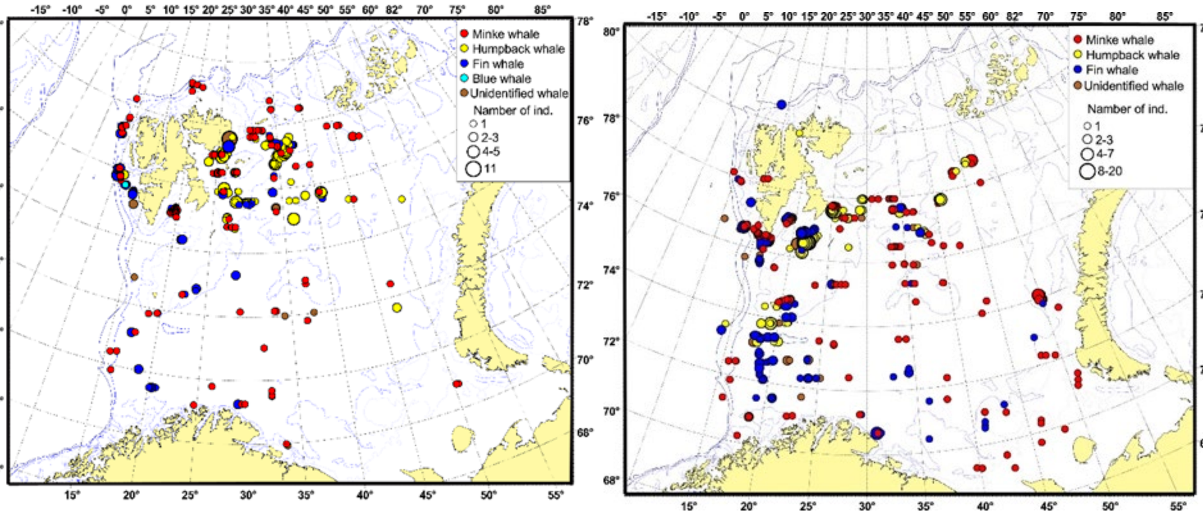

Figure 12.1.2. *Distribution of baleen whales in August-October: 2018 (left) and 2019 (right).*

In 2019, fin whales showed an apparent increase in abundance and were more numerous in association with the continental slope southwards from Svalbard (Spitsbergen) and around Bear Island than in 2018.

No blue whales (*Balaenoptera musculus*) were recorded in 2019.

Pinniped species recorded during the research period were harp seal (*Phoca groenlandica*), bearded seal (*Erignathus barbatus*) and walrus (*Odobenus rosmarus*). The main concentrations of harp seals were found north of 80°N in the area of newly formed ice. Walrus and bearded seal were also observed north of 80°N. Polar bears (*Ursus maritimus*) were not observed during this survey.

12.2 Seabird observations

Text by: P. Fauchald and R. Klepikovsky
Figures by: P. Fauchald

Seabird observations were carried out by standardized strip transect methodology. Birds were counted from the vessel's bridge while the ship was steaming at a constant speed of ca. 10 knots. All birds seen within an arc of 300 m from directly ahead to 90° to one side of the ship were counted. Counts were done only during daylight and when visibility allowed a complete overview of the transect. On the vessels "Helmer Hansen", "G.O. Sars" and "Johan Hjort", birds following the ship i.e. "ship-followers", were counted as point observations within the sector every ten minutes. Ship-followers included the most common gull species and Northern fulmar. On "Vilnyus", ship-followers were counted continuously along the transects, and by a point observation at the start of each transect. The ship-followers are attracted to the ship from surrounding areas and individual birds are likely to be counted several times. The numbers of ship-followers are therefore probably grossly over-estimated.

Total transect length covered by the Norwegian research vessels; "Helmer Hansen", "G.O. Sars" and "Johan Hjort", was 6975 km. Total transect length covered by the Russian research vessel; "Vilnyus", was 4123 km. A total of 106 633 birds belonging to 41 different species were counted. The highest density of seabirds was found north of the polar front. These areas were dominated by Brünnich's guillemots (*Uria lomvia*), little auk (*Alle alle*), kittiwake (*Rissa tridactyla*) and Northern fulmar (*Fulmarus glacialis*) (Figs. 12.2.1, 12.2.2).

Broadly, the distribution of the different species was similar to the distribution in the 2018 survey. Alcids were observed throughout the study area but the abundance and species distribution varied geographically. Little auks were found in the far north area between Spitsbergen and Franz Josef Land, Brünnich's guillemots were found in the central and northern part of the Barents Sea, Atlantic puffins (*Fratercula arctica*) were found in the western part and common guillemots (*Uria aalge*) were mainly found in the south. Among the ship-followers, black-backed gulls (*Larus marinus*) and herring gull (*Larus argentatus*) were found in the south. Glaucous gull (*Larus hyperboreus*) was found around Spitsbergen and in the southeastern area. Kittiwakes and Northern fulmars were found throughout the study area, but with highest density of kittiwakes in the eastern and northern areas.

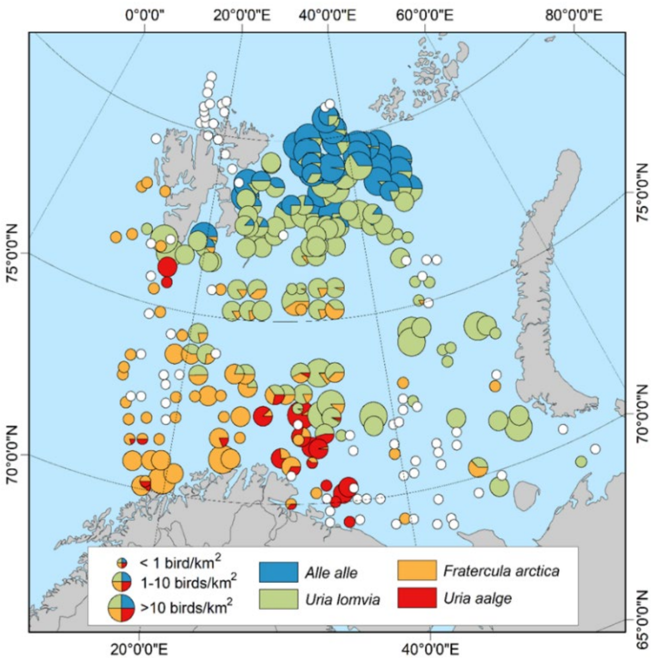

Figure 12.2.1 *Density of auk species along seabird transects in 2019. White circles show zero density.*

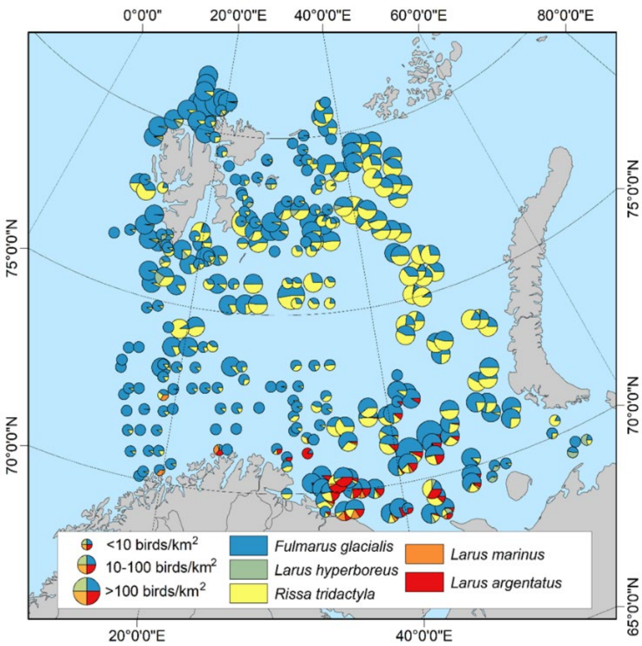

Figure 12.2.2. *Density of the most common gull species and Northern fulmar along seabird transects in 2018. White circles show zero density. Note that because these species are attracted to and tend to follow the ship, densities might be grossly over-estimated.*

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