IMR/PINRO

2
2022
Joint Report Series

JOINT REPORT

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

August-September 2021

Edited by
Dmitry Protzorkevich (PINRO)
Gro I. van der Meeren (IMR)

Institute of Marine Research – IMR

Polar branch of the FSBSI "VNIRO" ("PINRO")

Tittel/Title:

Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-September 2021

Undertittel /subtitle

IMR/PINRO Joint Report Series 2 2022

Rapportserie/Reportseries: Velg i nettversjonen IMR/PINRO Joint Report Series	Nr.–År/Year:	Dato/Date:	Distribusjon: Åpen/Open
Redaktør(er)/Editor(s): Dmitry Prozorkevich Gro I. van der Meeren	2-2022	11.03.2022	Prosjektnr.: 14153 Oppdragsgiver(e): IMR/VNIRO Program: Barent Sea Programme (IMR) Forskningsgruppe: Diverse Antall sider totalt: 111

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 at covering 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 indices estimation, and additional acoustic transects for the capelin stock size estimation. Due to military exercise by the Russian NAVY in the south-eastern part of the Barents Sea, the Russian RV changed its route and moved to the central part of the survey area in the end of August. This caused a delay and a decrease in the number of pelagic trawls of the 0-group survey and reduced area coverage.

The 19-th joint Barents Sea autumn Ecosystem Survey (BESS) was carried out during the period from 15-th August to 03-th October 2021 by the Norwegian research vessels: “G.O. Sars”, “Johan Hjort”, and “Helmer Hanssen”, and the Russian research vessel “Vilnyus”. Exchange of Russian and Norwegianexperts between each country’s respective vessels did not take place in 2021. We would like to express our sincere gratitudeto 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 2021. This report is a summary of observations and status assessment 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 information from BESS for future work.

Contents

1 BACKGROUND

Text by: G.O Johansen and D. Prozorkevich

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 thesein the Barents Sea ecosystem. The survey has since 2004 been conducted annually in the autumn,as a collaboration between the IMR in Norway and the Polar Branch of VNIRO (PINRO) in Russia. The general survey plan and tasks are usually agreed at the annual PINRO-IMR Meeting in March, but in 2021, due to the Covid-19 pandemic, it was agreed by correspondence. Ship routes and other technical details was agreed on by correspondence between the survey coordinators. Survey coordinators in 2021 were Dmitry Prozorkevich (PINRO) and Herdis Langøy Mørk (IMR). Geir Odd Johansen (IMR) took part in planning the survey. Exchange of Russian and Norwegian experts between each country's respective vessels did not take place in 2021 due to the Covid-19 pandemic. The 19-th BESS was carried out during the period from 5-th August to 03-th October by the Norwegian research vessels "G.O. Sars", "Johan Hjort", and "Helmer Hanssen", and the Russian vessels "Vilnyus". The scientists and technicians 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 "Helmer Hanssen", "Vilnyus", "G.O. Sars", and "Johan Hjort" for their dedicated work, as well as all the people involved in planning and reporting of BESS 2021. Special thanks Herdis Langøy Mørk (IMR) and Tatyana Prokhorova (PINRO) for the huge work on the compilation and verification the joint database.* This report is a summary of the observations and status assessments based on the survey data. Further interpretation on status, drivers, trends and consequences will be reported by ICES WGIBAR. Other ICES working groups and workshops (e.g. WGMME, WGZE, WGOH, WGPDMO, AFWG, WGWIDE, NIPAG, WGCRAB, WGEF, WKBAR and etc.) will use information from BESS for future work.

Table 1. *Vessels and participants in the Barents Sea Ecosystem Survey 2021.*

Research vessel	Participants
”*Vilnyus*” (03.08–30.09)	Pavel Krivosheya (Cruise leader, pelagic fish), Alexey Amelkin (Demersal fish), Alexandr Bessonov (Demersal fish), Natalia Pankova (Pelagic fish), Anna Mikhina (Plankton), Michael Nosov (Instrumentation), Sergey Harlin (Instrumentation), Maksim Gubanishchev (Hydrologist), Michael Dvinin (Hydrologist), Roman Klepikovsky (Sea birds and mammals), Marina Kalashnikova (Parasitologist), Alexander Benzik (Plankton, benthos), Alexandra Kudryashova (benthos).
”*G.O. Sars*” (20.08–14.09)	<u>Part 1 (20.08-02.09)</u> Erik Olsen (Cruise leader), Sarah Ann Bruck (Demersal fish), Janicke Skadal (Demersal fish), Eirik Odland (Demersal fish) ,Eyvind Ernstsen (Instrumentation), Jarle Wangensten (Instrumentation), Jane Strømstad Møgster (Plankton), Monica Martinussen (Plankton), Monica Sanden (Chemical contaminants), Guri Nesje (Chemical contaminants), Heidi Gabrielsen (Benthos), Sten-Richard Birkely (Benthos), Anja Helene Alvestad (Demersal fish), Thomas Sivertsen (Sea mammals), Lars Kleivane (Sea mammals), Susanne Tonheim (Pelagic fish), Timo Meissner (Pelagic fish), Gary Elton (Sea birds) <u>Part 2 (02.9-14.9)</u> Arved Staby (Cruise leader), Heidi Gabrielsen (Benthos), Sten-Richard Birkely (Benthos), Anja Helene Alvestad (Demersal fish), Thomas Sivertsen (Sea mammals), Lars Kleivane (Sea mammals), Susanne Tonheim (Pelagic fish), Timo Meissner (Pelagic fish), Elise Eidset (Demersal fish), Celina Eriksson Bjånes (Demersal fish), Sofie Gundersen (Demersal fish), Jörn Patrick Meyer (Instrumentation), Egil Frøyen (Instrumentation), Jan Henrik Simonsen (Plankton), Hilde Arnesen (Plankton), Hilde Elise Heldal (Chemical contaminants), Grethe Tveit (Chemical contaminants), Jon Ford (Sea birds), Anders Lund Eide (Radioactivity).
”*Johan Hjort*” (18.08-30.09)	<u>Part 1</u> (18.08-10.09) Harald Gjøsæter (Cruise leader), Rupert Wienerroither (Demersal fish), Audun Hjertager (Demersal fish), Grethe Thorsheim (Demersal fish), Diana Zaera-Perez (Demersal fish), Deanna Marie Leonard (Sea mammals), Daniela Fuchs (Sea mammals), Jan Frode Wilhelmsen (Instrumentation), John Nesheim (Instrumentation), Inger Henriksen (Pelagic fish), Lea Marie Hellenbrecht (Pelagic fish), Ann-Kristin Olsen (Plankton), Jon Rønning (Plankton), Anders Fuglevik (Chemical contaminants), Patrick-Andre Korneliussen (Chemical contaminants). <u>Part 2 (10.09-30.090)</u> Georg Skaret (Cruise leader), Andrey Voronkov (Benthos), Felicia Keulder-Stenevik (Benthos), Ida Vee (Benthos), Runar Smestad (Demersal fish), Vidar Fauskanger (Demersal fish), Erlend Langhelle (Demersal fish), Kjell Arne Fagerheim (Sea mammals), Nils Øien (Sea mammals), Magnar Mjanger (Instrumentation), Hege Rognaldsen (Instrumentation), Jostein Røttingen (Pelagic fish), Frøydis Tousgaard Rist (Pelagic fish), Erling Boge (Pelagic fish), Gaston Ezequiel Aguirre (Plankton), Eli Gustad (Plankton).
“Helmer Hansen” (12.09-03.10)	Rupert Wienerroither (Cruise leader), Mette Strand (Benthos), Anne KariSveistrup (Benthos), Silje Elisabeth Seim (Demersal fish), Tor Magne Ensrud (Demersal fish), Anne Sæverud (Demersal fish), Eirik Odland (Demersal fish), Arne Liaklev (Sea mammals), Frode Holen (Sea mammals), Jarle Kristiansen (Instrumentation), Lage Drivenes (Instrumentation), Vilde Regine Bjørdal (Pelagic fish), Merete Kvalsund (Pelagic fish), Astrid Fuglseth Rasmussen (Plankton), Terje Berge (Plankton).

2 SURVEY EXECUTION 2021

Text by: G.O. Johansen and D. Prozorkevich
Figures by: S. Karlson and G.O. Johansen

BESS aims at covering the entire, ice-free area of the Barents Sea and, progressing fromsouth 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),where some additional bottom trawl hauls for demersal fish survey indices estimation,and additional acoustic transects for the capelin stock size estimation are carried out. The planned vessel tracks for BESS 2021 are given in figure 2.1.

BESS 2021 was mostly executed according to this plan. The Russian RV “Vilnyus” covered the eastern and north-western of the Barents Sea within the REEZ. Norwegian RVs covered the western part of the Barents Sea and an area around Svalbard (Spitsbergen) within the NEEZ. “Johan Hjort” covered the eastern and north-eastern part of this area, “G.O. Sars” the western part, and“Helmer Hanssen” the areas west, north, and north-east of Svalbard (Spitsbergen). The realized research vessel tracks with sampling for the BESS 2021 are shown in Figure 2.2 and 2.3. Exceptions to the planned coverage were lack of coverage in the north-eastern part of the Barents Sea, within the 12 nautical mile zone west and north-west of Svalbard (Spitsbergen), and in the loophole (Figures 2.2 and 2.3).

The lack of coverage in north-east was due to delay of the Russian RV caused by military exercise by the Russian Navy in the south-eastern part of the REEZ in the Barents Sea. The Russian RV had to change its route and move to the central part of the survey area in the end of August. The consequences were a decrease in the number of pelagic trawls of the 0-group survey and reduced area coverage leading to possible underestimation of the polar cod stock size and problems with the estimation of 0-group indices.

The lack of coverage of coastal area around Svalbard (Spitsbergen) was due to delayed permit to take bottom trawl samples in this area. The consequences are fewer samples for assessing juvenile Greenland halibut, and some near shore benthic species and demersal fish.

The lack of coverage in the Loophole is caused by inability to access this area by both nations. The Russian part has survey time restrictions leaving too little time to enter the area. The Norwegian part cannot perform bottom trawling due to challenges related to catching sedentary species. Applying for permit to do this is difficult and trying to fulfil a possible permit would seriously hamper the flexibility needed when conducting an ecosystem survey of this size, with multiple boats and tight schedule. The consequences of this is severe for the data quality related to several ecosystem components, including assessment of several commercial species. Coverage of this area or parts of it has been a problem of variable impact in the survey since 2015 and must be addressed in the future.

BESS 2021 was largely conducted according to the planned time schedule. An exception was the early coverage in the south-western corner of REEZ. This is due to the earlier start of the Russian part of the survey compared to the Norwegian and is difficult to avoid due to the tight time schedules for Norwegian vessels participating in other surveys. Other than that, the survey progressed as expected. The planned schedule for BESS 2021 was 151 days, while the effective vessel days (time between first and last sample in the vessel logs) was 134 days. The difference between these two is as expected, as the vessels need time to prepare before sampling, and return to port after the survey. The progression of the survey in time and space in 2021 can be characterized as good (Figure 2.4). Note that in reports from earlier years, only the planned schedule is reported.

It was decided to keep all the main tasks of the survey like previous years, and most ecosystem components were well examined in 2021. Norwegian vessels conduct chemical pollution assessment every third year in the Barents Sea, and 2021 was such a year. The sampling and results related to this is described in its own chapter in this survey report (chapter 4). In addition to standard sampling at BESS, the standard oceanography sections “Vardø-Nord” and “Sørkapp-Vest”, and the new standard section “Hinlopen”, were sampled in the Norwegian survey area, and the “Kola”, “Kanin” were sampled in the Russian survey area (Fig. 2.3). Other major changes or irregularities are not noted for the execution of BESS 2021.

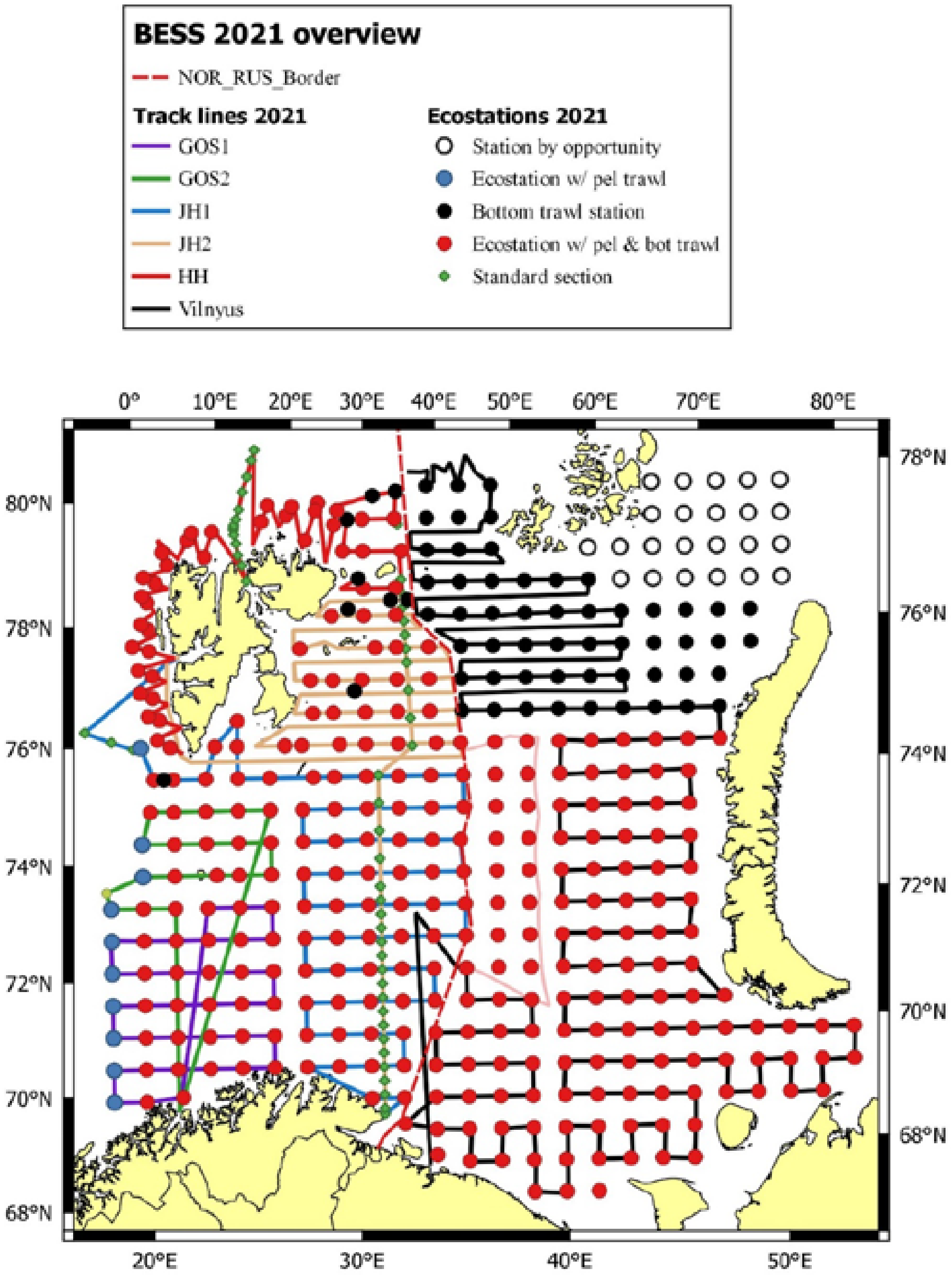


Figure 2.1 *BESS 2021, planned survey map with ecosystem stations and vessel tracks.*

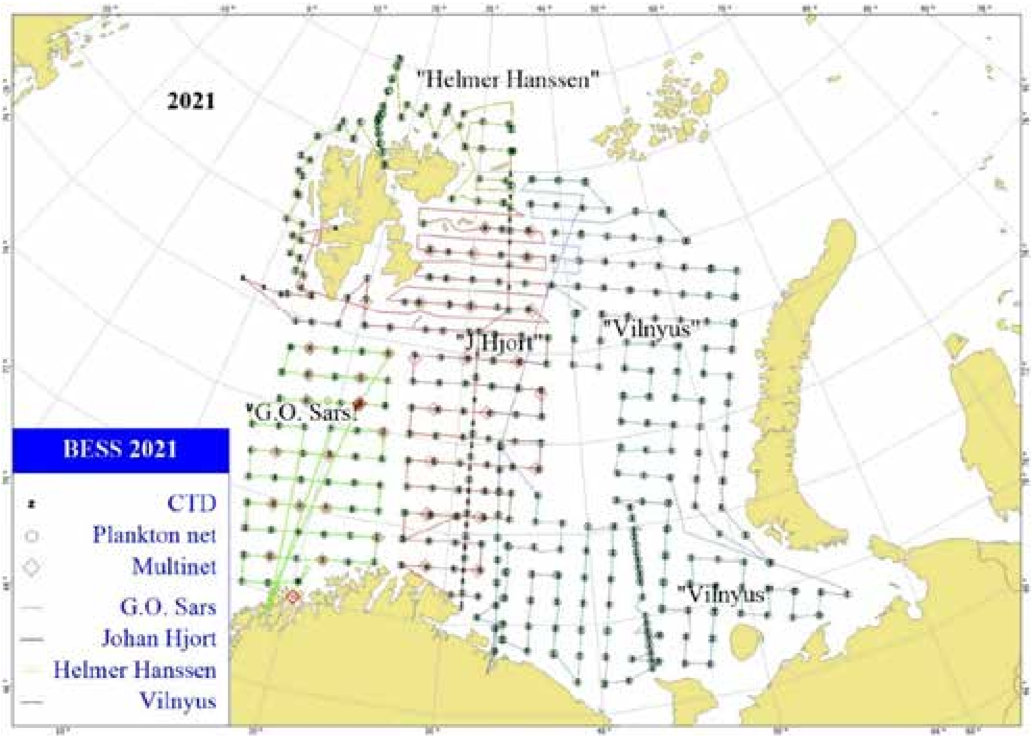


Figure 2.2 *BESS 2021, realized vessel tracks with pelagic and bottom trawl sampling stations, note that some trawl stations are taken in addition to the regular ecosystem stations.*

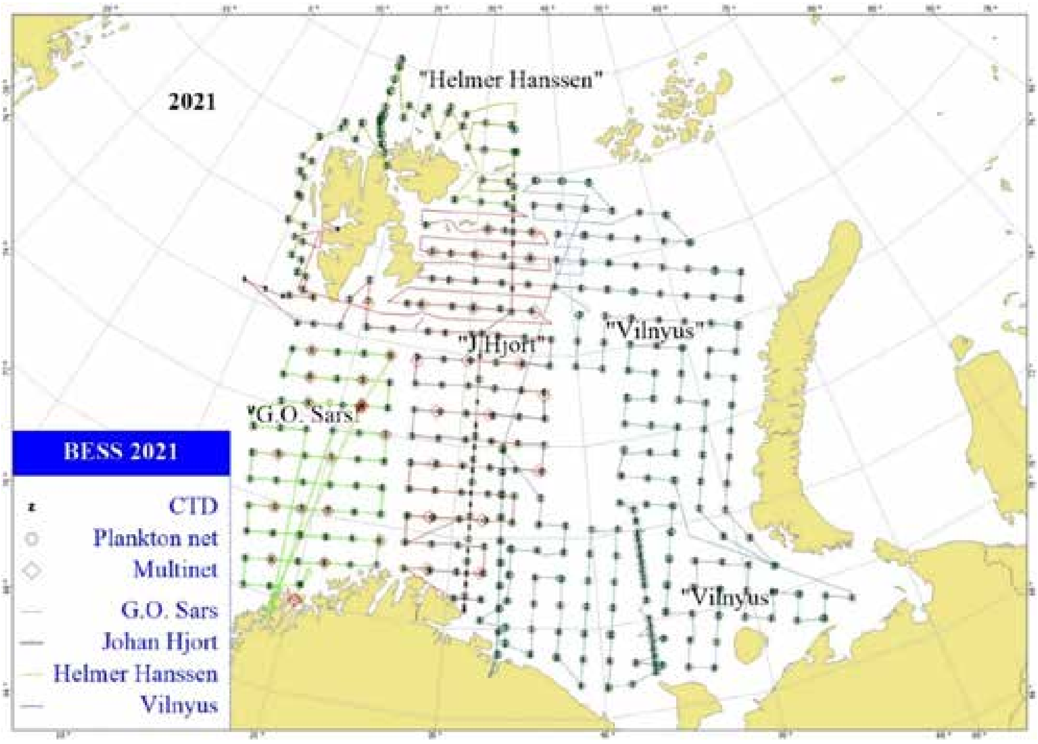


Figure 2.3 *BESS 2021, realized vessel tracks with hydrography and plankton samples at ecosystem stations.*

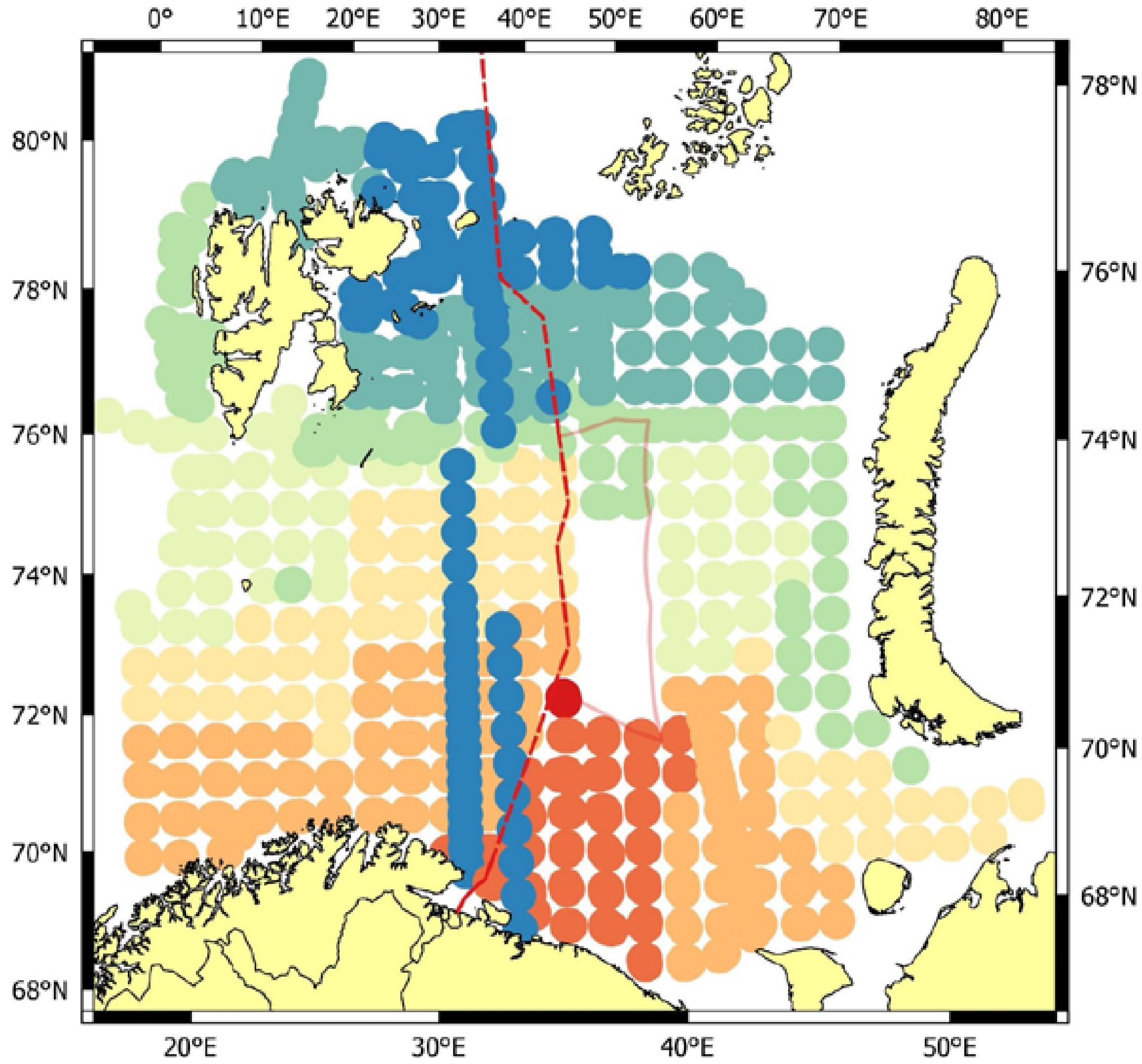


Figure 2.4 *Development of BESS 2021 in space and time. Points represents samples taken at ecosystem stations during the survey. The colour of the points represents days after 1-st August 2021 in the period of the survey, 5-th August to 30-th September. The colour scale from red (early in the survey) to blue (late in the survey). Late stations in vertical lines are hydrographic sections taken at towards the end of the survey.*

2.1 Sampling methods

No adjustments of sampling gear were done in 2021 compared to 2020. The survey sampling manuals can be obtained by contacting the survey coordinators. These manuals include methodological and technical descriptions of equipment, the trawling and capture procedures by the sampling tools, sampling and registration of the catch in the lab, and the methods that are used for calculating the abundance and biomass of the biota.

2.2 Special investigations

BESS is a useful platform for conducting additional studies in the Barents Sea. These studies canbe 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 thestandard monitoring activities at the survey. The special investigations vary from year to year, andbelow is a list of special investigation conducted on Russian Norwegian vessels at BESS 2021, with contact persons.

2.2.1 Annual monitoring of pollution levels

In 2021 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 RV "Vilnyus" during BESS in the southern and eastern parts of the Barents Sea. The results from chemical analyses will be reported in 2022. More detailed information an available in the annual ICES WGIBAR reports.

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

2.2.2 Collection of samples for biochemical studies

Frozen samples of commercial and non-commercial fish and invertebrates were collected for biochemical studies (ratio of body parts, chemical composition of nutrients, molecular weight of muscle proteins, amino acids and lipid fractions composition) in accordance with a research program. Samples were frozen at a temperature not higher than minus 18° C immediately after catching before rigor mortis.

Contact: Andrey Baryshnikov, PINRO (baryshnikov@pinro.ru)

2.2.3 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)

http://www.ices.dk/community/groups/Pages/WGPDMO.aspx ; https://www.amazon.com/Barents-Sea-Ecosystem-Management-Cooperation/dp/8251925452 (pp. 743-749)

2.2.4 Parasitological study

The purpose of this study is to monitor the infestation of commercial fish species in the Barents Sea with helminths that are hazardous to human health. 1000 specimens of six fish species were studied in order to identify hazardous parasites. Statistical processing of parasitological data consisted in determination of three indicators of the degree of parasite infestation: *prevalence* – the proportion (%) of fish infested with a parasite of this species of the number of examined fish; *abundance* – the number of parasites of this species per one examined fish; *confidence interval* (CI) – the interval that covers the parameter of the prevalence with a designated confidence level. Helminths of two species that are hazardous to human health have been identified (larvae of nematodes *Anisakis simplex* and *Pseudoterranova decipiens*). The first of them are mostly found in cod, haddock and long rough dab. Capelin and Arctic cod are infested with them to a lesser extent (Tables 2.2.4.1; 2.2.4.2).

Table 2.2.4.1 - *Indicators of the total infestation of fish with larvae of the nematode Anisakis simplex*

Fish species	Number of examined fish, specimens	Average length (min-max), cm	Infestation rates	
			Prevalence (CI), %	Abundance, specimens
Cod	100	50.6 (17.0-78.0)	99.0 (96.0-100)	29.9
Haddock	225	41.1 (22.0-59.0)	98.2 (96.0-100)	16.5
Long rough dab	200	33.5 (19.0-47.0)	80.5 (68.6-80.9)	6.8
Beaked redfish	25	22.2 (19.0-27.0)	92.0 (78.1-99.2)	2.7
Capelin	225	15.2 (11.5-18.5)	39.3 (30.3-46.1)	0.5
Arctic cod	225	15.3 (11.0-23.5)	36.9 (34.6-48.5)	0.6

Table 2.2.4.2 - Indicators of the total infestation of fish with larvae of the nematode *Pseudoterranova decipiens*

Fish species	Number of examined fish, specimens	Average length (min-max), cm	Infestation rates	
			Prevalence (CI), %	Abundance, specimens
Cod	100	50.6 (17.0-8.0)	8.0 (3.4-14.2)	0.1
Haddock	225	41.1 (22.0-59.0)	1.8 (0.5-4.5)	0.02
Long rough dab	200	33.5 (19.0-47.0)	8.0 (4.6-12.2)	0.1

The obtained data indicate the maintaining of a high level of invasion of most bottom fish species with the nematode *A. simplex l*. For long rough dab, the results from studies indicated a four-time decrease in the abundance of invasion and a 3.3-time decrease in the proportion (%) of fish infested with the nematode *P. decipiens l.*, which was observed in 2020 (prevalence was 8.0 %, abundance index was 0.20 specimens). These results were compared with their average values that were obtained for the 2014-2019 period (prevalence was 26.4 %, abundance index was 0.75 specimens).

Contact: Yury Bakay, PINRO (bakay@pinro.ru)

2.2.5 Parasites in fish, freeze samples

In 2021, 51 whole Atlantic cod were collected for the FHF-project (FHF nr. 901628, IMR nr. 15661) ***Kartlegge forekomst av kveis i hvitfisk i norske farvann gjennom året***. As requested, fish were of commercial size (if possible > 2kg and no upper limit), and frozen immediately after catch for later analyses. Fish samples were stored with information about station number, catching date and project number. Fish were inspected for ascaridoid parasites by the UV-press method at IMR facilities (Reception lab and Parasite-lab). Nematodes were morphologically screened for genus determination, and *Anisakis*, *Pseudoterranova*, *Contracaecum* and *Hysterothylacium* were recognized. Moreover, subsamples of worms from each fish host species and sampling area were identified by sequencing of the mtDNA *cox2* gene. Ascaridoid abundance was significantly positively related to fish size (length). Parasites were mostly located in the fish viscera. Only *A. simplex* (sensu stricto) and *Pseudoterranova* spp. were found in the flesh of the fish. Massive infections with *Contracaecum spp*. and *A. simplex* (s.s.) were found in and around the pyloric caeca of all fish examined (Prevalence=100%), while high burden of adult *H. aduncum* was observed in the stomach lumen and intestine of the fish. A small amount of *Pseudoterranova* spp. was also detected in the viscera samples.

Contact: Arne Levsen (ArneLevsen@hi.no)

2.2.6 Cartilaginous fish, freeze samples

During the BESS cruise data and samples of various skates species have been collected and are contributing to our knowledge of their distribution, life history, population structure, and morphological traits for species distinction. The spinytail skate (*B. spinicauda*) samples contribute to an ongoing collaborative effort with UiT. In addition, there are skate species where species identification might be difficult. *B. spinicauda* e.g. is a very large and therefore vulnerable skate species which often gets mixed up with another large skate species *D. intermedius* (NO: "storskate" (=large skate), which however has never been confirmed in the Barents Sea, yet many records exist. Whole individuals or images of live caught specimen are therefore contributing to 1) unambiguously document their presence (or absence) in the Barents Sea, and 2) conduct full dissection (where applicable) to record various life history parameters and take samples e.g. for ageing and genetics. The recording and mapping of skate egg catches contributes to an effort to identify egg capsule accumulation areas.

*Contact: Claudia Junge (*Claudia Junge@hi.no*)*

2.2.7 Additional sampling of capelin otholites

During the BESS cruise numerous otolith of pelagic fish are sampled and mounted for age-reading. The mounting of otoliths is necessary for precise age-reading. However, one large disadvantage of the mounting is that otoliths cannot be used for any other analysis. Therefore, we have started to collect additional otoliths which are not mounted. These otoliths will be used to build up a collection of reference material covering samples in space and time which can be used in the future. The collection of loose otoliths provide the unique possibility to utilize these otoliths in the future for any type of otolith analyses, such as microstructure, microchemistry or otolith shape analysis. During the survey, 10 loose otoliths were sampled from capelin at each trawl haul targeting capelin.

*Contact: Georg Skaret (*Georg.skaret@hi.no*)*

2.2.8 Microplastic trawl samples, Manta trawl

During BESS 2021, IMR and VNIRO added Manta trawl sampling for microplastics in the surface, to map out distributions and identify presence of areas with higher concentrations and to provide a baseline for future monitoring studies. Stations selected for sampling is indicated in Fig 2.2.8.1. There is ongoing work to harmonize protocols for digestion and characterization.

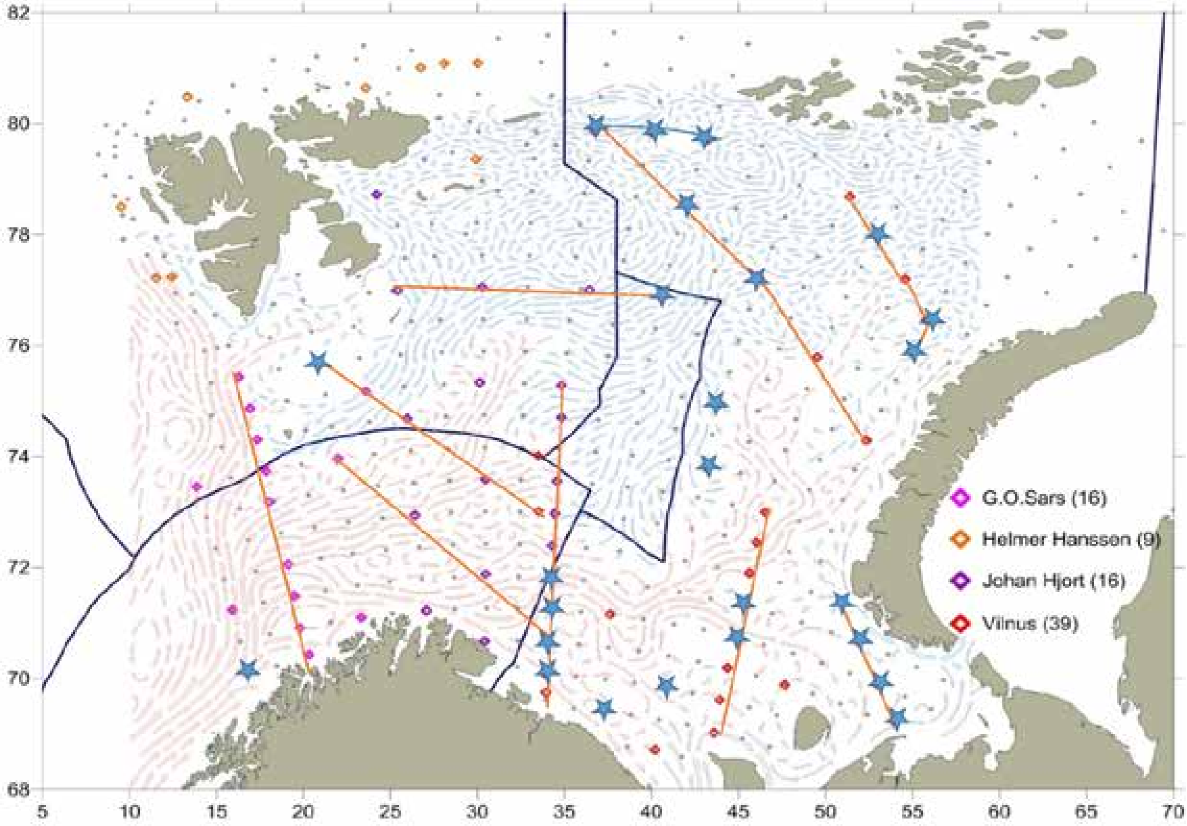


Figure 2.2.8.1. *Position of microplastic section and background station on the area of BESS 2021.*

Contact: Bjørn Einar Grøsvik (Bjorn.grosvi@hi.no*)*

3 DATA MANAGEMENT

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

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).

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 mentioned in the "Background" chapter 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 and assembled into a complete pdf-report when the main components are completed. Some post-survey information notincluded in the written report (e.g. plankton and fish stomach samples which need longerprocessing time) will be published as individual parts of the report later. All reports from BESS from 2004 until the latest are available at this web site: https://imr.brage.unit.no/imr-xmlui/handle/11250/2658167.

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 1981–2010.

In August–September 2021, surface temperature was on average 0.7°C higher than the long-term mean in most of the surveyed area (70%), with the largest positive anomalies (>1°C) in the southeastern and northwestern Barents Sea, especially south of the Svalbard (Spitsbergen) (Fig. 4.1.1.9). Negative anomalies (about −0.5°C on average) were found in the southwestern and central Barents Sea. Compared to 2020, the surface temperature in 2021 was much lower (by 1.2°C on average) in almost all over the surveyed area (~90%), with the largest negative differences (>2°C in magnitude) in the central and southeasternmost parts of the sea. Positive differences in temperature between 2021 and 2020 were found in the northwestern Barents Sea (south of the Svalbard (Spitsbergen) and around Bear Island).

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 0.8 and 0.5°C respectively) in about 80% of the surveyed area, with the largest positive anomalies in the east, especially at 50 m depth. Negative anomalies (about −0.3°C on average) were mostly found in the northern Barents Sea. Compared to 2020, the 50 and 100 m temperatures in 2021 were higher (on average, by 0.6 and 0.4°C respectively) in two thirds of the surveyed area; negative differences were observed in some separate areas of the Barents Sea and reached the largest values at 50 m depth.

Bottom temperature was in general 0.7°C above average in three fourths of the surveyed area, with the largest positive anomalies in the southeastern Barents Sea (Fig. 4.1.1.10). Negative anomalies (−0.5°C on average) were mainly found in the northern part of the sea, especially north of 77°N. Compared to 2020, the bottom temperature in 2021 was on average 0.5°C higher in three fourths of the surveyed area. Bottom waters were colder (on average, by 0.5°C) than in 2020 in some separate parts of the sea, with the largest differences in temperature in the southeast. In August–September 2021, the area covered by bottom water with temperatures below zero was 39% in the Barents Sea (71–79°N 25–55°E) that was 1% larger than in 2020 and the largest since 2011.

Surface salinity was on average 0.3 higher than the long-term mean in 80% of the surveyed area, with the largest positive anomalies (>0.4) in the north and southeast (Fig. 4.1.1.11). Negative anomalies (–0.1 on average) were observed in the southwestern part of the sea as well as in a small area west of Kolguev Island. In August–September 2021, surface waters were on average 0.2 saltier than in 2020 in about 80% of the surveyed area; they were fresher (on average, by 0.2) mainly in the coastal area of the southwestern Barents Sea as well as east of the Svalbard (Spitsbergen) and in a small area northwest of Kolguev Island.

Salinity of deeper waters was lower than average (by 0.1 on average) in about 60% of the surveyed area at 50 m depth and almost all over the sea (85% of the area) at 100 m depth, with the largest negative anomalies in coastal waters in the southwestern Barents Sea as well as east of Bear Island and around Kolguev Island. Positive anomalies were mainly observed in the northwestern part of the sea. In August–September 2021, waters at 50 and 100 m were fresher (by 0.1 on average) than in 2020 in about 55% of the surveyed area, with the largest negative differences in the southeastern Barents Sea and over the

Spitsbergen Bank. Significant positive differences (>0.1) in salinity between 2021 and 2020 were mainly observed at 50 m depth in some areas between 72 and 76°N. At a depth of 50 m, both positive and negative anomalies and differences were larger than at 100 m. At a depth of 100 m, salinity anomalies and differences of <0.1 in magnitude occupied 88 and 92% of the surveyed area respectively.

Bottom salinity was slightly lower than average almost all over the surveyed area (~90%), with the largest negative anomalies (>0.1 in magnitude) mainly in the northern (some small areas) and southeastern Barents Sea as well as over the Spitsbergen Bank (Fig. 4.1.1.12). Positive anomalies were found in some areas around the Svalbard (Spitsbergen). In August–September 2021, the bottom waters were a bit fresher than in 2020 in half of the surveyed area, with the largest negative differences (>0.1 in magnitude) in the southeast. These waters were saltier compared to 2020 mainly in the southwestern and eastern Barents Sea as well as east of Bear Island. As a whole, bottom salinity anomalies and differences were small (<0.1 in magnitude) almost all over the surveyed area (83 and 84% respectively).

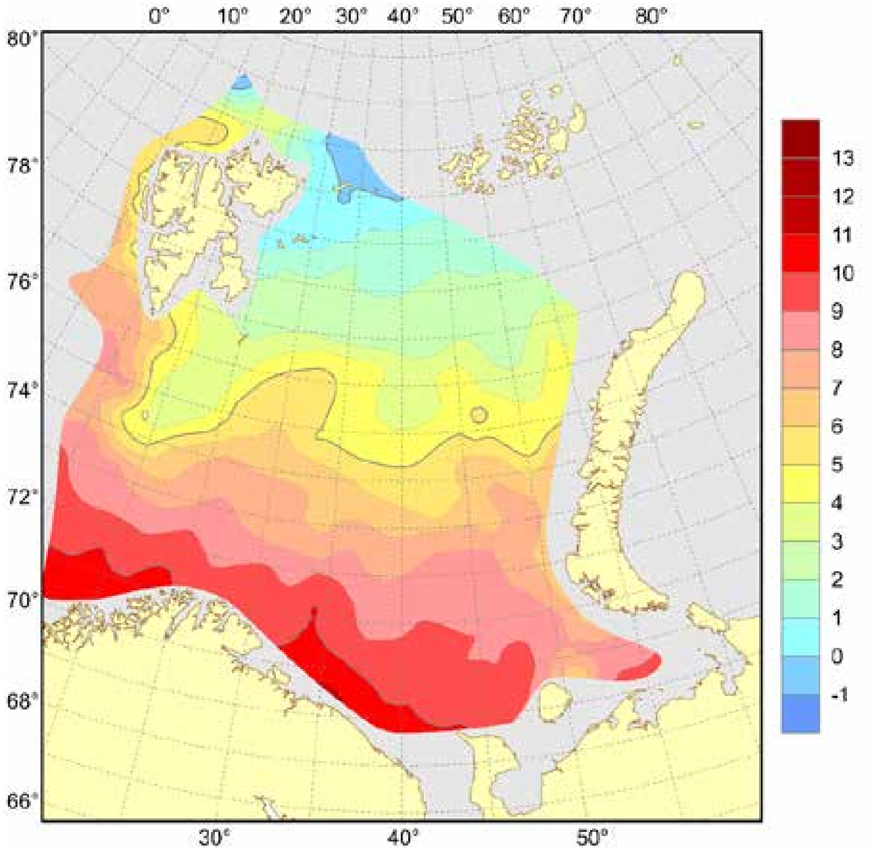


Figure 4.1.1.1. *Distribution of surface temperature (°C), August–September 2021.*

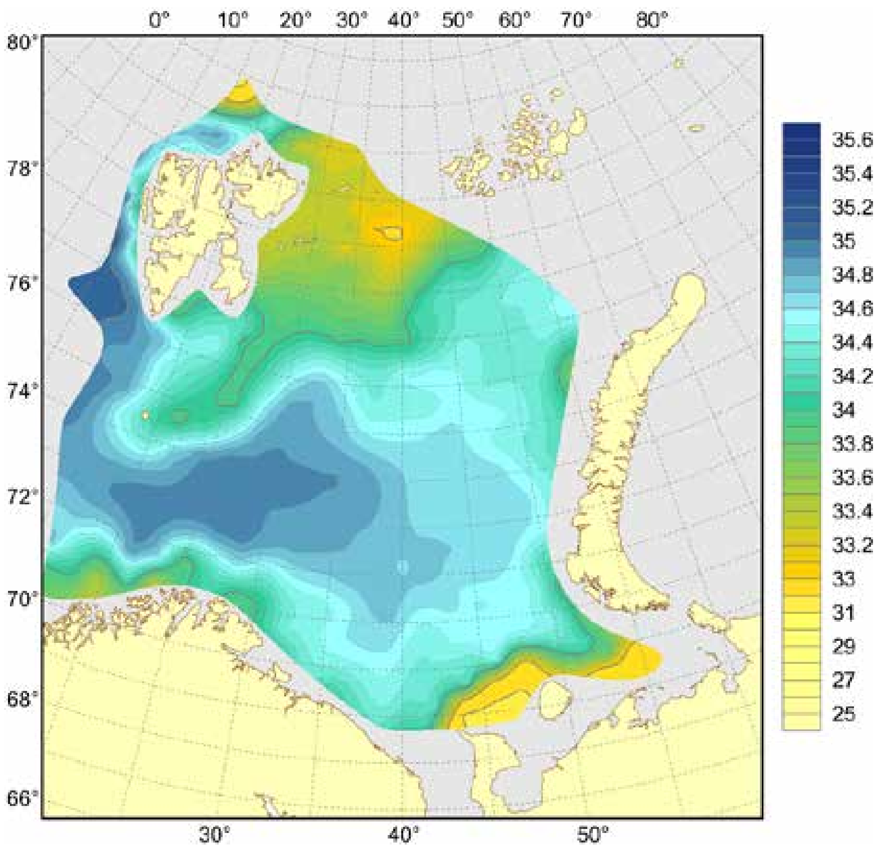


Figure 4.1.1.2. *Distribution of surface salinity, August–September 2021.*

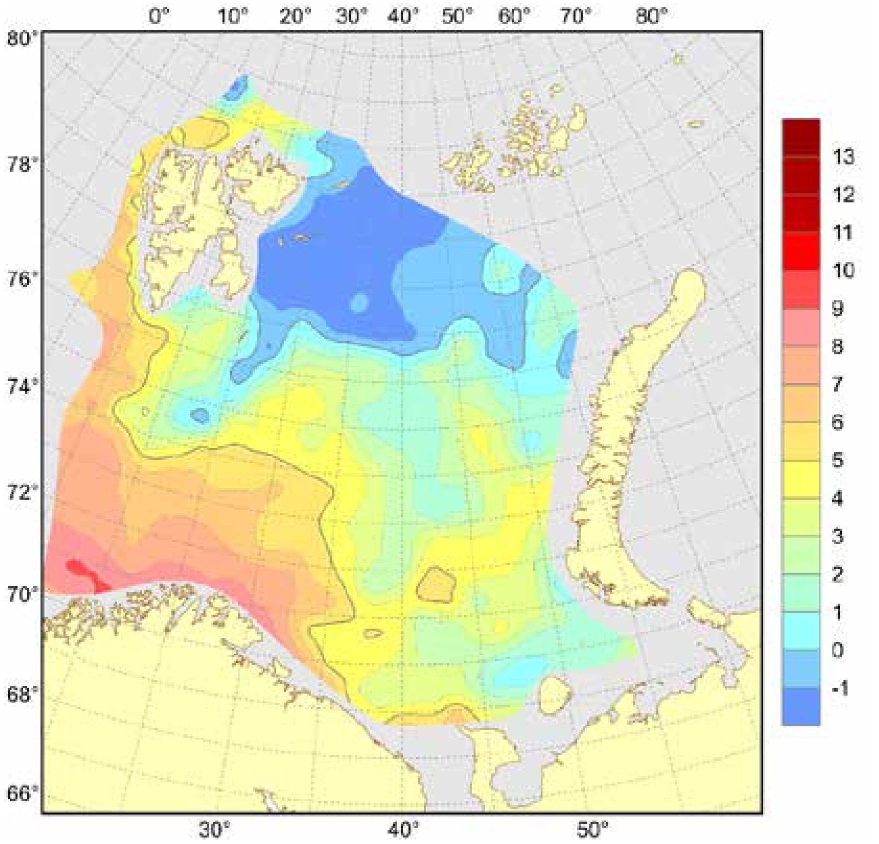


Figure 4.1.1.3. *Distribution of temperature (°C) at the 50 m depth, August–September 2021.*

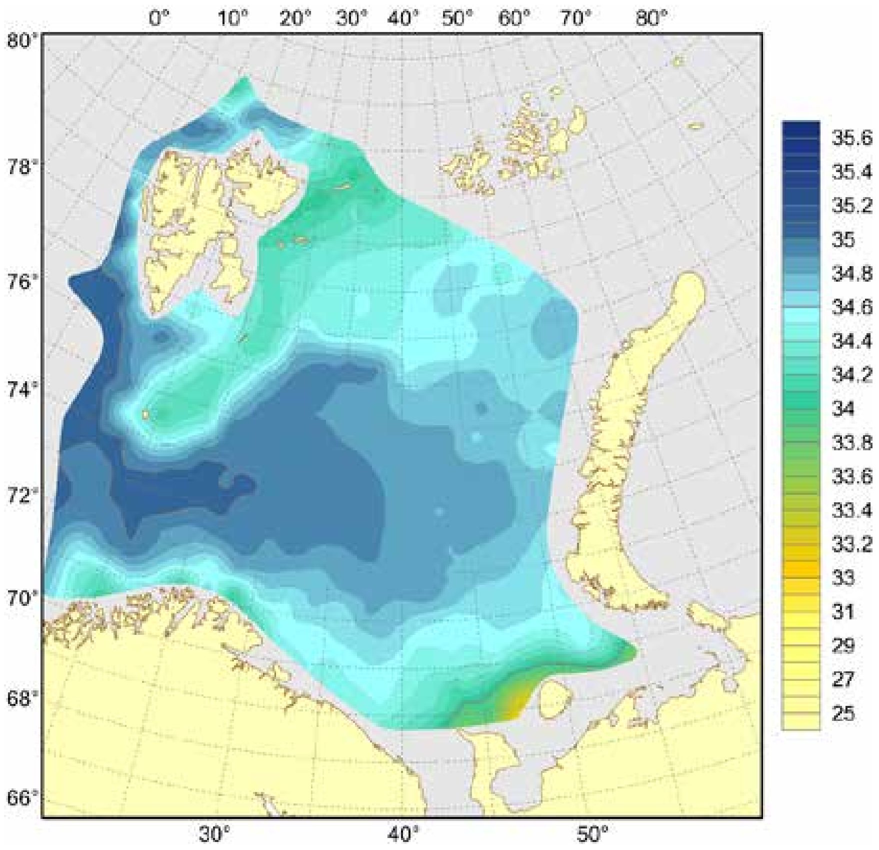


Figure 4.1.1.4. *Distribution of salinity at the 50 m depth, August–September 2021.*

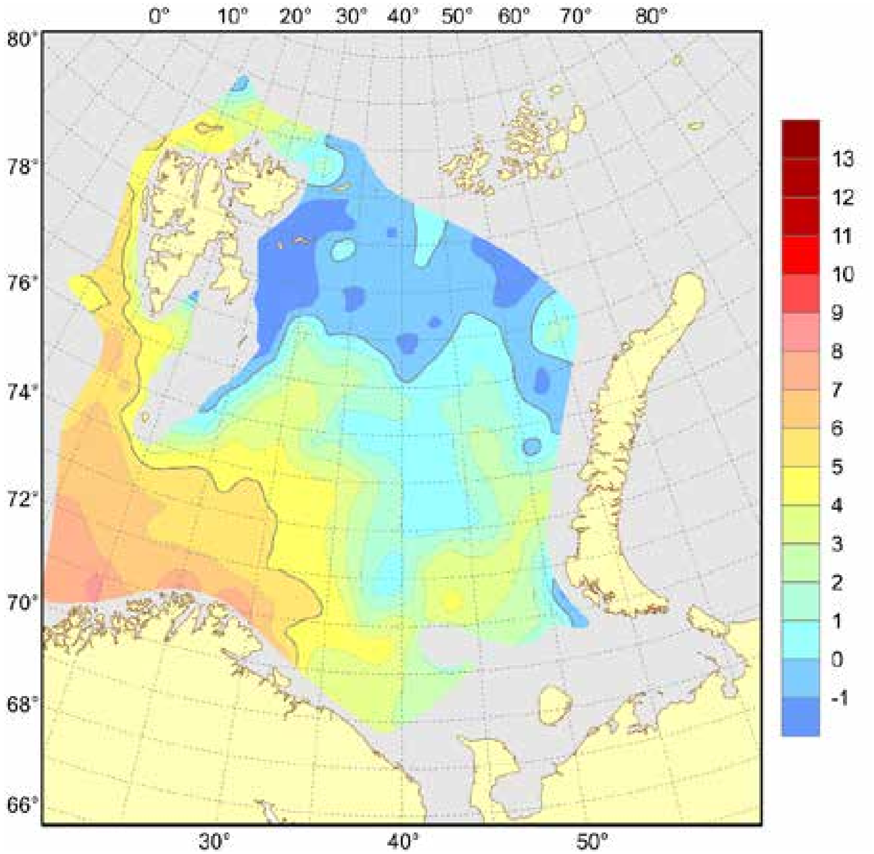


Figure 4.1.1.5. *Distribution of temperature (°C) at the 100 m depth, August–September 2021.*

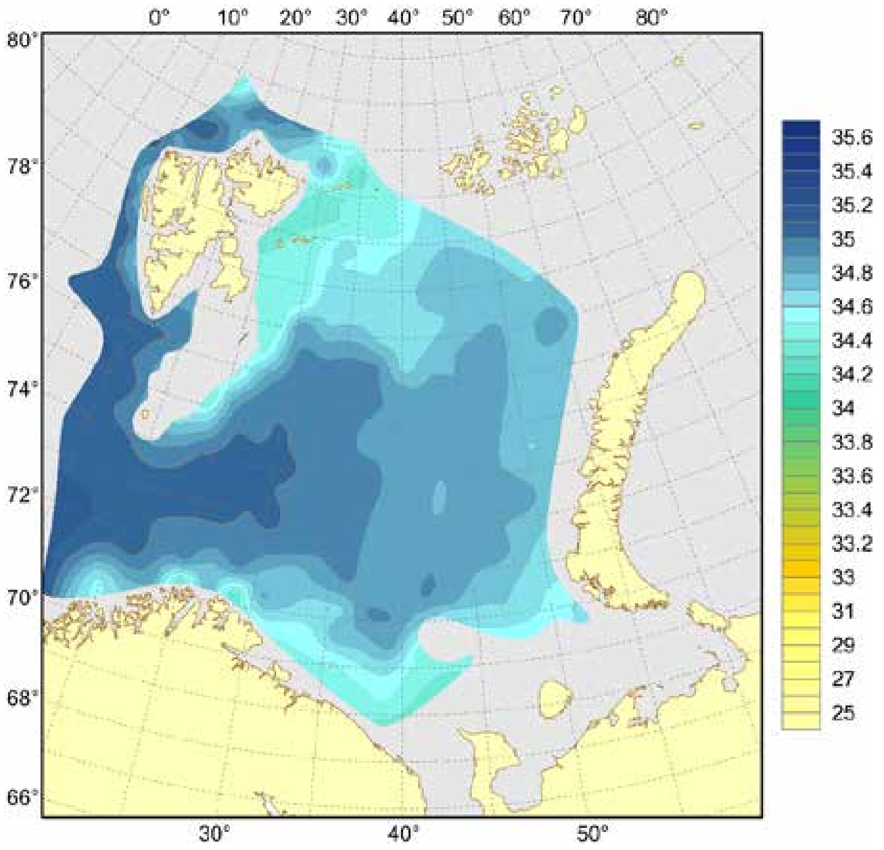


Figure 4.1.1.6. *Distribution of salinity at the 100 m depth, August–September 2021.*

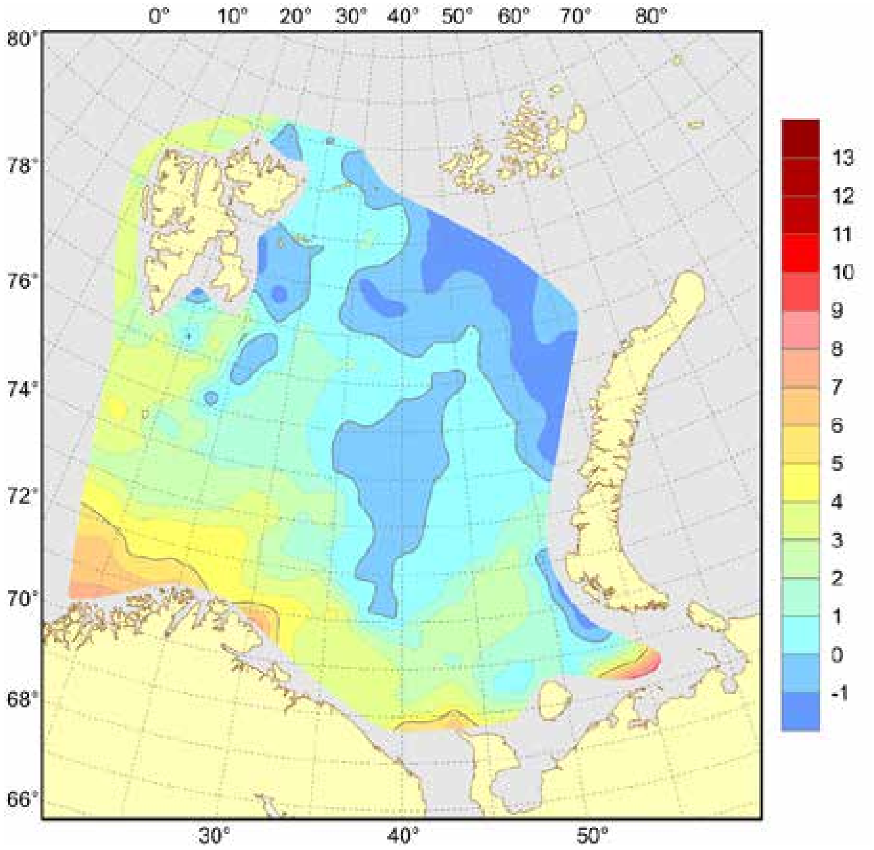


Figure 4.1.1.7. *Distribution of temperature (°C) at the bottom, August–September 2021.*

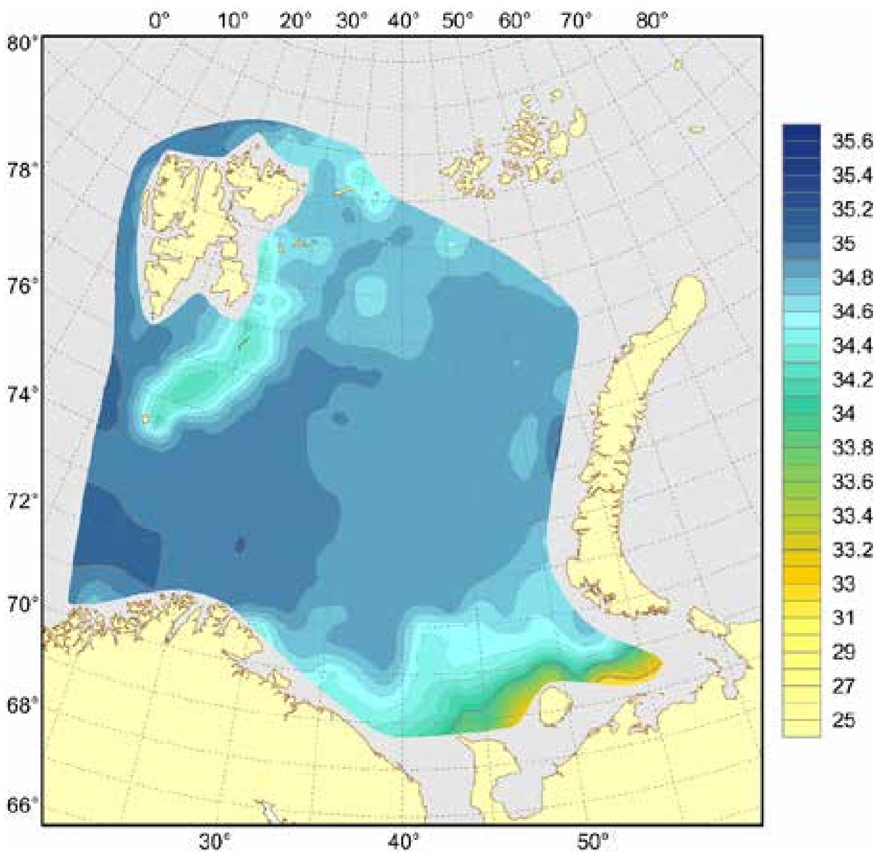


Figure 4.1.1.8. *Distribution of salinity at the bottom, August–September 2021.*

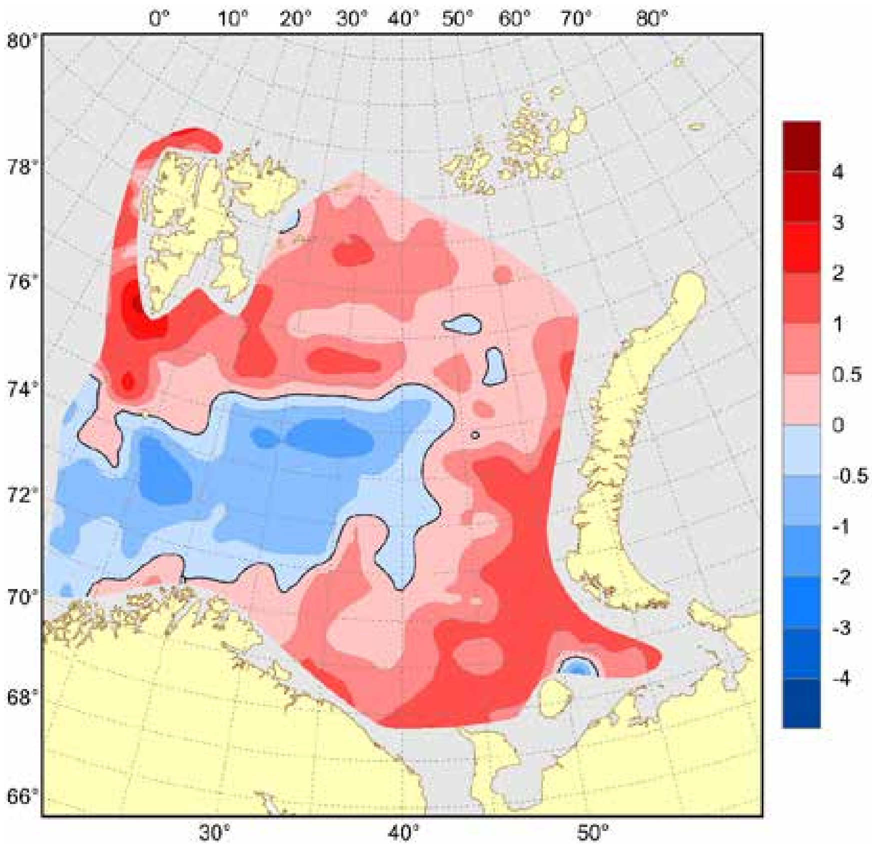


Figure 4.1.1.9. *Surface temperature anomalies (°C), August–September 2021.*

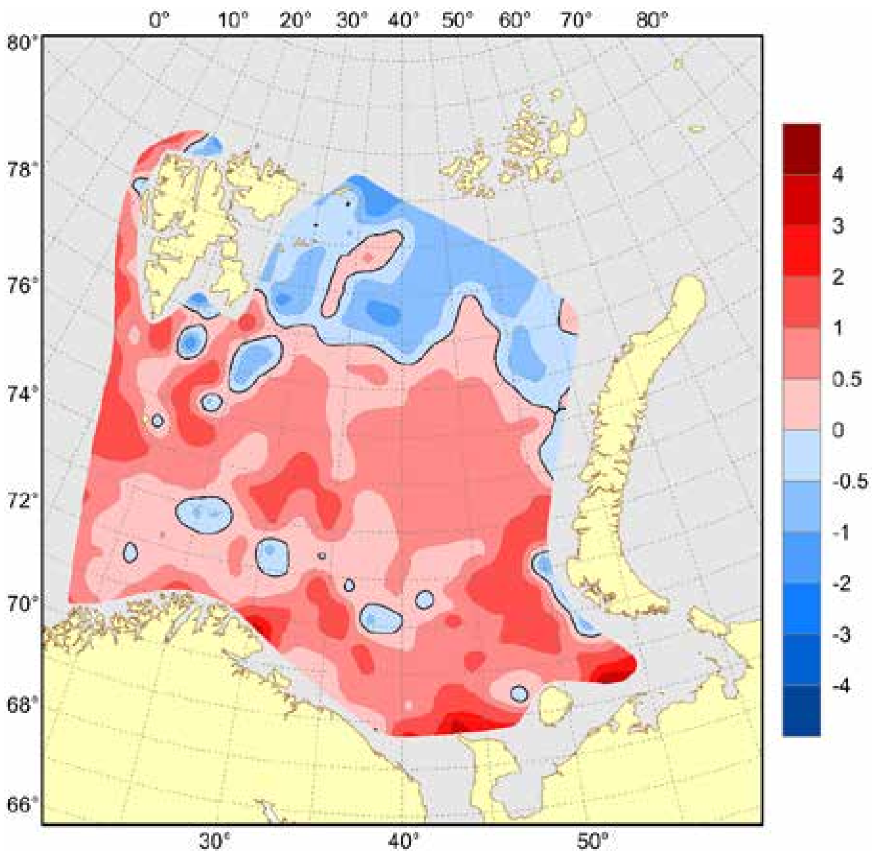


Figure 4.1.1.10. *Temperature anomalies (°C) at the bottom, August–September 2021.*

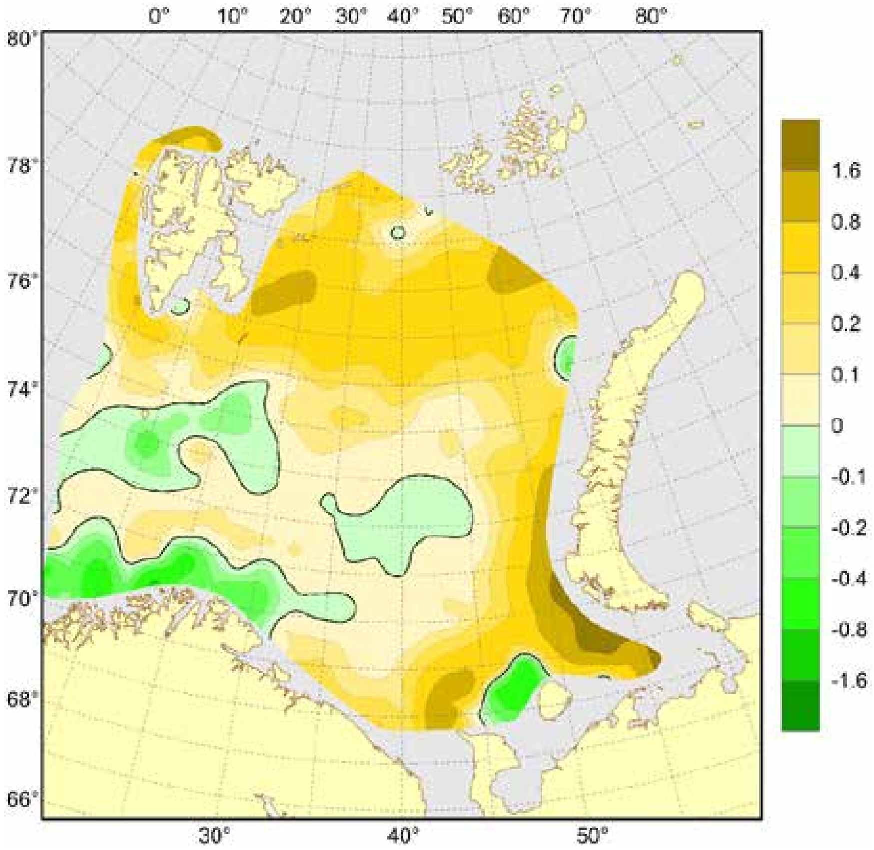


Figure 4.1.1.11. *Temperature anomalities at the bottom, August–September 2021.*

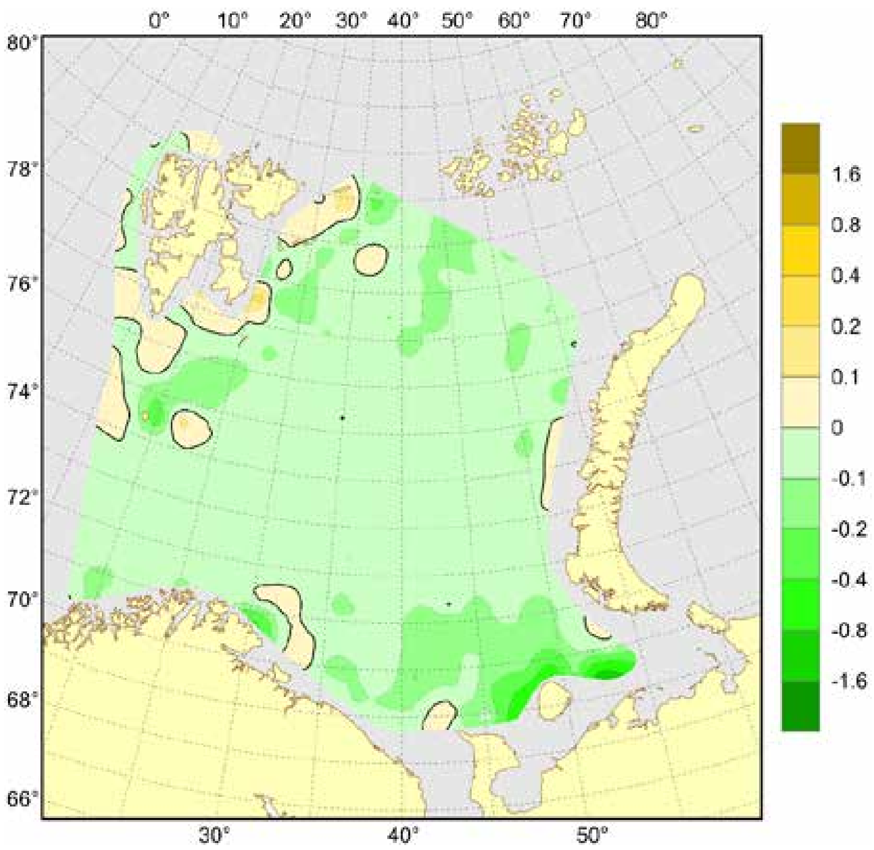


Figure 4.1.1.12. *Salinity anomalies at the bottom, August–September 2021.*

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 higher than the long-term mean (1981–2010) and 0.1°C colder than in 2020 (Table 4.1.2.1). A slight cooling as compared to 2020 was also observed in the Vardø–North Section (Table 4.1.2.1).

The Kola and Kanin Sections cover the flow of coastal and Atlantic waters in the southern Barents Sea. In August–September 2021, the Kola Section was sampled twice: in the middle of August (Table 4.1.2.1) and in late September. In August, the temperature anomaly (relative to 1981–2010) averaged over 0–200 m in the Kola Section decreased from +0.7°C in coastal waters in the inner part of the section to +0.5 and +0.4°C in Atlantic waters in the central and outer parts respectively, that was typical of warm years. The highest anomaly (+0.8°C) was observed in the upper 50 m layer in coastal waters, whereas the lowest anomaly (+0.2°C) was found in the same layer in Atlantic waters in the outer part of the section. In late September, temperature of coastal and Atlantic (central part of the section) waters (0–200 m) was still typical of warm years with anomalies of +0.4 and +0.6°C respectively, whereas temperature of Atlantic waters in the outer part of the section was only 0.2°C higher than average. Compared to 2020, the upper 50 m layer along the Kola Section in August–September 2021 was 0.3–0.5°C colder (by 1.0°C in the outer part of the section in September). Deeper waters (50–200 m) in August–September 2021 were 0.2–0.5°C warmer than in the previous year, except the outer part of the section, where they were 0.3°C colder in September. The mean salinity of Atlantic waters in the Kola Section (0–200 m) in August–September was 0.05–0.08 lower than the long-term mean (1981–2010), except coastal waters in August (salinity was equal to average). The active layer along the section in August–September 2021 was almost as salty as in 2020, it was 0.05 fresher only in Atlantic waters of the central part of the section in August. In the Kanin Section, the mean temperature of the whole water column in August was 1.4 and 0.7°C higher than the long-term mean (1981–2010) in the shallow inner and deeper 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 1965–2021. 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), 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	VN	FBI
	0–50	50–200	0–200	0–bot.	0–bot.	50–200	50–200
1965	6.7	3.9	4.6	4.6	3.7	3.8	5.2
1966	6.7	2.6	3.6	1.9	2.2	3.2	5.3
1967	7.5	4.0	4.9	6.1	3.4	4.4	6.3
1968	6.4	3.7	4.4	4.7	2.8	3.4	5.0
1969	6.7	3.1	4.0	2.6	2.0	3.8	6.3
1970	7.8	3.7	4.7	4.0	3.3	4.1	5.6
1971	7.1	3.2	4.2	4.0	3.2	3.8	5.6
1972	8.7	4.0	5.2	5.1	4.1	4.6	6.1
1973	7.7	4.5	5.3	5.7	4.2	4.9	5.7
1974	8.1	3.9	4.9	4.6	3.5	4.3	5.8
1975	7.0	4.6	5.2	5.6	3.6	4.5	5.7
1976	8.1	4.0	5.0	4.9	4.4	4.4	5.8
1977	6.9	3.4	4.3	4.1	2.9	3.6	4.9
1978	6.6	2.5	3.6	2.4	1.7	3.2	4.9
1979	6.5	2.9	3.8	2.0	1.4	3.6	4.7
1980	7.4	3.5	4.5	3.3	3.0	3.7	5.5
1981	6.6	2.7	3.7	2.7	2.2	3.4	5.3
1982	7.1	4.0	4.8	4.5	2.8	4.1	6.0
1983	8.1	4.8	5.6	5.1	4.2	4.8	6.1
1984	7.7	4.1	5.0	4.5	3.6	4.2	5.7
1985	7.1	3.5	4.4	3.4	3.4	3.7	5.6
1986	7.5	3.5	4.5	3.9	3.2	3.8	5.5
1987	6.2	3.3	4.0	2.7	2.5	3.5	5.1
1988	7.0	3.7	4.5	3.8	2.9	3.8	5.7
1989	8.6	4.8	5.8	6.5	4.3	5.1	6.2
1990	8.1	4.4	5.3	5.0	3.9	5.0	6.3
1991	7.7	4.5	5.3	4.8	4.2	4.8	6.2
1992	7.5	4.6	5.3	5.0	4.0	4.6	6.1
1993	7.5	4.0	4.9	4.4	3.4	4.2	5.8
1994	7.7	3.9	4.8	4.6	3.4	4.8	5.9
1995	7.6	4.9	5.6	5.9	4.3	4.6	6.1
1996	7.6	3.7	4.7	5.2	2.9	3.7	5.7
1997	7.3	3.4	4.4	4.2	2.8	4.0	5.4
1998	8.4	3.4	4.7	2.1	1.9	3.9	5.8
1999	7.4	3.8	4.7	3.8	3.1	4.8	6.1
2000	7.6	4.5	5.3	5.8	4.1	4.2	5.8
2001	6.9	4.0	4.7	5.6	4.0	4.2	5.9
2002	8.6	4.8	5.8	4.0	3.7	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	4.8	6.4
2005	8.0	4.4	5.3	5.2	3.8	5.0	6.2
2006	8.3	5.3	6.1	6.1	4.5	5.3	6.9
2007	8.2	4.6	5.5	4.9	4.3	4.9	6.5
2008	6.9	4.6	5.2	4.2	4.0	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	-	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	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	8.7	4.7	5.8	-	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	7.8	4.4	5.2	5.5	4.1	4.7	5.9
2020	8.2	4.3	5.3	-	-	5.1	6.2
2021	7.9	4.5	5.3	6.0	4.3	5.0	6.1
Average 1981–2010	7.6	4.2	5.0	4.6	3.6	4.4	6.0

4.2 Antropogenic pollution

4.2.1 Marine litter

Text by: T. Prokhorova, B. E. Grøsvik, R. Klepikovskiy
Figures by: P. Krivosheya

Anthropogenic litter floating at the surface and collected in trawls in 2020 was observed onboard all Norwegian vessels and Russian vessel "Vilnyus".

Plastic dominated among anthropogenic pollutants on the water surface (72.4 % of observations) (Fig. 4.2.1.1). The maximum surface observation of plastic litter was 5 m^3, and it was a part of fishery trawl. The average surface observation of plastic was 0.01 m^3(except the single maximum catch of 5 m^3). Due to currents, recorded debris could be dumped directly in some areas and transported from other areas. Wood was recorded in 13.2 % of the observations. The maximum surface observation of wood was 1.13 m^3, with the average of 0.23 m^3. Metal, paper and rubber was observed singularly (3.9-5.3 % of the observations).

Fishery related litter was recorded in 25.5 % of plastic litter observations at the surface (Fig. 4.2.1.2). Fishery related litter was represented by ropes (OSPAR code 31, 32), pieces of net (OSPAR code 115, 116) and floats/buoys (OSPAR code 37). Fishery plastic both maximum and average observations (5 m^3 and 0.02 m^3 (except the single maximum catch of 5 m^3) correspondingly) was larger than non-fishery plastic (0.11 m^3 and 0.006 m^3 correspondingly).

We found litter density (m^3 per km^2) of surface litter in the Russian part of the survey area (using length and width of observations tracks). The maximum amount was 3.125 m^3 per km^2 with the average of 0.015 m^3 per km^2. Most of the surface litter amount was plastic (the maximum catch was 3.125 m^3 per km^2 with the average of 0.0008 m^3 per km^2(except the single maximum catch of 3.125 m^3 per km^2). The maximum catch of wood was 0.82 m^3 per km^2 with the average of 0.004 m^3 per km^2. Density of other litter types (rubber, metal and paper) was insignificant.

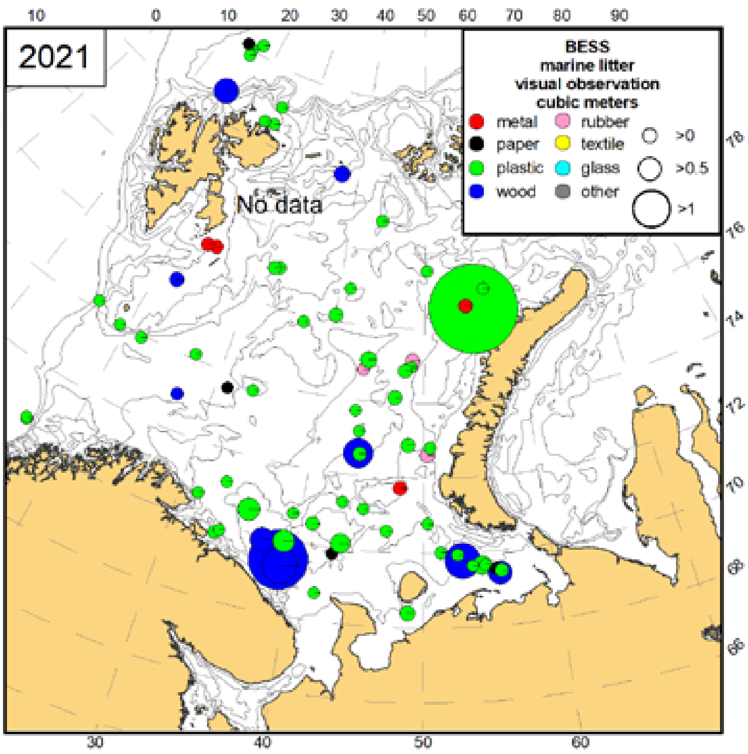


Figure 4.2.1.1 *Type of observed anthropogenic litter (m^3) at the surface in the BESS 2021.*

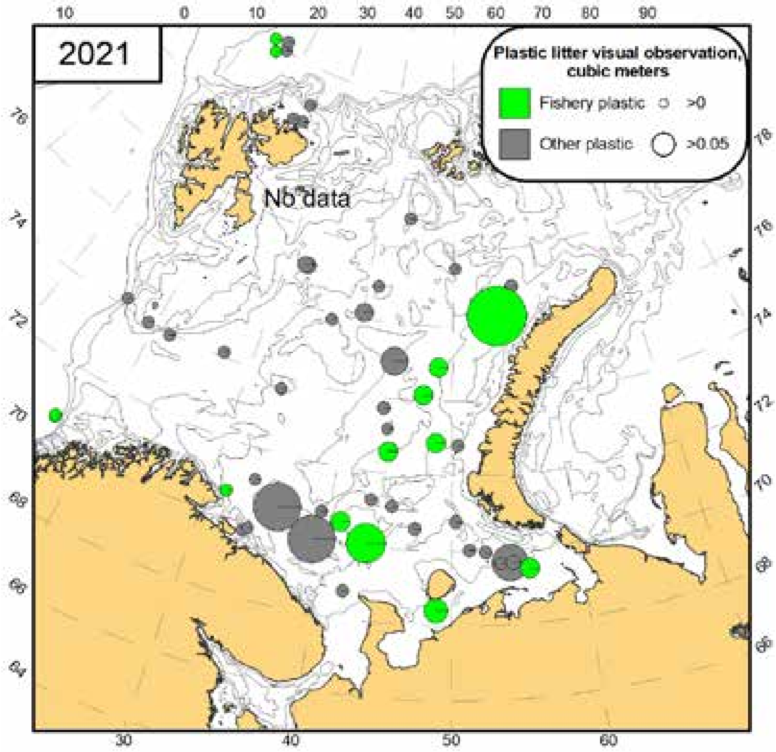


Figure 4.2.1.2 *Litter observations of plastic at the surface indicated as fishery related and other litter in the BESS 2021.*

Anthropogenic litter was observed in 11.5 % of pelagic trawl stations (Fig. 4.2.1.3). Plastic was observed in all pelagic trawls with anthropogenic litter in 2021. Weight of plastic litter from pelagic trawls was from 0.5 g to 11 kg with average of 0.012 kg (except the single maximum catch of 11 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 (textile and metal) was observed singularly. The maximum catch of litter by pelagic trawl was 5.5 kg per n.mile, with the average of 0.017 kg per n.mile, and it is 2 times lower, than in 2020. Litter was observed throughout the survey in the bottom trawl catches (28.1 % of the bottom trawl stations, Fig. 4.2.1.4).

Plastic also dominated the litter content from the bottom trawls (89.6 % of stations with observed litter). Weight of plastic litter in bottom trawls was from 0.0001 g to 6 kg with average of 0.04 g (except the single maximum catch of 6 kg). Wood was registered in bycatch on the 10.4 % of stations with observed litter in 2021 (compared with 5.8 % in 2020 and 24.8 % in 2019). Textile, metal and rubber were observed among the bottom trawl catches sporadically. The maximum catch of litter by bottom trawl was 12.5 kg per n.mile, with the average of 0.095 kg per n.mile.

Litter from fishery was a significant part of plastic litter both in the pelagic and bottom trawls (36.6 % and 66.1 % respectively, Fig. 4.2.1.5).

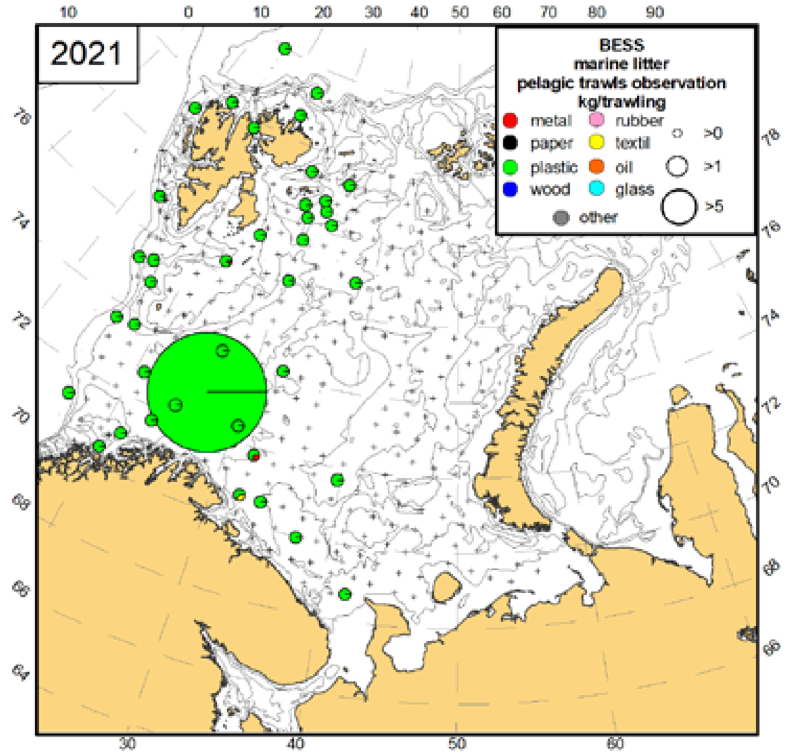


Figure 4.2.1.3 *Type of anthropogenic litter collected in the pelagic trawls (kg) in the BESS 2021 (crosses – pelagic trawl stations).*

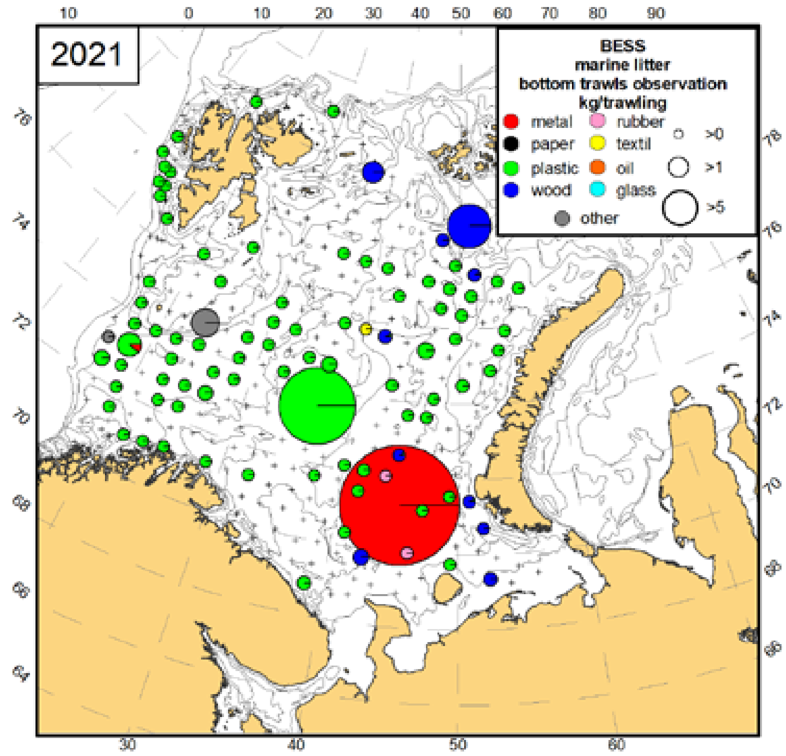


Figure 4.2.1.4 *Type of anthropogenic litter collected in the bottom trawls (kg) in the BESS 2021 (crosses – bottom trawl stations).*

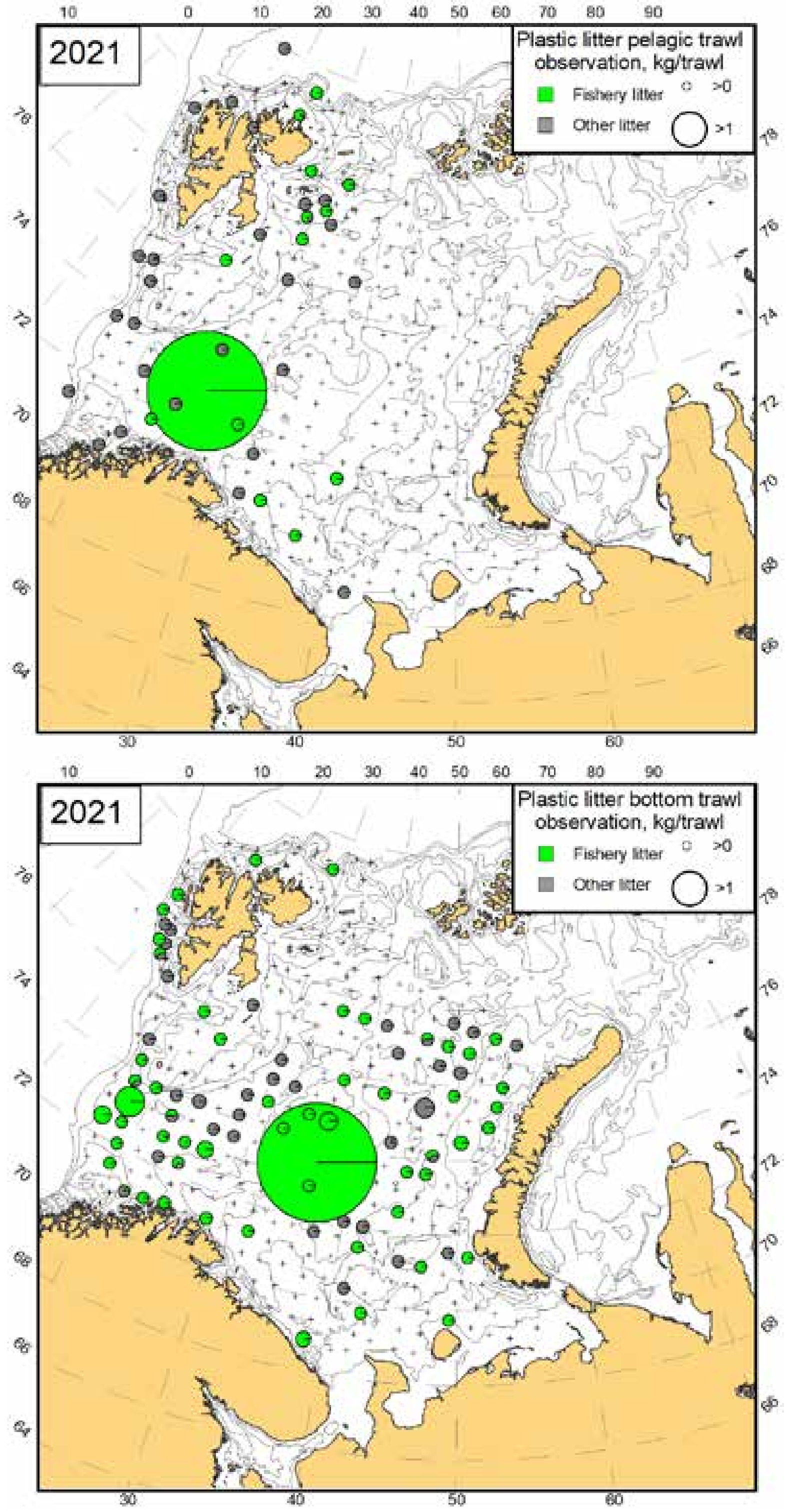


Figure 4.2.1.5 *Fishery plastic proportion among the plastic litter collected in the pelagic (the upper figure) and bottom trawls (the lower figure) in the BESS 2021 (crosses – trawl stations).*

5 PLANKTON COMMUNITY

5.1 Phytoplankton, chlorophyll a and nutrients

Text by: E. Bagøien

Phytoplankton samples were collected from predetermined stations dispersed within the Norwegian sector of the Barents Sea during the joint ecosystem cruise in 2021. 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 in about 25 of the samples have been analysed at IMR in Flødevigen using the Utermöhl sedimentation method for volumes of 50 ml.

Nutrient and chlorophyll samples were collected from rosette-mounted water-bottles released at various depths at the CTD stations in the Norwegian sector of the Barents Sea. 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: Espen Bagøien, Irina Prokopchuk, Jon Rønning

Figure by: E. Bagøien

Mesozooplankton sampling stations during the joint Norwegian-Russian Barents Sea ecosystem cruise in 2021 are presented in Fig. 5.2.1. 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.

The spatial distribution of total mesozooplankton biomass shown in Fig. 5.2.1 is based on a total of 319 samples, of which 171 were located in the Norwegian sector and 148 in the Russian sector. Within the Norwegian sector, the average biomass was 5.9 (± 4.4 SD) g dry-weight m^{-2}. This was lower than in 2020 (6.7 g dry-weight m^{-2}) and below the 20-year long-term mean for 2001-2020 (7.0 g dry-weight m^{-2}). Note that the density of stations west and northwest of Svalbard (Spitsbergen) in 2021 was somewhat higher than usual in earlier years and compared to the rest of survey area. The average zooplankton biomass for the samples within the Russian sector was 6.7 (± 4.5 SD) g dry-weight m^{-2}, which is not comparable to the average reported for the Russian sector in 2020 due to markedly different spatial coverages. All the stations shown in Fig. 5.2.1 are included in the 2021 biomass averages presented above. The area around Franz Joseph Land was not sampled in 2021, which contrasts with 2020.

Comparison 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 improve the regularity of the sampling grid across the survey area in 2021, most stations belonging to the Hinlopen-section north of Svalbard (Spitsbergen) and the whole Vardø-North section were omitted when calculating average biomass (omitted stations not shown in Fig. 5.2.1). The purpose of this was to avoid weighting of areas with higher sampling density. However, 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 patterns in biomass distribution. Addressing such challenges is a task for the ICES working group (WGIBAR), which makes 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 2021, we observed the familiar pattern of comparatively high biomasses (> 10 g dry-weight m^{-2}) in the southwestern region and parts of the central eastern region as well as northeast of Svalbard (Spitsbergen), along with relatively low biomasses in the central region as well as just west of Novaja Zemlja (Fig. 5.2.1).

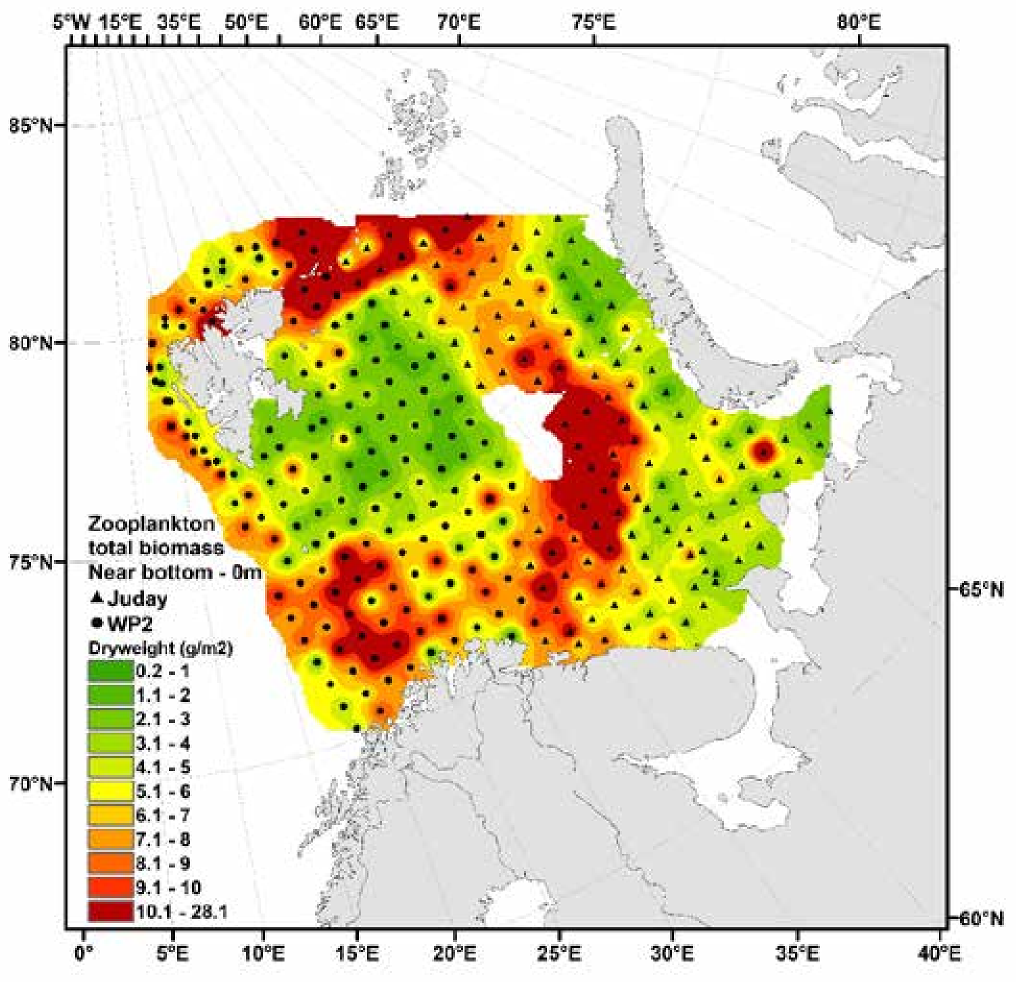


Figure 5.2.1. *Distribution of total zooplankton biomass (g dry-weight m^{-2}) from near-bottom to surface in the Barents Sea during BESS 2021 - based on a total of 319 stations. The data visualized were collected by WP2 and Juday nets with mesh-size 180 μm. Interpolation was made in ArcGIS v.10.6, module Spatial Analyst, using inverse distance weighting (IDW).*

Several factors may impact the levels of zooplankton biomass in the Barents Sea:

- Advective supply of zooplankton from the Norwegian Sea
- 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 are evaluated in more detail in WGIBAR report.

5.3 Macrozooplankton

5.3.3. Distribution and biomass indices of jellyfish

Text by E. Eriksen, T. Prokhorova and A. Dolgov
Figures by S. Karlson

Biomass of gelatinous zooplankton was calculated by different software during the last for decades: SAS (for the new 23 fisheries subareas, 1980-2017) and MatLab (for the new 15 WGIBAR-subareas (1980-2018, WGIBAR 2018) and R (for the new 15 WGIBAR-subareas (2003-2021). Due to software upgrading (led to challenges with script running in SAS) and personal resource limitation (MatLab), we decided to developed R-scripts (R is free software) for estimation of biomass indices (for 15 WGIBAR-subareas). Two data sets (annual biomass indices calculated by R and SAS) were analyzed for similarities and were found highly significant (r=0.97).

Here, we presented time series for biomass indices calculated by SAS (1980-2017) and by R (2018-2021). Spatial biomass indices calculated by R for 2004-2021.

In August-October 2021, lion's mane jellyfish (*Cyanea capillata*; Scyphozoa) was the most common jellyfish species, both with respect to weight (average catch of 19.8 kg, corresponding to 9.1 tonnes per sq nmi) and occurrence (found at 238 stations), widely distributed in the covered area (Fig. 5.3.3.1). High catches (> 10 tonnes per sq nmi) were observed in the central and southeastern Barents Sea.

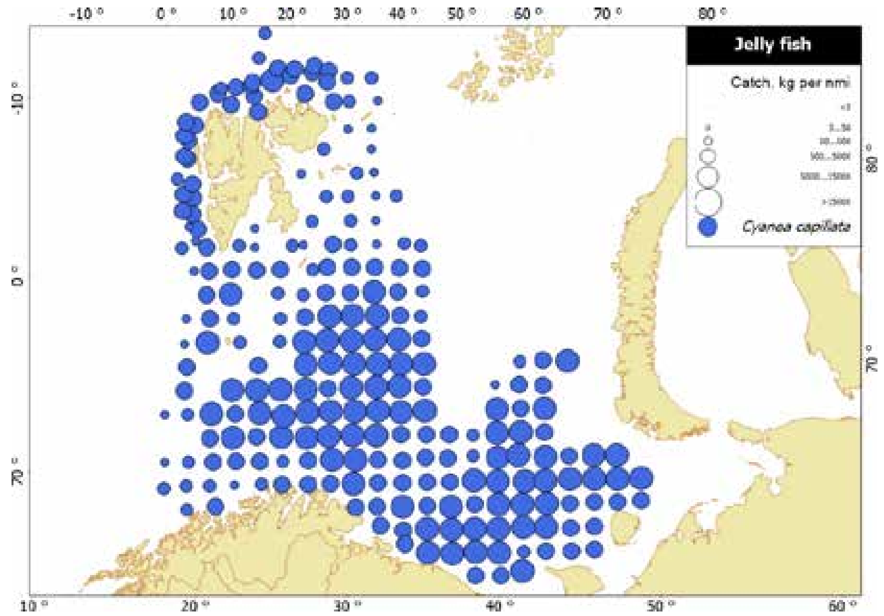


Figure 5.3.3.1. *Distribution of* Cyanea capillata *(wet weight; kg per square natical mile) in the Barents Sea, August-October 2021. Catches both day and night from standard pelagic trawl 0-60 m depth.*

Moon jellyfish *Aurelia aurita* was found at 33 stations in the southern Barents Sea with averaged biomass of 356 kg per sq nmi.

Single specimens of blue stinging jellyfish, *Cyanea lamarckii*, were found in the western Barents Sea with average biomass 30 kg per sq nmi. In 2021, *C. lamarckii* were recorded totally at 21 stations that was an increasing from previous year (Fig. 5.3.3.2). *C. lamarckii* has been regularly observed in the Barents Sea in recent years and the presence of this warm-temperate species may be linked to the inflow of Atlantic water masses.

Ctenophores were found at 13 stations in the central, northern, and southeastern Barents Sea with an average biomass of 18 kg per sq nmi.

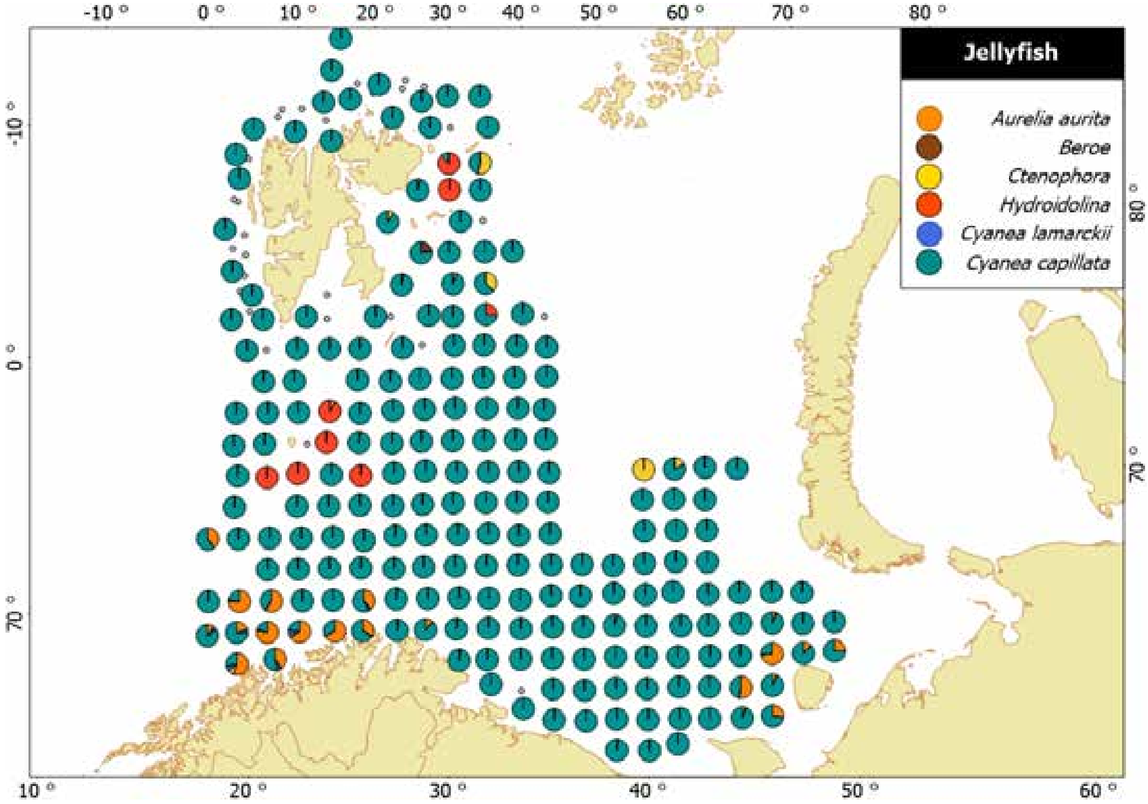


Figure 5.3.3.2. *Jellyfish composition in catches in the surveyed area in August-October 2021.*

Geographical distribution of jellyfish, mainly *C. capillata,* showed an increase in central, southern, eastern, and northern areas since 2013 with the widest distribution in 2017, when biomasses reached almost 5 million tonnes (Fig. 5.3.3.3).

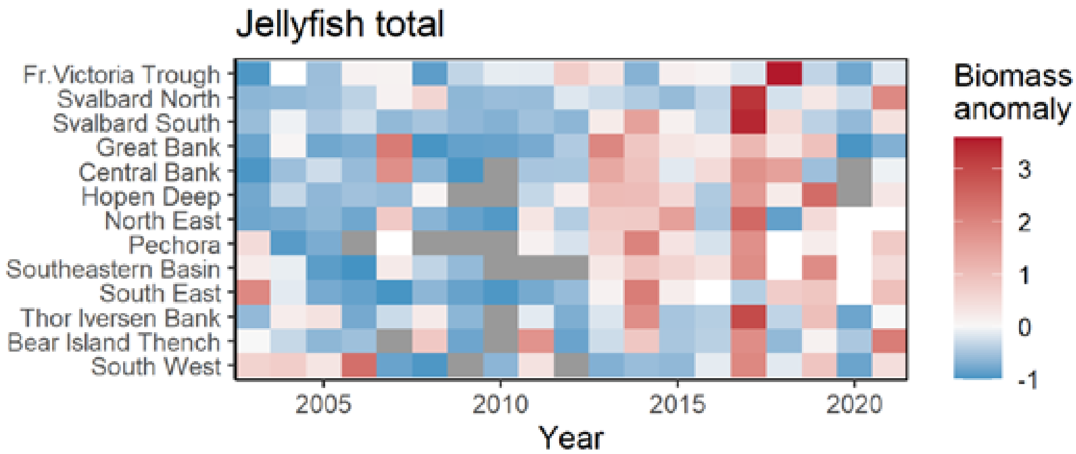


Figure 5.3.3.3. *Geographical distribution of jellyfish, mainly* C. capillata, *in the Barents Sea in August-September 2003-2021.*

Biomass indices were calculated as total for all jellyfishes for the period 1980-2003. In addition to the total biomass for all jellyfishes, biomass for large jellyfish, dominating by *C. capillata*, small jellyfish dominating by *A. aurita*, and other jellyfish (found occasionally) were also calculated for the period 2004-2021. In 2021, total jellyfish biomass in the Barents Sea was twice higher than in

2020 and reached 2.7 million tonnes (Fig. 5.3.3.4). Biomasses were dominated by *C. capillata* (2.6 million tonnes).

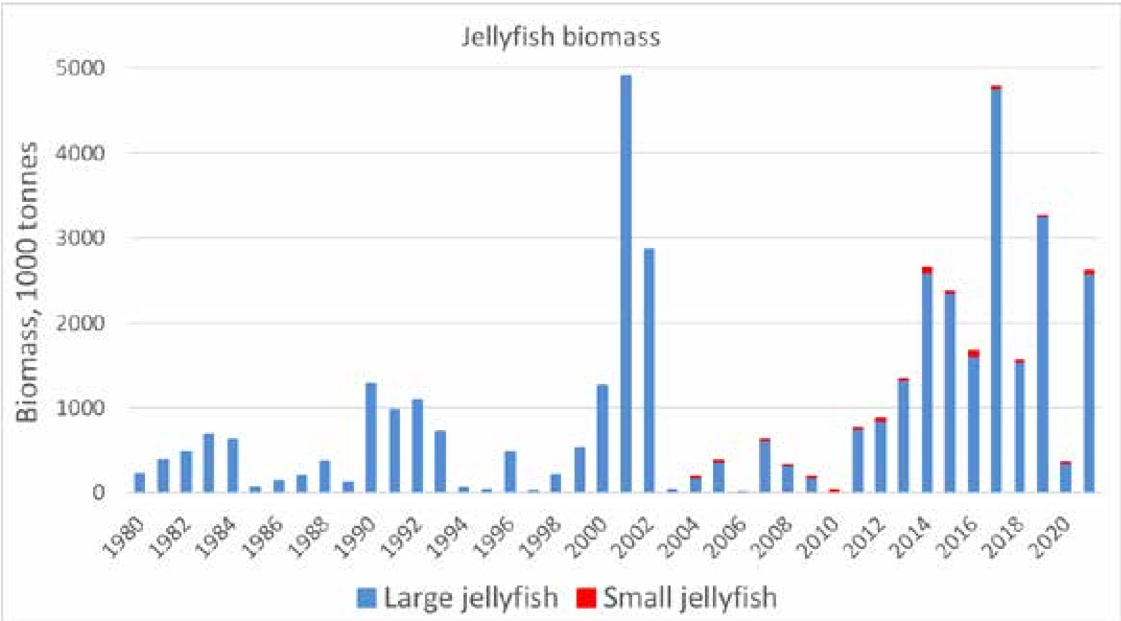


Figure 5.3.3.4. *Total biomass of jellyfish in the Barents Sea in August-September 1980-2021. Large jellyfish were dominating by* C. capillata, *small jellyfish dominated by* A. aurita, *and other jellyfish (found occasionally). Biomass estimates in 2018 and 2020 were underestimated due to lack of complete coverage.*

6 FISH RECRUITEMENT (YOUNG OF THE YEAR)

Text by: E. Eriksen, D. Prozorkevich and T. Prokhorova
Figures by: D. Prozorkevich

Area coverage and estimations

In 2021, coverage of the 0-group fish was suboptimal, especially for polar cod due to lack of coverage in some areas in the southeastern and eastern parts of the Barents Sea (Fig. 6.1). Uncomplete coverage of 0-group distribution area could influence abundance and biomass indices for cod, capelin and especially polar cod.

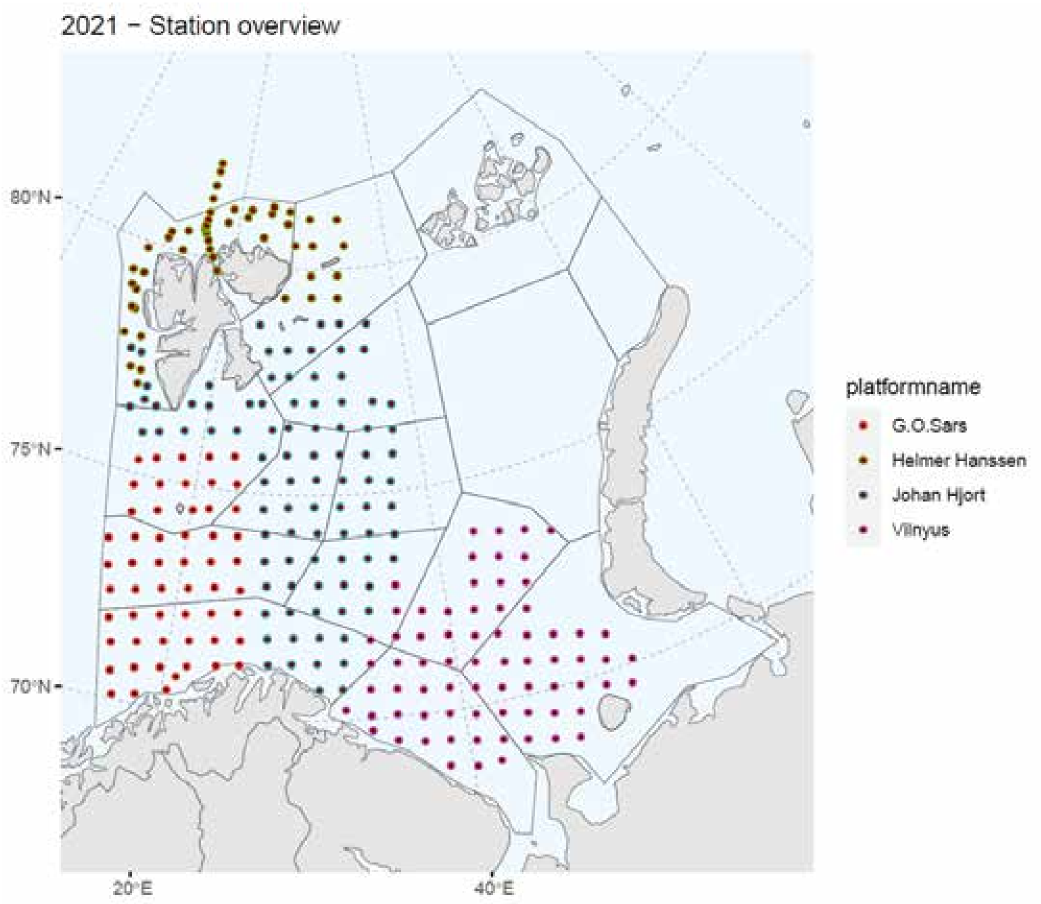


Figure 6.1. *Map showing spatial coverage of the 0-group fish in the Barents Sea in 2021. Colored dots indicated vessel coverage, while grey lines 15 WGIBAR-subareas (regions) used in estimations.*

Abundance and biomass estimates were calculated by different software during the last for decades: SAS (for the new 23 fisheries subareas, 1980-2017) and MatLab (for the new 15 WGIBAR-subareas (Fig. 6.2, 1980-2018, WGIBAR, 2018) and R (for the new 15 WGIBAR-subareas (Fig. 6.2, 2003-2021). Due to software upgrading (led to challenges with script running in SAS) and personal resource limitation (MatLab), we decided to developed R-scripts (R is free software) for estimation of abundance and biomass indices (for 15 WGIBAR-subareas). Two data sets (annual abundance and biomass indices calculated by R and SAS) were analyzed for similarities, and were found highly significant (for capelin r=0.95, cod r=0.99, haddock r=0.94, for herring r=0.73, for redfish r= 0.99, and polar cod r=0.94).

Here, we presented time series for abundance indices calculated by SAS (1980-2017) and by R (2018-2021). Spatial abundance indices calculated by R for 2004-2021. 0-group abundance indices for cod, haddock, herring, capelin, polar cod and redfish presented with correction for trawl capture efficiency (*Keff*) for "Harstad" trawl (Eriksen et al. 2011), while abundance for other fish were not corrected for capture efficiency. The biomass was calculated using a long-term length-weight key and abundance with *Keff*.

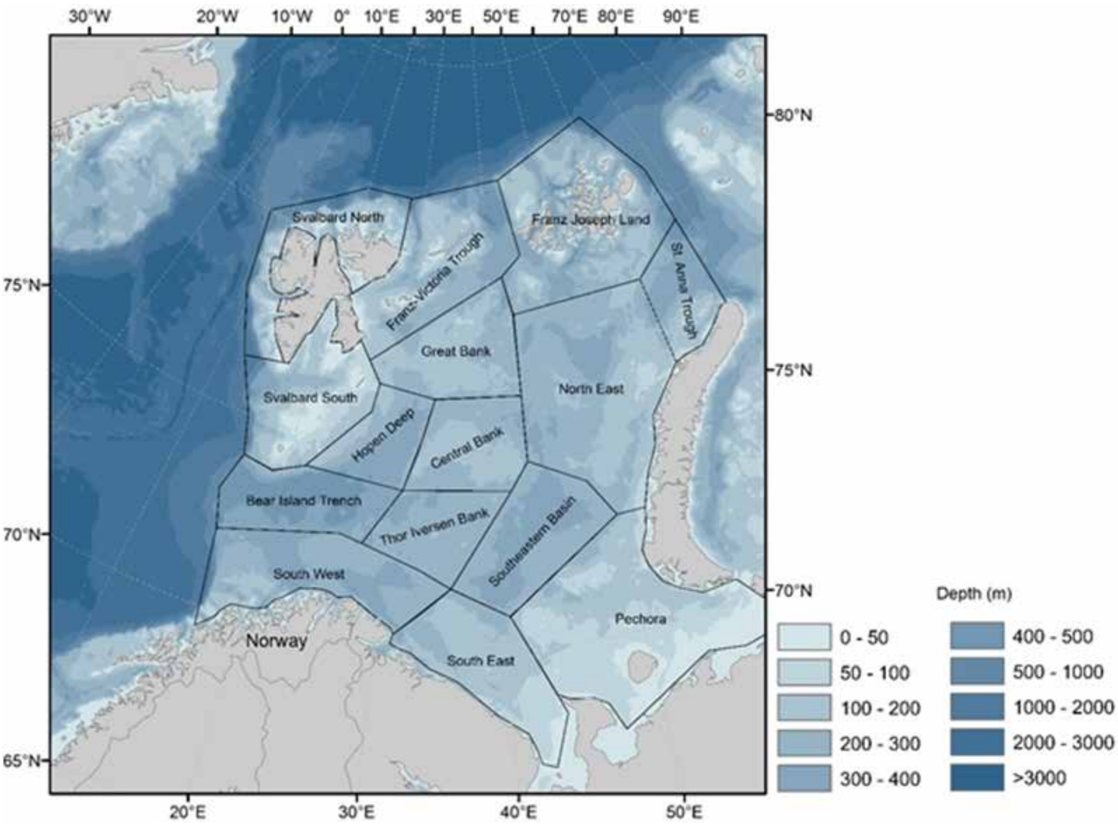


Figure 6.2. *Map showing subdivision of the Barents Sea into 15 WGIBAR-subareas (regions) used to calculate estimates of 0-group abundance based on the BESS.*

Total biomass

Zero-group fish are important consumers of plankton and are prey for predators (larger fish, sea birds and marine mammals) and, therefore, are important for transfer of energy between trophic levels in the ecosystem. Estimated total biomass of 0-group fish species (cod, haddock, herring, capelin, polar cod, and redfish) varied from a low of 44 thousand tonnes in 1987 to a peak of 2.91 million tonnes in 2004 with a long-term average of 1.2 million tonnes (Figure 6.3). In 2021, estimated total biomass of 0-group fish species was slightly below the long term mean and was close to 1 million tonnes. In 2021, 0-group fish biomasses were dominated by cod, haddock and herring, and their biomasses were higher than in 2018-2020. Biomasses of polar cod and capelin were underestimated due to lack of coverage (see above) and were lower than in 2020 and were very low in 2021.

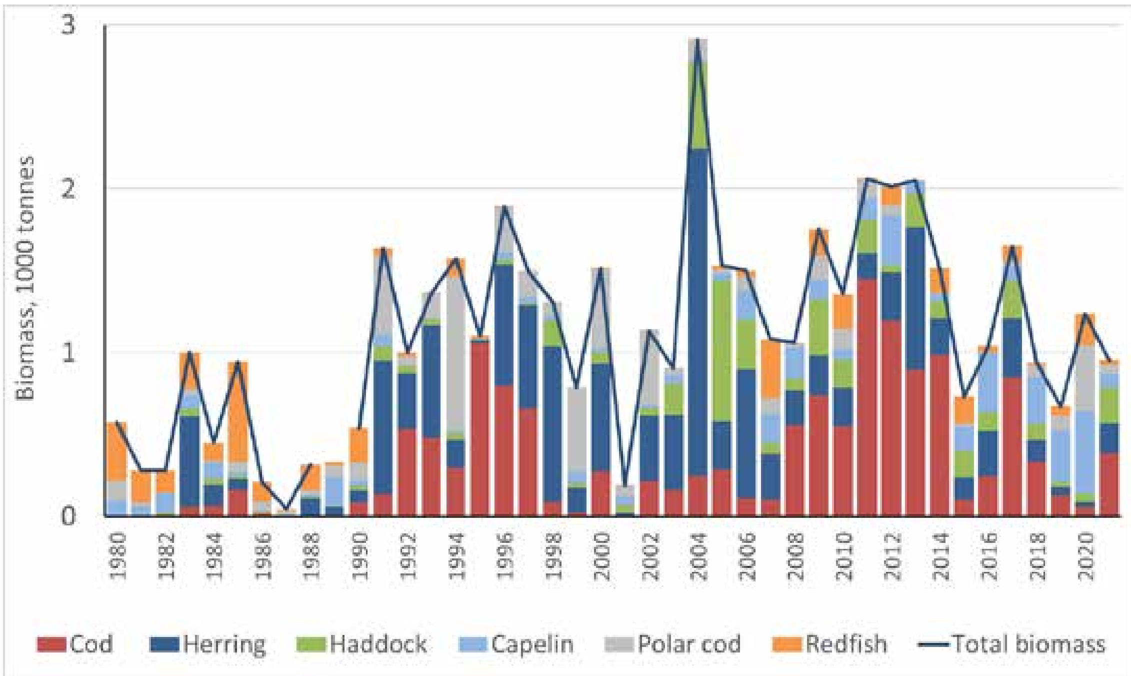


Figure 6.3. *Biomass of 0-group fish species in the Barents Sea, August–October 1980–2021. The biomass of 0-group fishes were estimated based on long-term length-weight key and annual abundance indices with Keff.*

6.1 Capelin (*Mallotus villosus*)

The highest average abundance per strata were found in the north central (Great Bank, $81*10^9$ ind.) and western (Bear Island Trench, $64*10^9$ ind.) areas.

The 0-group capelin body length varied from 1 to 7.5 cm in 2021, while most of capelin were medium size with body length of 3.5-5.4 cm in 2021, which smaller than in the 2020 (5-6.4 cm), while close to the 2019 (4-5.4 cm). Larger individuals (with an average length above 5 cm) were found mainly in central, western and southern areas (Great, Central and Thor Iversen Banks and South West and South West).. In the Franz Victoria Trough strata, the smallest capelin with average length of (2.2 cm) per strata were found. Length distribution in the Svalbard South and Svalbard North showed two peaks and most likely indicated fish two spawning periods (spring and summer). Early, both pre- and post-spawners were observed in Bear Island area in June 2017. So the summer spawning of capelin is available in the area. The smallest (< 3 cm) capelin in the northern areas most likely came from summer spawning. Small capelin (< 3 cm) from summer spawning were also found in the Pechora polygon, where summer offspring have been commonly observed.

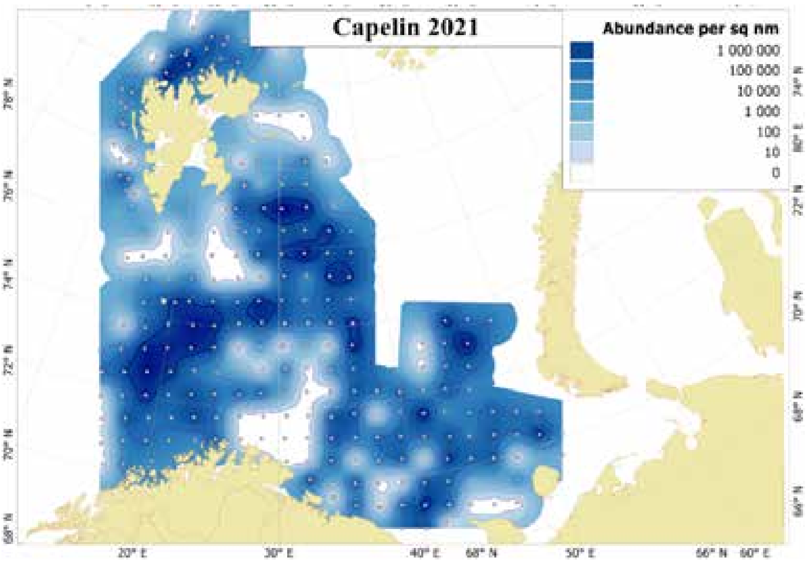


Figure 6.1.1. *Distribution of 0-group capelin (*Mallotus villosus*), August-September 2021. Abundance is corrected for capture efficiency (Keff). Dots indicate sampling locations.*

A record strong year class of capelin occurred in 2019, followed by less strong (2020) and intermediate (2021) year classes. Estimated abundance of 0-group capelin varied from 958 million in 1993 to $1.5*10^{12}$ individuals in 2019 with a long-term average of $366*10^9$ individuals for the 1980-2021 period (Figure 6.1.2). In 2021, the eastern Barents Sea was not fully covered, where 0-group capelin were also found, and thus abundance and biomass indices were slightly underestimated.

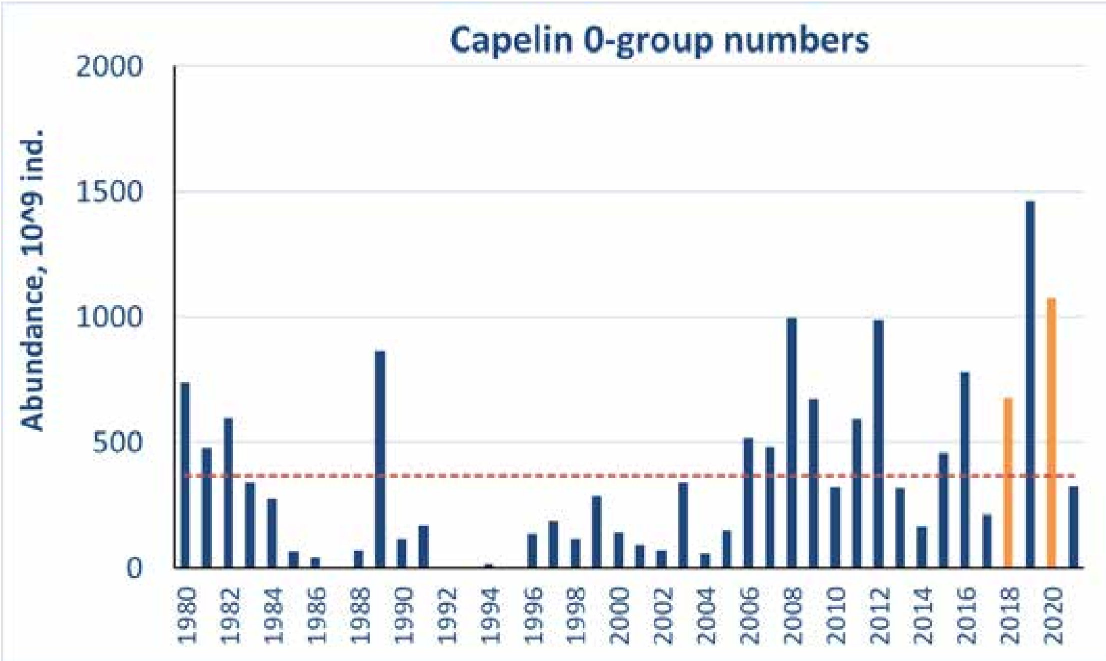


Figure 6.1.2. *0-group capelin abundance estimates corrected for Keff (blue columns). Orange line shows the long-term average, while red column showed indices that were corrected for lack of coverage.*

In 2021, the total abundance index for 0-group capelin was slightly below the long term mean and was $325*10^9$ individuals (Figure 6.1.2). Estimated biomass of 0-group capelin was much lower than in 2020 and slightly lower than the long-term mean and was 82 thousand tonnes. Therefore, the 2021-year class of capelin seemed to be intermediate.

6.2 Cod (*Gadus morhua*)

The highest average abundance per polygon were found in the southern (South East, 85*10^9 ind., and South West, 53*10^9 ind.) areas. In 2021, the eastern Barents Sea was not fully covered, where 0-group cod were also found.

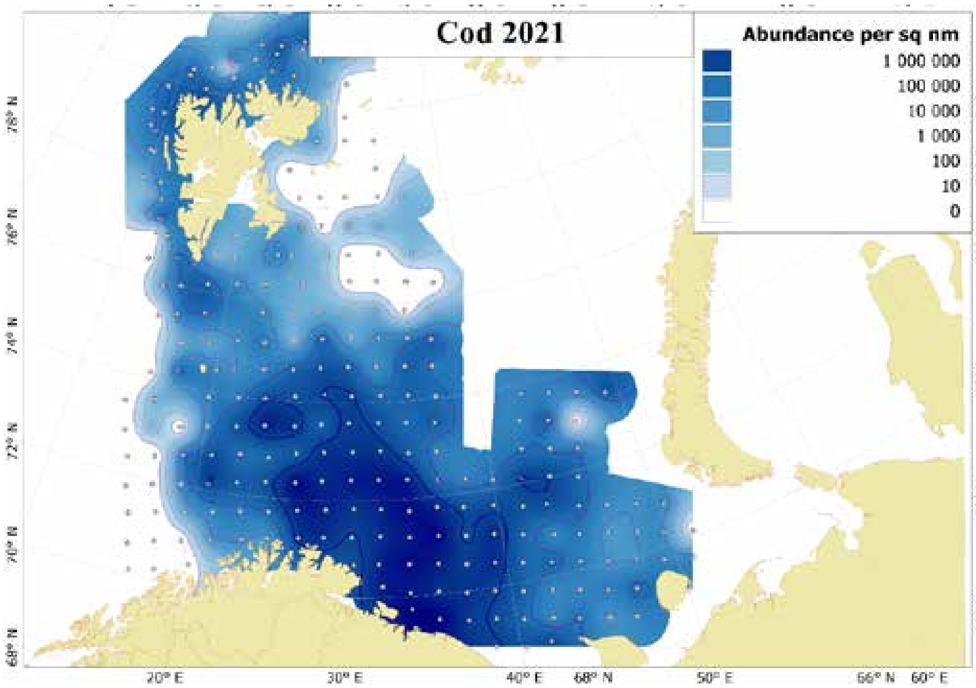


Figure 6.2.1. *Distribution of 0-group cod (*Gadus morhua*), August-September 2020. Abundance is corrected for Keff. Dots indicate sampling locations.*

In 2021, 0-group cod were smaller than in 2020 (6,5 – 8.4 cm) and were dominated by fish of 5.5-7.5 cm length. The largest cod (with an average length > 10.0 cm) were observed in the South West followed by fish (with an average length between 8.5 - 10.0 cm) observed in the Bear Island Trench, while smallest cod (with an average length < 6.0 cm) were found mainly in the South East polygons.

Estimated abundance of 0-group cod varied from 276 *10^9 in 1980 to 464*10^{12} individuals in 2014 with a long-term average of 115*10^9 individuals for the 1980-2021 period (Figure 3.6.2). In 2021, the total abundance index for 0-group cod was above the long term mean and was 207*10^9 individuals. Cod estimated biomass in 2021 (385 thousand tonnes) was much higher than in 2020 (56 thousand tonnes) and was slightly higher than the long term mean for 1980-2021 (340 thousand tonnes).

The distribution of 0-group cod in the Barents Sea was not fully covered (see above), and therefore abundance index may be slightly underestimated. The abundance index of 2021-year class is well above the long-term mean, and thus may be characterized as strong.

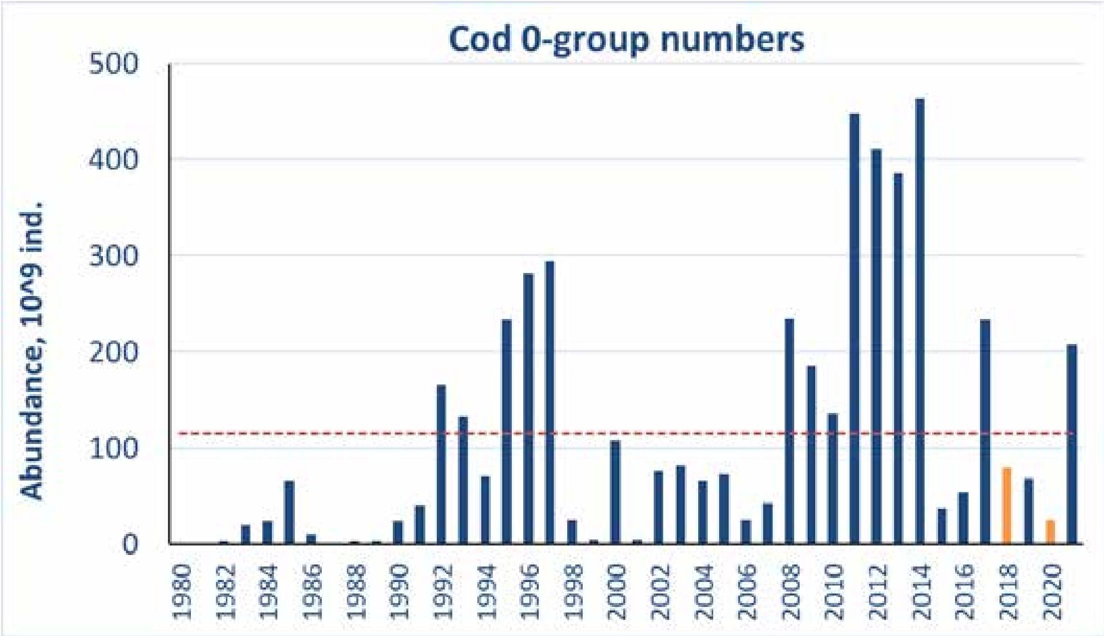


Figure 6.2.2. *0-group cod abundance estimates corrected for Keff (blue columns). Orange line shows the long-term average, while red column showed indices that were corrected for lack of coverage.*

6.3 Haddock *(Melanogrammus aeglefinus)*

Half of haddock abundance were found in the South-West polygon and was as high as $16*10^9$ ind. Haddock were also distributed along the western Svalbard (Spitsbergen) archipelago (Fig. 6.3.1.).

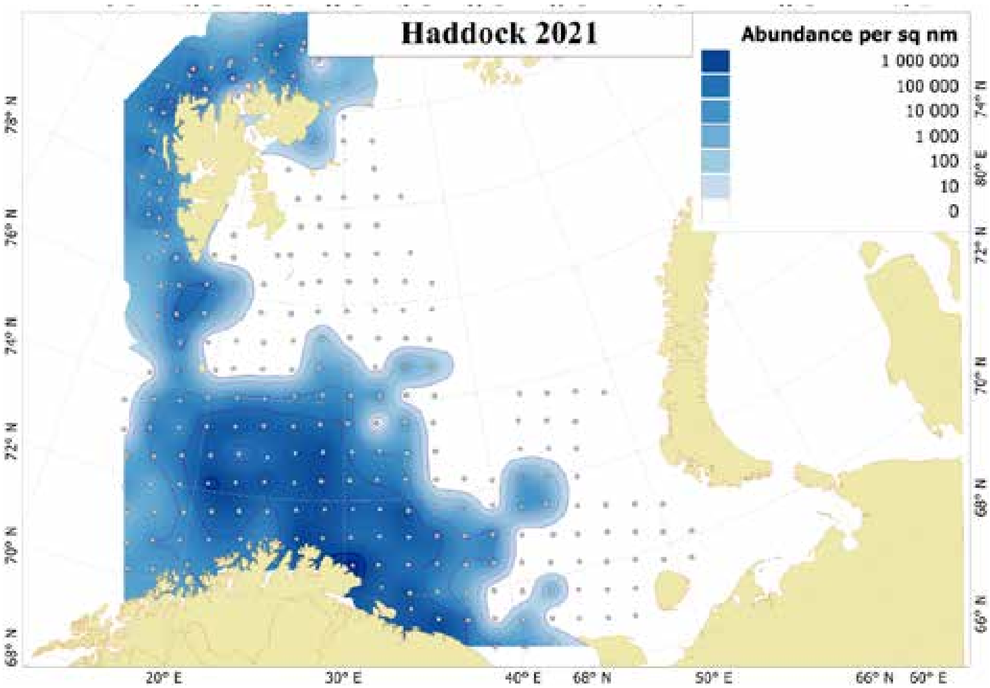


Figure 6.3.1. *Distribution of 0-group haddock (*Melanogrammus aeglefinus*), August-September 2021. Abundance is corrected for Keff. Dots indicate sampling locations.*

In 2021, 0-group haddock dominated by fish of 7.5 – 10.0 cm length. The largest haddock (with an average length > 9.0 cm) were observed in the central areas (Hopen Deep and central Bank), while smallest haddock were found close to the coast in South-East and Pechora (with an average length < 8.3 cm).

Estimated abundance of 0-group haddock varied from 75 $*10^6$ ind. in 1981 to $92*10^9$ individuals in 2005 with a long-term average of $12*10^9$ individuals for the 1980-2021 period (Figure 6.3.2).

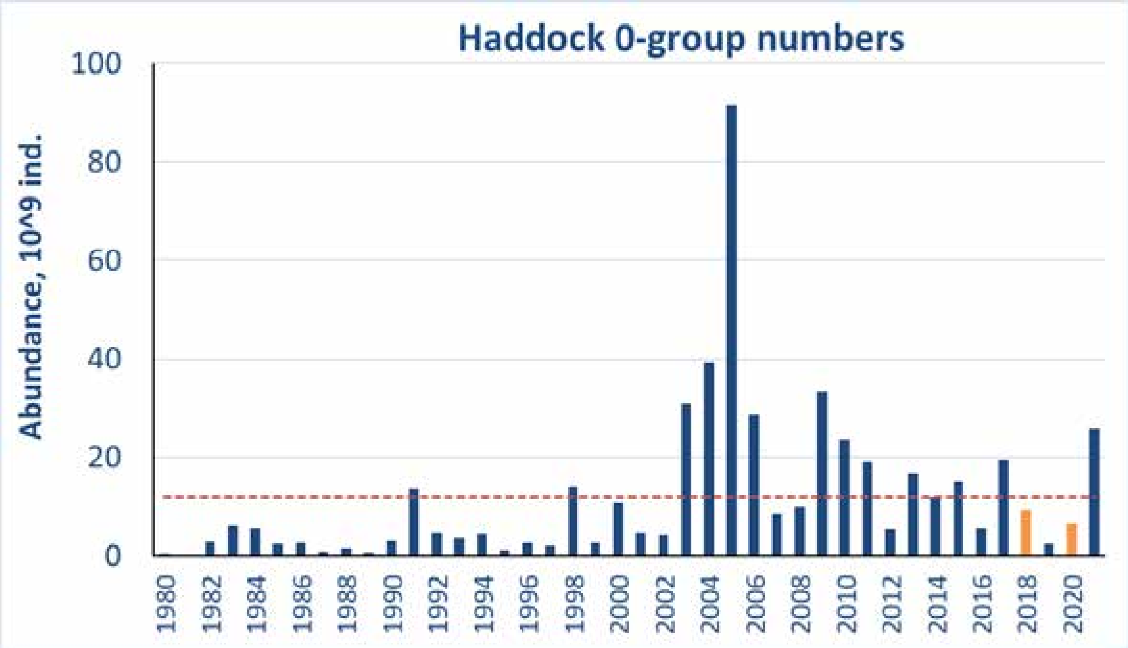


***Figure 6.3.2**. 0-group haddock abundance estimates corrected for Keff (blue columns). Orange line shows the long-term average, while orange column showed indices that were corrected for lack of coverage.*

In 2021, the total abundance estimates for 0-group haddock were three time higher than in 2020 and twice of the long term mean and was $26*10^9$ individuals. Haddock estimated biomass in 2021 (216 thousand tonnes) was much higher than in 2020 (56 thousand tonnes) and was much higher than the long term mean for 1980-2021 (114 thousand tonnes). Lack of coverage in the eastern Barents Sea will not influence the level of abundance indices due to 0-group haddock distributes usually in the western and central areas. Thus the 2021-year class may be characterized as strong.

6.4 Herring (*Clupea harengus*)

0-group herring were found in the southern Barents Sea (Fig. 6.4.1). The highest average abundance per polygon ($116*10^9$ ind.) fish of average size (with an average length of 5.6 cm) were found in the South-West polygon.

0-group herring length distribution had two peaks (3.5 - 4.5 cm and 5.0 - 5.9 cm) in 2021. Larger individuals were observed in the Bear Island Trench, Hopen Deep and Central Bank with average length of 6.0 cm, while smallest in the southeastern areas.

Estimated abundance of 0-group herring varied from $37*10^6$ ind. in 1981 to $774*10^9$ individuals in 2004 with a long-term average of $155*10^9$ individuals for the 1980-2021 period (Figure 6.4.2). In 2021, the eastern Barents Sea was not fully covered, however zero border of herring distribution were found in the east, and thus it will not influence abundance and biomass indices estimates.

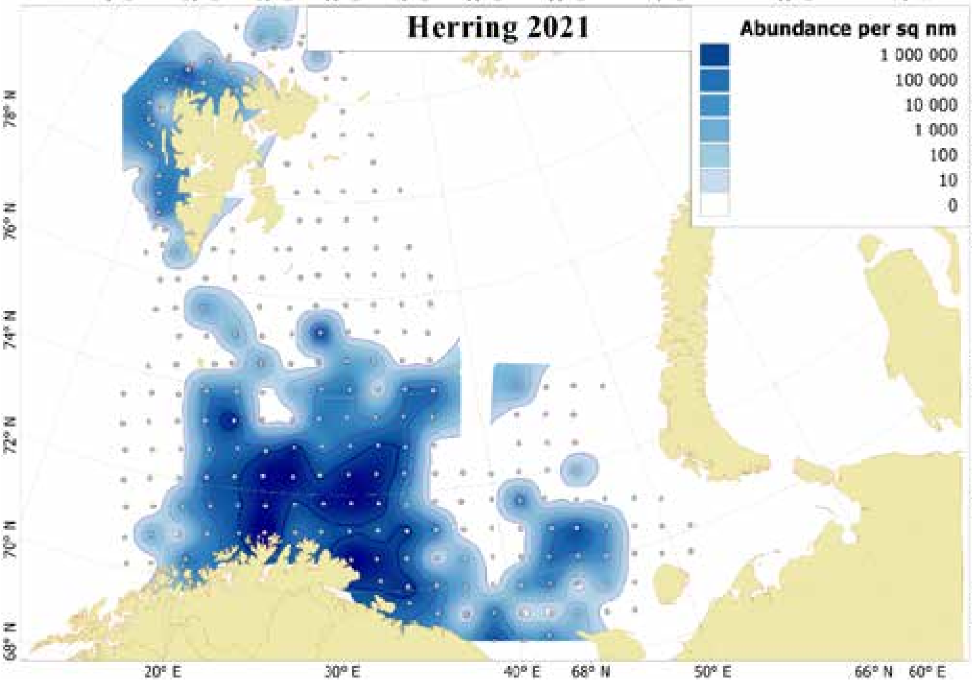


Figure 6.4.1. *Distribution of 0-group herring (*Clupea harengus*), August-September 2021. Abundance are corrected for Keff. Dots indicate sampling locations.*

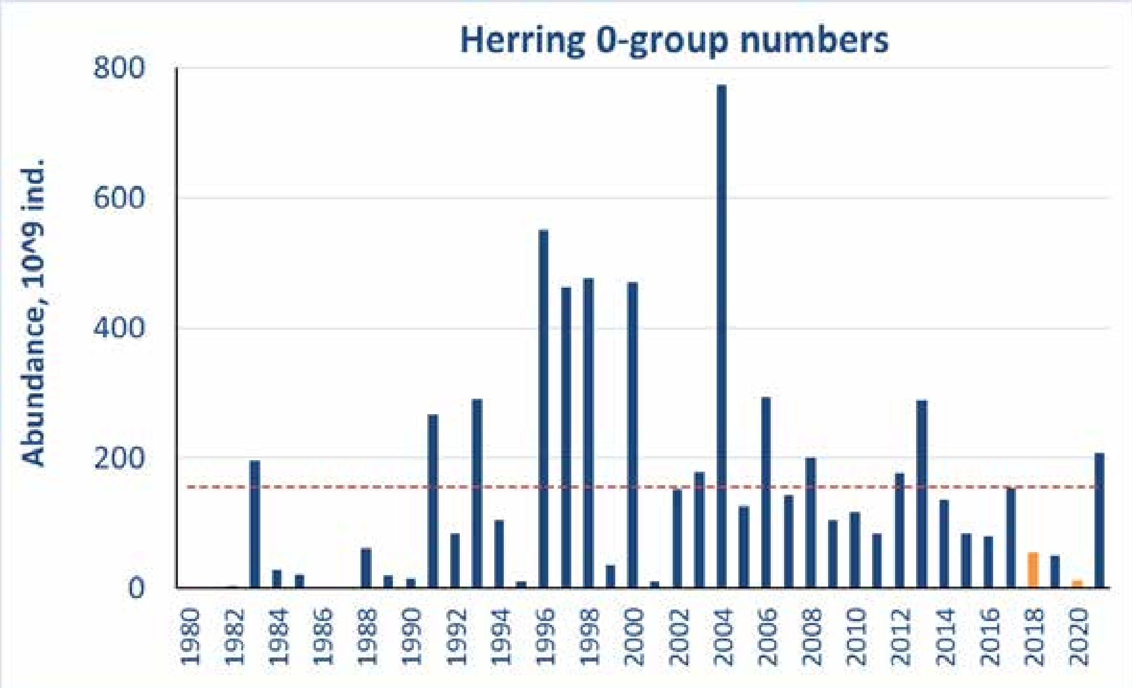


Figure 6.4.2. *0-group herring abundance estimates corrected for Keff (blue columns). Orange line shows the long-term average. Abundance of herring in 2018 and 2020 were some underestimated due to lack of coverage in the eastern Barents Sea.*

In 2021, the total abundance index for 0-group herring was higher to the long term mean and was $209*10^9$ individuals (Figure 6.4.2). Estimated biomass of 0-group herring was higher than in 2018-2020, while almost four times lower the long term mean (328 thousand tonnes) and was 184 thousand tonnes. Therefore, the 2021-year class of herring seemed to be intermediate.

6.5 Polar cod (*Boreogadus saida*)

Polar cod were found around the Svalbard (Spitsbergen) archipelago in 2021 (Fig. 6.5.1). Coverage of the 0-group polar cod was not complete, especially in the in the and eastern parts of the Barents Sea (Fig. 6.1), and thus south-eastern component of polar cod could not fully be presented here.

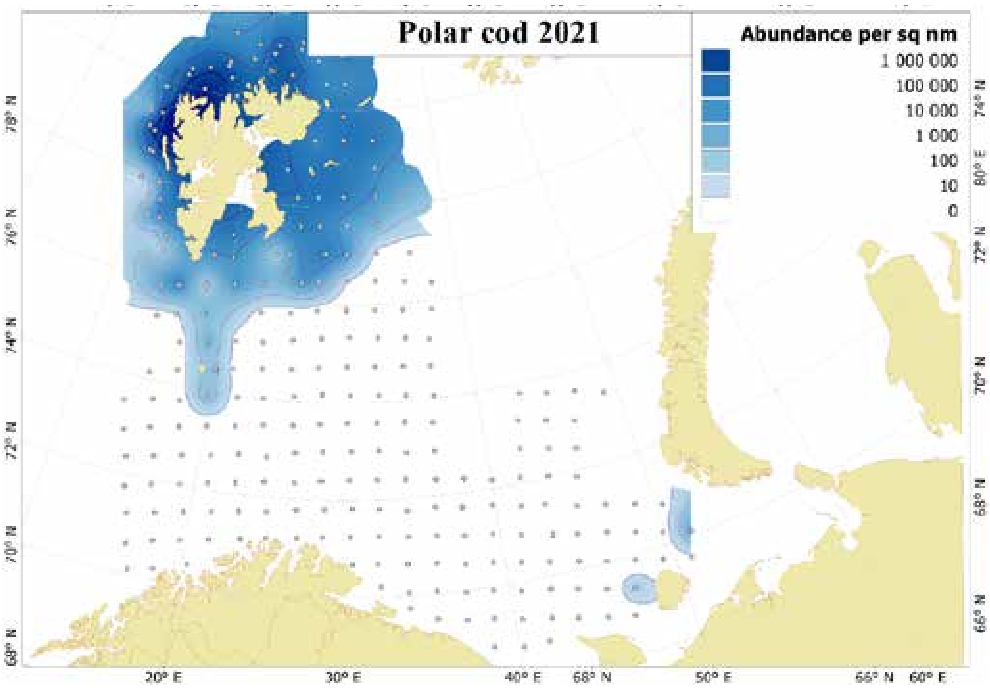


Figure 6.5.1. *Distribution of 0-group polar cod (*Boreogadus saida*), August-September 2021. Abundance is corrected for Keff. Dots indicate sampling locations.*

The largest polar cod with an average length of 5.4 cm were observed in the Svalbard North polygons, while smallest with an average length of 2.9 cm were observed in the Pechora polygon.

Estimated abundance of 0-group polar cod varied from $201*10^6$ million in 1995 to 2 $189*10^9$ individuals in 1994 with a long-term average of $315*10^9$ individuals for the 1980-2021 period. In 2018, 2020 and 2021, the southeastern and eastern Barents Sea was not fully covered, where 0-group polar cod were often found, and thus abundance and biomass indices were underestimated. The eastern component has been dominated in abundance and biomass during 1980, 1990 and early 2000s. In 2021, the total abundance index for 0-group polar cod was lower than the long-term mean and was $136*10^9$ individuals (Figure 6.5.2). Low abundance of 0-group cod in the traditional core area, the Pechora Sea, most likely due to redistribution of spawning sites out of the Barents Sea and into the western part of Kara Sea. This is indirectly confirmed by 2019-2020 studies in the Kara Sea, where a significant amount of the mature polar cod was found.

In 2021, estimated biomass of 0-group polar cod was much higher than long term mean (137 thousand tonnes for the period 1980-2021) and was 59 thousand tonnes. The abundance index of 2021-year class is very low than the long-term mean, and thus may be characterized as weak, however, the uncertainty of this estimate is significant, due to the incomplete coverage of the survey area.

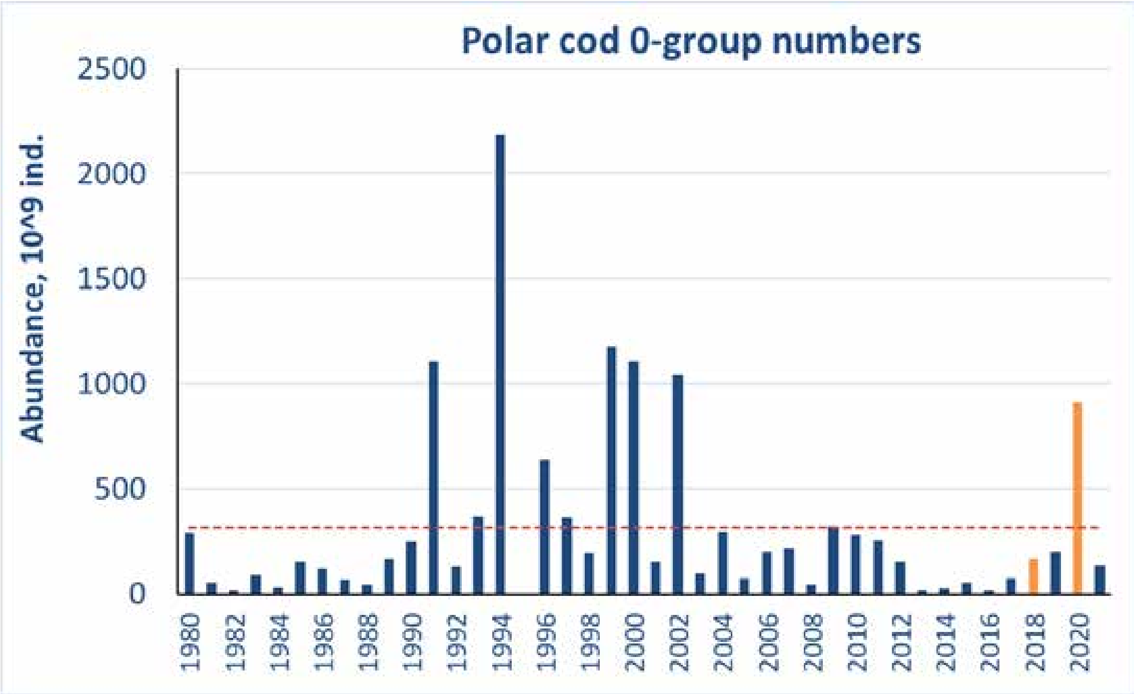


Figure 6.5.2. *0-group polar cod abundance estimates corrected for Keff for the period 1980-2021 (blue columns). Orange line shows the long-term average, while orange column showed indices that were corrected for lack of coverage.*

6.6 Saithe (*Pollachius virens*)

Saithe distribution and abundance varied a lot between years and some few individuals were found on some few stations only. In 2021, saithe were widely distributed in the southern and central areas (Fig. 6.6.1).

0-group saithe distributes generally along the Norwegian coast, while some part of them were transported to the Barents Sea. Therefore, abundance indices for saithe may not represent year classes strength but give indication of abundance in the Barents Sea.

Largest saithe with an average of 10 cm were observed in the South-West and South East polygons, fish with an average of 8.5-9.0 cm were found in the central and western areas, and smallest with an average of 7.0 cm were found in the Central Bank polygon.

Saithe abundance indices varied from some few hundreds to $4.8*10^9$ individuals (2004). In 2021, abundance was low than long term mean (435 $*10^6$ ind. for the period 1980-2021), but higher than in 2019-2020 and was $238*10^6$ individuals (Fig. 6.6.1).

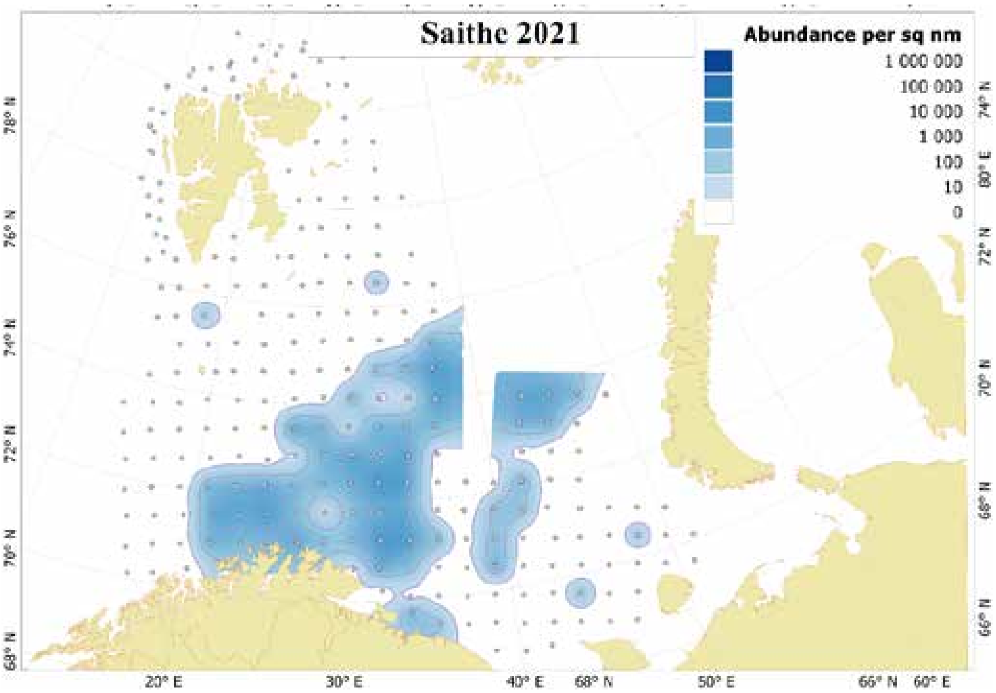


Figure 6.6.1. *Distribution of 0-group saithe (*Pollachious virens*) in August-September 2021. Abundance was corrected for Keff. Dots indicate sampling locations.*

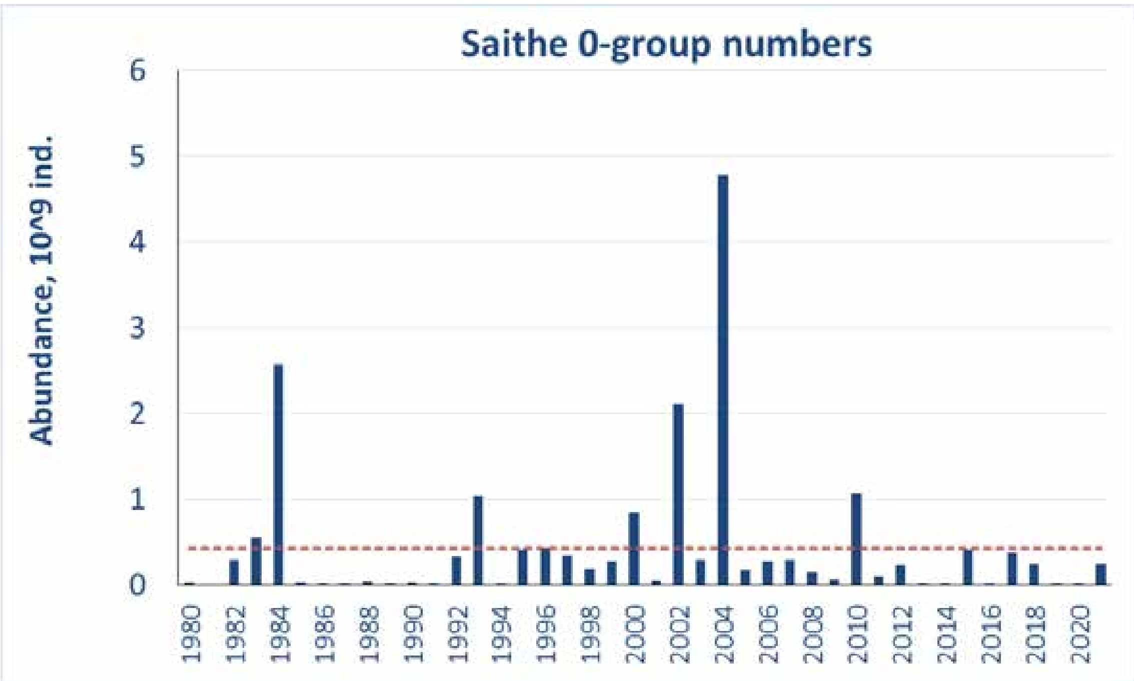


Figure 6.6.2. *0-group saithe abundance estimates corrected for Keff (blue columns). Orange line shows the long-term average.*

6.7 Redfish (mostly *Sebastes mentella*)

0-group redfish was distributed from north of Norwegian coast to the northwest of Svalbard (Spitsbergen) archipelago in 2021 (Figure 6.7.1). The densest concentrations and the largest fish with an average of 3.7 cm were found in the Svalbard North polygon.

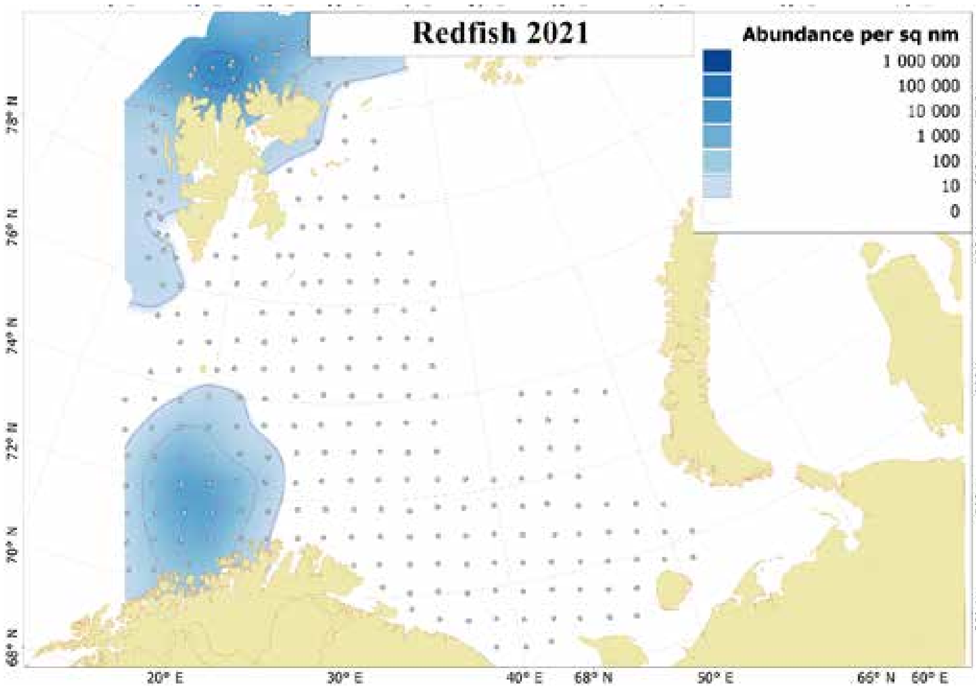


Figure 6.7.1. *Distribution of 0-group redfishes* ***(****mostly* Sebastes mentella*) in August-September 2021. Abundance corrected for Keff. Dots indicate sampling locations.*

Estimated abundance of 0-group deepwater redfish varied from $23*10^6$ individuals in 2001 to $1.6*10^{12}$ ind. in 1985, and long term abundance was $0.222*10^{12}$ ind for the 1980-2021 period (Figure 6.7.2). In 2021, the total abundance index for 0-group deepwater redfish was very low and was $41.4*10^9$ ind, which is much lower than the long-term mean.

Thus the 2021-year class may be characterized as a weak. Estimated biomass were also lower than long term mean (of 96 thousand tonnes) and was 28 thousand tonnes in 2021.

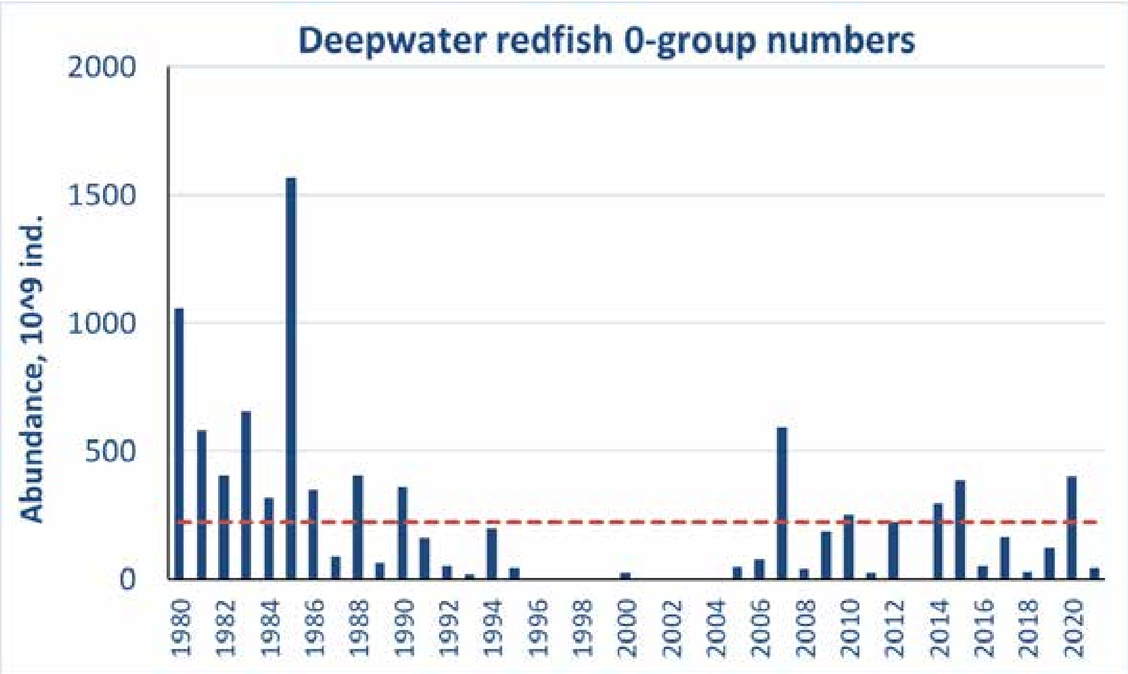


Figure 6.7.2*. 0-group deepwater redfish abundance corrected for Keff (blue column). Orange line shows the long-term average.*

6.8 Greenland halibut (*Reinhardtius hippoglossoides*)

0-group Greenland halibut was distributed west, north, and south of Svalbard (Spitsbergen) in 2021 similar to distribution in 2018-2020 (Figure 6.8.1).

0-group Greenland halibut length varied from 3.0 to 8.9 cm. Larger fish were found in the Svalbard North and Svalbard South polygons, and fish length were with an average of 6.8 cm, while slightly smaller fish were found in the Fr. Victoria Trough with average of 6.3 cm. In 2021, the total abundance index for 0-group fish were 53.6 million individuals, that was higher than long term mean of 29 million individuals.

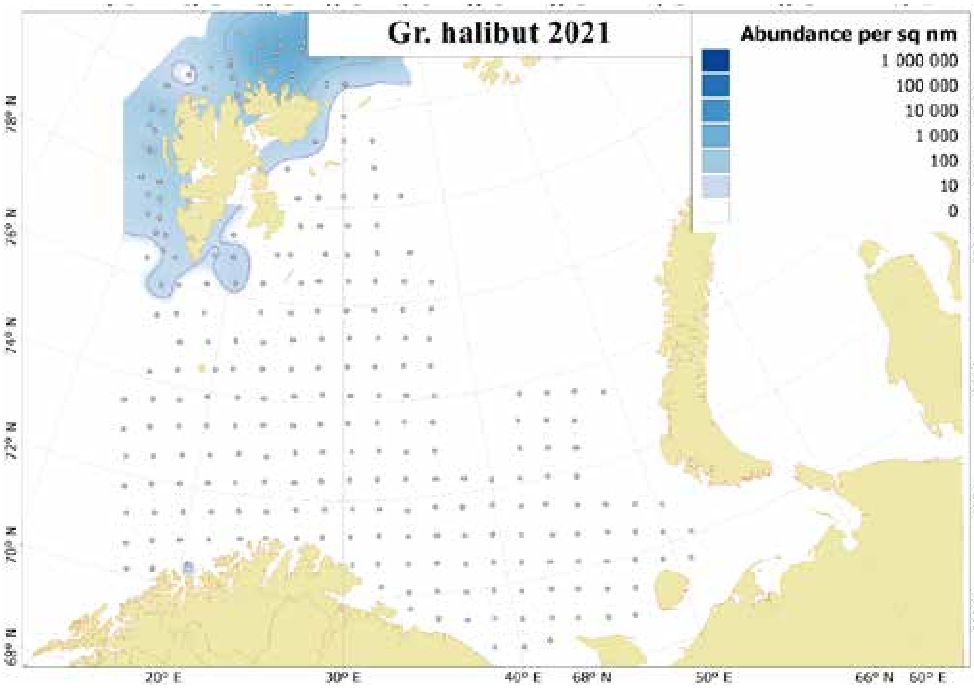


*Figure 6.8.1. Distribution of 0-group Greenland halibut (*Reinhardtius hippoglossoides*), August-September 2021. Dots indicate sampling locations.*

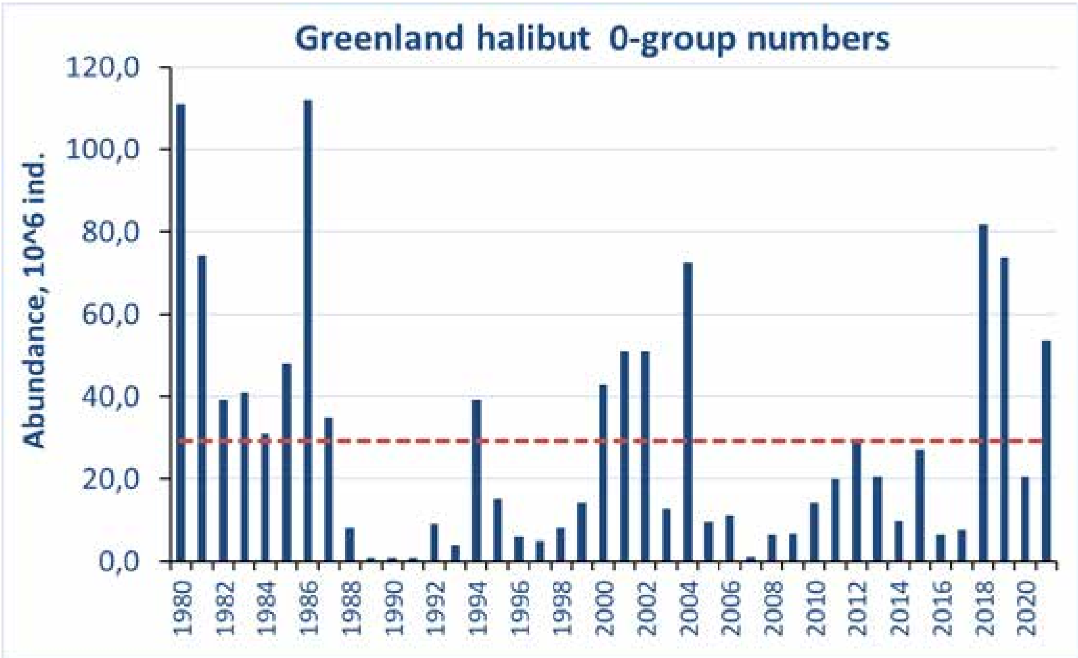


Figure 6.8.2. 0-group Greenland halibut abundance estimates were not corrected for Keff (blue column). Orange line shows the long-term average.

0-group Greenland halibut distributes mainly in the Svalbard (Spitsbergen) fjords and close to seabed, therefore, abundance indices in the open sea areas may not represent year classes strength but give some indication about recruitment dynamics.

6.9 Long rough dab (*Hippoglossoides platessoides*)

In 2021, 0-group long rough dab were mainly distributed in the north, south and east of Svalbard (Spitsbergen), and the southwestern and southeastern corner of the Barents Sea (Figure 6.9.1). In 2021, the eastern Barents Sea was not covered well, but probably long rough dab was not distributed here numerously.

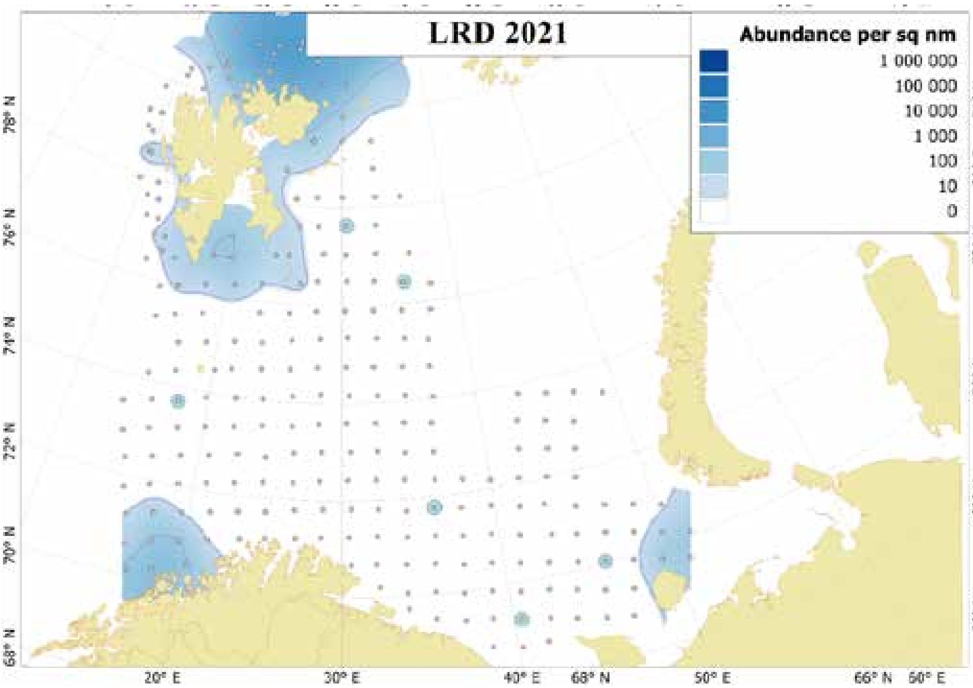


Figure 6.9.1. *Distribution of 0-group long rough dab (*Hippoglossoides platessoides*), August-September 2021. Dots indicate sampling locations.*

Larger long rough dab were found in the northern polygons (Great bank, Svalbard North, and Fr. Victoria Trough) with av average of 4 cm, while smallest long rough dab were found in the South West polygon with an average of 1.6 cm.

In 2021, the total abundance index for 0-group fish were 128.6 million individuals that was lower that was in 2020 and four times lower than long term mean (571 $*10^6$ individuals). Thus the 2021-year class of long rough dab may be characterized as a weak.

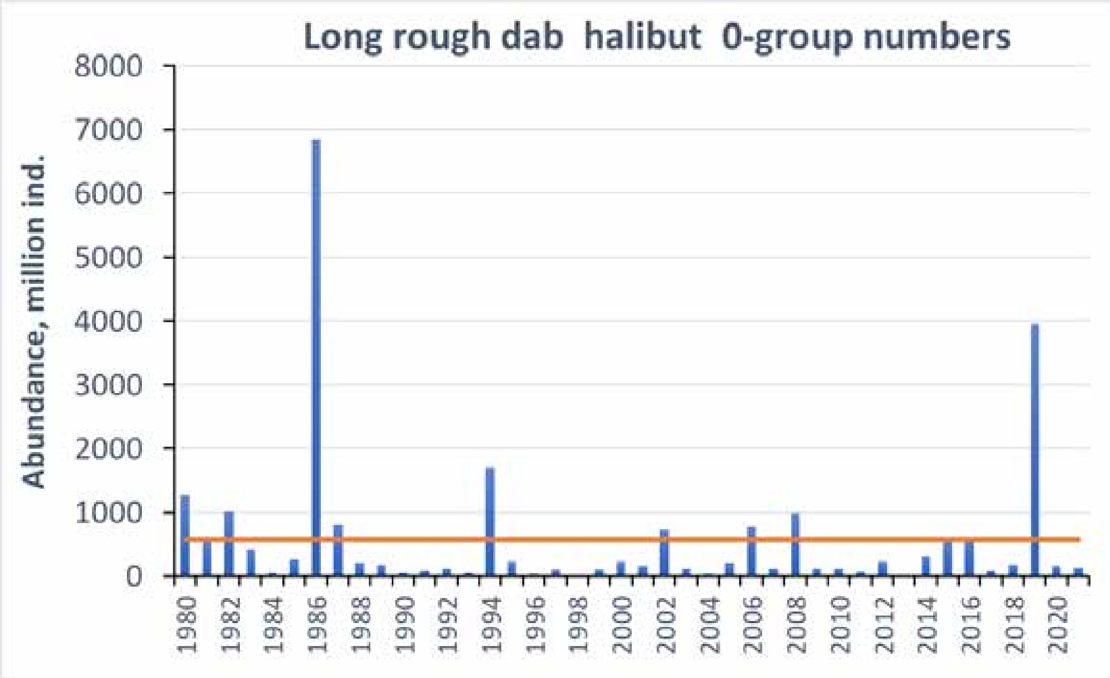


Figure 6.9.2. *0-group long rough dab abundance estimates were not corrected for Keff (blue column). Orange line shows the long-term average.*

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*).

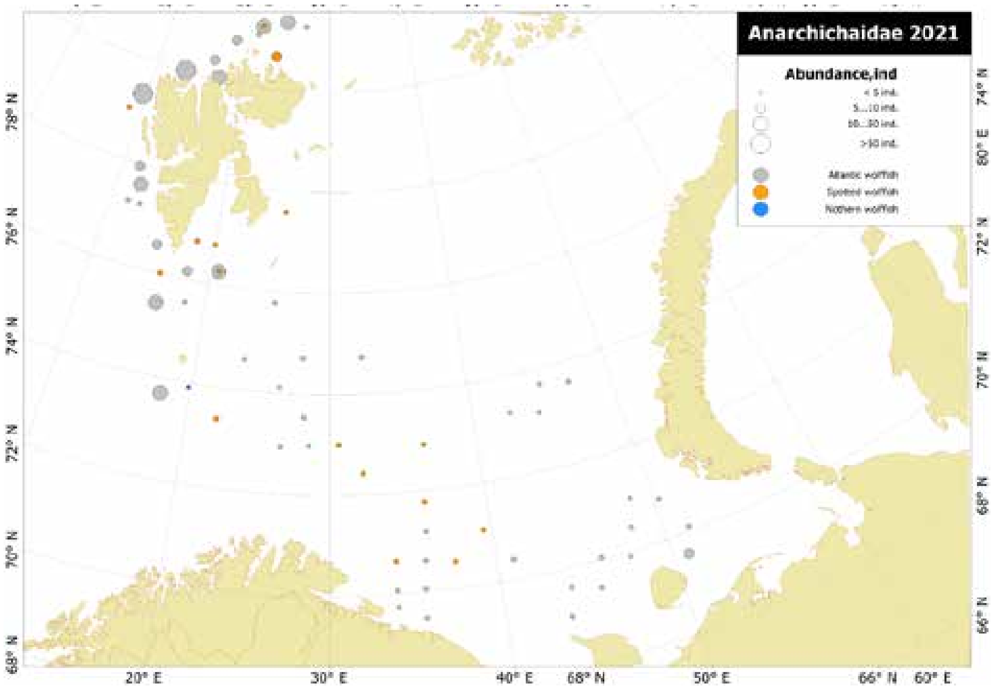


Figure 6.9.1. *Distribution of wolffish (Anarchicaidae), August-September 2021. Dots indicate wolffish species and their numbers.*

Atlantic wolffish were widely distributed from southeast to northwest. Spotted wolffish were found in the southcentral and northwestern areas, while one specimen of Northern wolffish was found south for Bear Island (Fig. 6.1.1).

The largest Atlantic wolffish were found in the southern polygons (South East, Pechora, and Southeastern basin), and were with an average above 7 cm. The smallest fish with an average of 6.0 cm were found in the western polygons (Thor Iversen Bank and Hopen Deep).

The largest spotted wolffish were found in the southern and western polygons (South East, Southeastern Basin and Thor Iversen Bank), and fish length were with an average close and higher than 9 cm. The smallest fish with an average below than of 7.0 cm were found in the north.

The northern wolfish length was 7.5 cm.

Abundance indices were calculated for all three species of wolffish and fish which were identified to the family level (Total abundance of wolffishes, Fig. 6.9.2) and for each species separately (Fig. 6.9.3) for the period 2003-2021. Total abundance indices were highest in 2003 followed by strong recruitment (age 0) in 2015 and 2019-2020. In 2003, many of wolffishes were identified to higher taxa. The strong recruitment in 2015 indicated a strong year classes of Atlantic wolffish and in 2019-2020 indicated a strong year classes both of Atlantic wolffish and spotted wolffish. Northern wolffish were seldom captured by pelagic trawl.

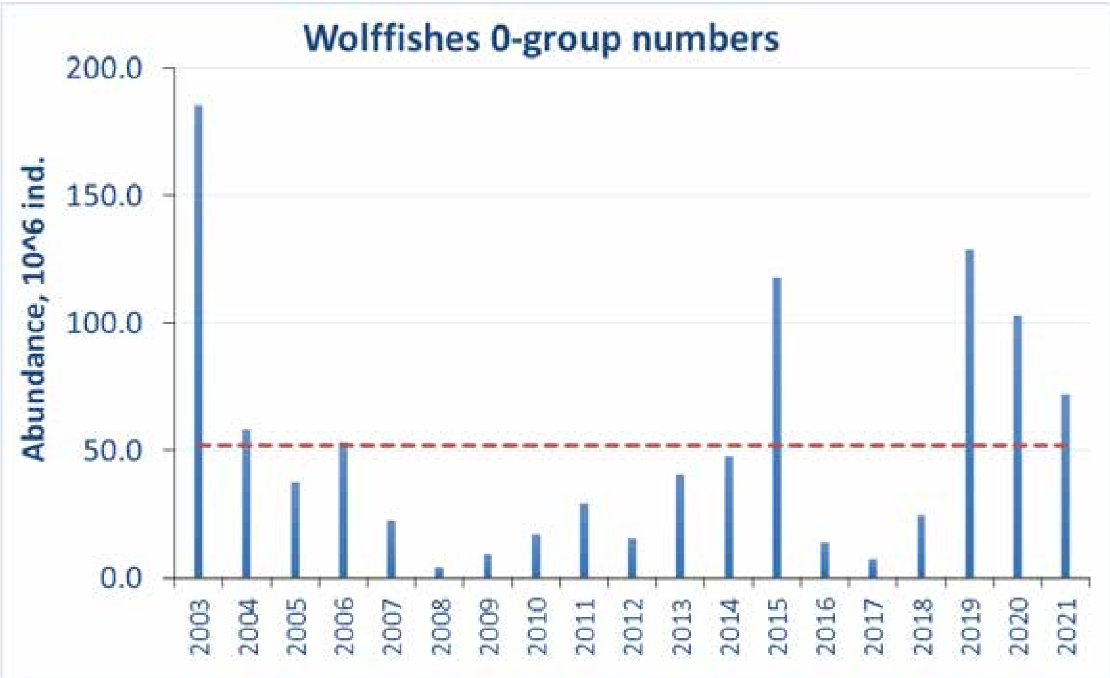


Figure 6.10.2. *0-group wolffishes abundance estimates were not corrected for Keff (blue columns). Orange line shows the long-term average, while indicate abundance estimates. Abundance of wolffishes in 2018 and 2020 were some underestimated due to lack of coverage in the eastern Barents Sea.*

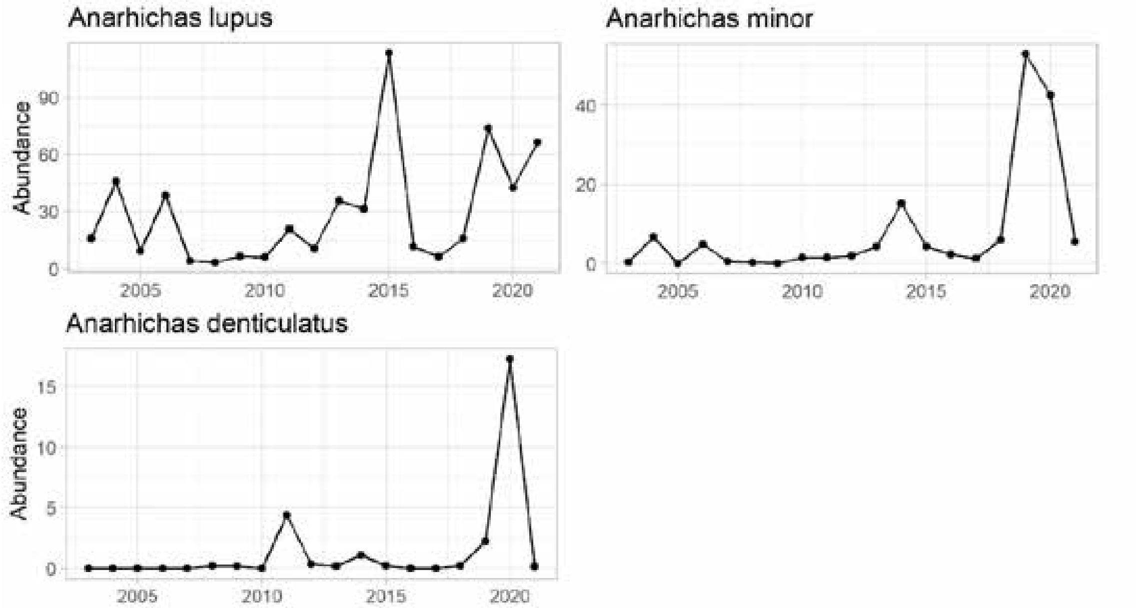


Figure 6.10.3. *0-group of Atlantic wolffish (*Anarhichas lupus*), Spotted wolffish (*Anarhichas minor*) and Northern wolffish (*Anarhichas denticulatus*). Abundance estimates were not corrected for Keff.*

In 2021, the total abundance index for 0-group wolffishes was $72*10^6$ individuals, which was higher that long term mean of $52*10^6$ individuals and dominated by strong year classes of Atlantic wolffish ($66*10^6$ individuals).

6.11 Sand eels (*Ammodytes marinus*)

In 2021, 0-group sand eels were mainly found in two separate areas in the southern Barents Sea: north for Finnmark coast and in the south-east of the Barents Sea. Some few catches were also taken in the central area and north of Svalbard (Spitsbergen) (Figure 6.11.1).

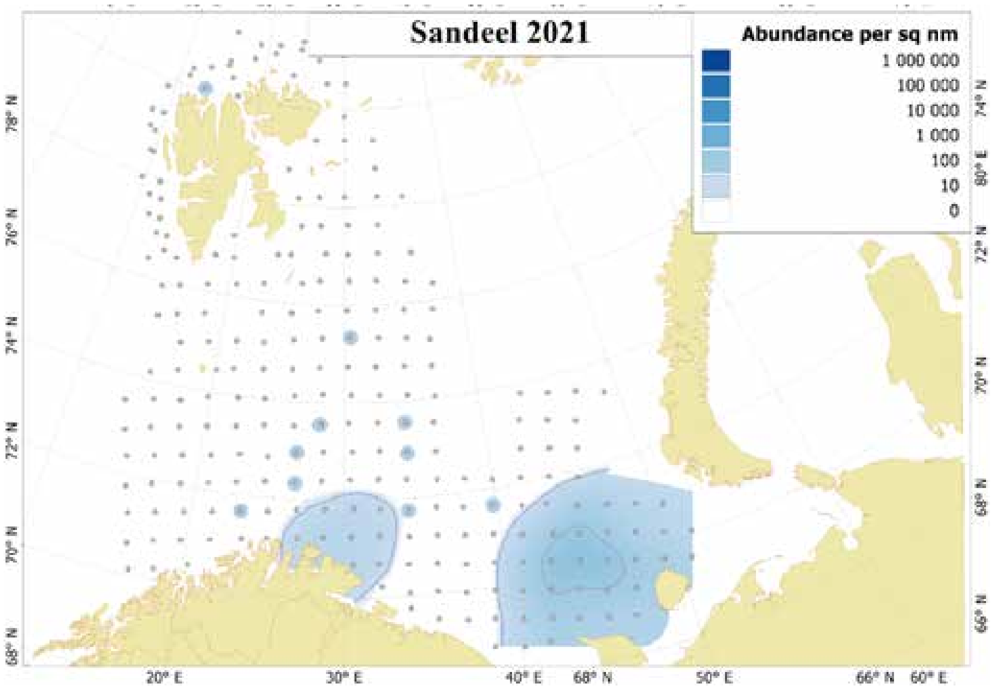


Figure 6.11.1. *Distribution of 0-group sand eels (*Ammodytes marinus*), August-September 2021. Dots indicate sampling locations.*

Largest sand eels with an average of 10 cm and larger were found in the Hopen Deep and Southeastern Basin, while smallest fish were found in Svalbard South (5.6 cm), Pechora (6.2 cm) and South East (6.4 cm). Estimated abundance of sand eels was low ($409.8*10^6$ ind.) in 2021 and was almost 10 time lower than long term mean ($4*10^9$ ind.) (Fig. 6.11.2).

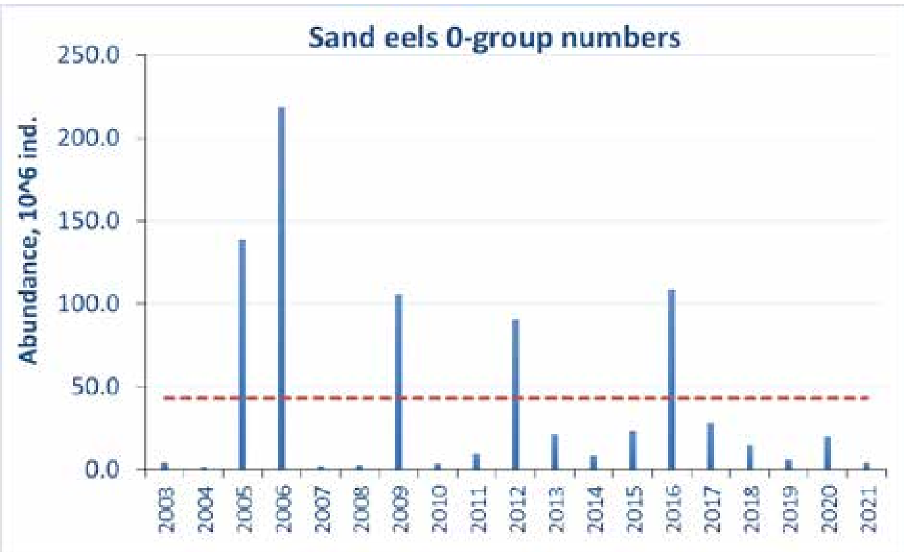


Figure 6.11.2. *0-group sand eels abundance estimates were not corrected for Keff (blue columns). Orange line shows the long-term average, while indicate abundance estimates. Abundance of sand eels in 2018 and 2020 were underestimated due to lack of coverage in the eastern Barents Sea.*

In 2021, the total abundance index for 0-group fish was low and therefore 2021 year classes of sand eels is characterized as weak.

7 COMMERCIAL PELAGIC FISH

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

7.1 Capelin (*Mallotus villosus*)

The coverage of the capelin distribution was considered to be complete for 2021 (see Figure 7.1.1.1).

7.1.1 Geographical distribution

The coverage of the capelin distribution was considered to be complete for 2021, and the geographical distribution of capelin recorded acoustically is shown in Figure 7.1.1.1. The distribution of the main concentrations was similar as for 2020 with most capelin found in the typical feeding areas east and southeast of Svalbard (Spitsbergen). However, the distribution extended a bit further north and east than in 2020.

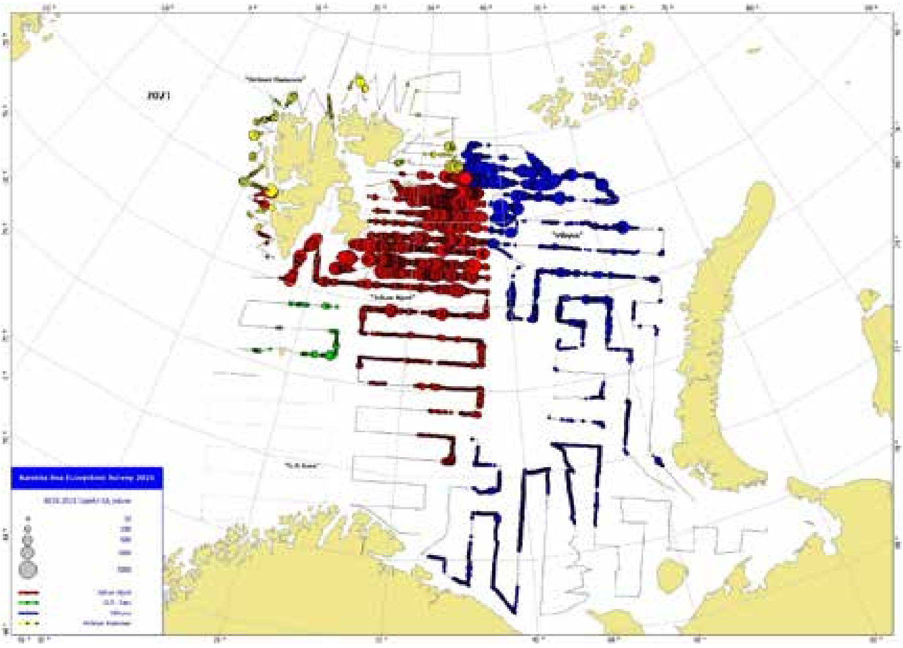


Figure. 7.1.1.1 *Geographical distribution of capelin (Mallotus villosus) in autumn 2021 based on acoustic recordings. Circle sizes correspond to s_A values (m^2/nm^2) per nautical mile.*

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 2021 and 2020 is given in the table 7.1.2.3 with the 2020 estimate shown on a shaded background.

The total stock was estimated to about 4 million tons, which is above the long-term average level (2.8 million tons), and the highest total estimate since 2008. About 36 % (1.44 million tons) of the 2021 stock had length above 14 cm and was therefore considered to be maturing. The 2-year old capelin (2019 year-class) completely dominated in the capelin stock in terms of biomass the highest estimated biomass of 2-year-olds since 1991. This corresponds well with the high abundance of 1-year-olds observed last year and high abundance of 0-group capelin in 2019. The abundance of 1-year-olds was also above average. This agrees well with the results of the 0-group estimates from 2020 when the abundance of this capelin year-class was estimated to be above average.

Average weight at age had dropped significantly for the abundant 2-year-olds which is expected due to density dependent growth (figure 7.1.2.2). For 1 and 3-year-olds the weight-at-age was similar as last year, whereas the 4-year-olds had higher weight-at-age than last year, but there were very few of them observed.

A more detailed description of biology and stock development of the Barents Sea capelin can be found in the report 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 2022.

Table 7.1.2.1 *Barents Sea capelin. Summary of results from the acoustic estimate in August-September 2021.*

Length (cm)	Age/year class					Sum	Biomass (10^3 t)	Mean weight (g)
	1	2	3	4	5	10^9		
	2020	2019	2018	2017	2016			
7.0-7.5	1.92					1.92	2.53	1.32
7.5-8.0	4.82					4.82	9.07	1.88
8.0-8.5	15.46					15.46	34.93	2.26
8.5-9.0	26.72	1.07				27.79	73.09	2.63
9.0-9.5	53.27	2.98				56.25	170.44	3.03
9.5-10.0	60.28	6.18				66.46	227.95	3.43
10.0-10.5	32.24	14.56				46.8	187.67	4.01
10.5-11.0	15.64	44.08				59.72	284.86	4.77
11.0-11.5	4.68	39.57				44.25	241.61	5.46
11.5-12.0	2.93	40.58	0.02			43.53	278.59	6.4
12.0-12.5	1.41	34.22				35.63	265.09	7.44
12.5-13.0	0.93	31.6	0.17			32.7	285.18	8.72
13.0-13.5	0.35	26.38	0.24			26.97	273.76	10.15
13.5-14.0	0.13	18.48	0.44			19.04	224.8	11.81
14.0-14.5	0.07	15.84	0.34			16.25	215.82	13.28
14.5-15.0		13.36	0.53			13.89	215.3	15.5
15.0-15.5		14.24	0.23			14.47	251.54	17.38
15.5-16.0		9.74	1.51			11.25	223.36	19.85
16.0-16.5		6.27	0.68			6.95	154.24	22.18
16.5-17.0		6.74	0.32			7.06	177.3	25.1
17.0-17.5		2.774	1.03	0.01		3.814	105.26	27.6
17.5-18.0		1.043	0.454			1.497	48.24	32.23
18.0-18.5		0.164	0.924			1.089	36.55	33.58
18.5-19.0		0.115				0.115	4.3	37.39
19.0-19.5		0.0344	0.1013	0.0006		0.1362	5.38	39.46
19.5-20.0				0.0208		0.0208	0.91	43.87
20.5-20.5				0.0002		0.0002	0.01	47.88
TSN (10^9)	220.85	330.0204	6.996	0.0316		557.89		
TSB (10^3 t)	757.71	3081.46	157.23	1.22			3997.62	
Mean length (cm)	9.58	12.57	16.11	18.95		11.43		
Mean weight (g)	3.43	9.34	22.47	38.66				7.17

Target strength estimation based on formula: TS= 19.1 log (L) – 74.0

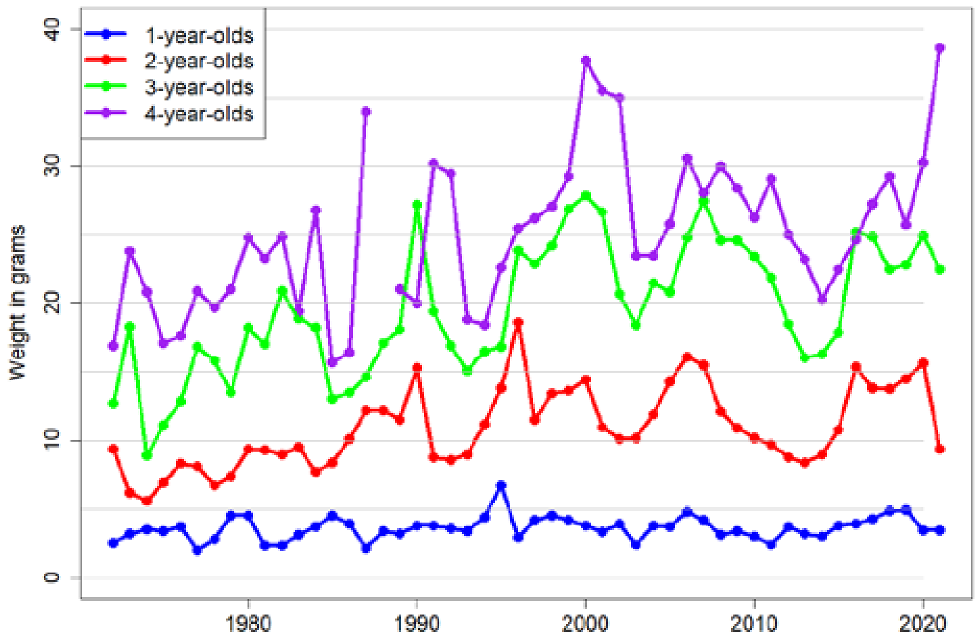


Figure 7.1.2.1. *Weight at age (grams) for capelin from capelin surveys (prior to 2003) and BESS.*

Table 7.1.2.3. *Summary of acoustic stock size estimates for capelin in 2020-2021. A comparison between the estimates this year and last year (shaded background).*

Year class		Age	Numbers (10^9)		Mean weight (g)		Biomass (10^3 t)	
2020	2019	1	220.8	366.4	3.4	3.46	758	1270
2019	2018	2	329.9	31.0	9.3	15.64	3081	490
2018	2017	3	7.0	4.2	22.5	24.93	157	100
2017	2016	4	0.1	0.8	38.7	30.24	1	30
otal stock in:								
2021	2020	1-4	557.9	402.7	7.2	4.68	3998	1884

Table 7.1.2.2. *Barents Sea capelin. Summary acoustic estimates by age in autumn 1973- 2021.*

Year	Age										Sum
	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	.41	23.8	01	30.1	5.14
1974	1.06	3.5	3.06	5.6	1.53	8.9	.07	20.8	+	25.0	5.73
1975	0.65	3.4	2.39	6.9	3.27	11.1	.48	17.1	01	31.0	7.81
1976	0.78	3.7	1.92	8.3	2.09	12.8	.35	17.6	27	21.7	6.42
1977	0.72	2.0	1.41	8.1	1.66	16.8	.84	20.9	17	22.9	4.80
1978	0.24	2.8	2.62	6.7	1.20	15.8	.17	19.7	02	25.0	4.25
1979	0.05	4.5	2.47	7.4	1.53	13.5	.10	21.0	+	27.0	4.16
1980	1.21	4.5	1.85	9.4	2.83	18.2	.82	24.8	01	19.7	6.71
1981	0.92	2.3	1.83	9.3	0.82	17.0	.32	23.3	01	28.7	3.90
1982	1.22	2.3	1.33	9.0	1.18	20.9	.05	24.9			3.78
1983	1.61	3.1	1.90	9.5	0.72	18.9	.01	19.4			4.23
1984	0.57	3.7	1.43	7.7	0.88	18.2	.08	26.8			2.96

Year	Age 1		2		3		4		5		Sum
	B	AW	B	AW	B	AW	B	AW	B	AW	B
1985	0.17	4.5	).40	8.4	0.27	13.0	).01	15.7			0.86
1986	0.02	3.9	).05	10.1	0.05	13.5	+	16.4			0.12
1987	0.08	2.1	).02	12.2	+	14.6	+	34.0			0.10
1988	0.07	3.4	).35	12.2	+	17.1					0.43
1989	0.61	3.2	).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	).04	30.2			7.29
1992	1.25	3.6	1.69	8.6	2.17	16.9	).04	29.5			5.15
1993	0.01	3.4	).48	9.0	0.26	15.1	).05	18.8			0.80
1994	0.09	4.4	).04	11.2	0.07	16.5	+	18.4			0.20
1995	0.05	6.7	).11	13.8	0.03	16.8	).01	22.6			0.19
1996	0.24	2.9	).22	18.6	0.05	23.9	+	25.5			0.50
1997	0.42	4.2	).45	11.5	0.04	22.9	+	26.2			0.91
1998	0.81	4.5	).98	13.4	0.25	24.2	).02	27.1	+	29.4	2.06
1999	0.65	4.2	1.38	13.6	0.71	26.9	).03	29.3			2.77
2000	1.70	3.8	1.59	14.4	0.95	27.9	).08	37.7			4.27
2001	0.37	3.3	2.40	11.0	0.81	26.7	).04	35.5	+	41.4	3.63
2002	0.23	3.9	).92	10.1	1.04	20.7	).02	35.0			2.21
2003	0.20	2.4	).10	10.2	0.20	18.4	).03	23.5			0.53
2004	0.20	3.8	).29	11.9	0.12	21.5	).02	23.5	+	26.3	0.63
2005	0.10	3.7	).19	14.3	0.04	20.8	+	25.8			0.32
2006	0.29	4.8	).35	16.1	0.14	24.8	).01	30.6	+	36.5	0.79
2007	0.93	4.2	).85	15.5	0.10	27.5	+	28.1			2.12
2008	0.97	3.1	2.80	12.1	0.61	24.6	).05	30.0			4.43
2009	0.42	3.4	1.82	10.9	1.51	24.6	).01	28.4			3.77
2010	0.74	3.0	1.30	10.2	1.43	23.4	).02	26.3			3.50
2011	0.50	2.4	1.76	9.7	1.21	21.9	).23	29.1			3.71
2012	0.54	3.7	1.37	8.8	1.62	18.5	).06	25.0			3.59
2013	1.04	3.2	1.81	8.4	0.94	16.0	).16	23.2	+	29.1	3.96
2014	0.32	3.0	).95	9.0	0.64	16.3	).04	20.3			1.95
2015	0.14	3.8	).40	10.8	0.20	17.9	).09	22.5	+	28.1	0.84
2016	0.12	3.9	).12	15.3	0.08	25.2	).00	24.7			0.33
2017	0.37	4.3	1.70	13.8	0.42	24.9	).01	27.3			2.51
2018	0.29	4.9	).80	13.8	0.48	22.4	).01	29.3			1.60
2019	0.09	4.9	).13	14.5	0.16	22.8	).03	25.7			0.41
2020	1.27	3.5	).49	15.6	0.10	24.9	).03	30.2	+	22.6	1.88
2021	0.76	3.4	3.08	9.3	0.16	22.5	).00	38.7			4.00
Average	0.63	3.6	1.30	11.0	0.78	19.8	).18	25.3	07	27.8	2.84

7.2 Polar cod (*Boreogadus saida*)

7.2.1 Geographical distribution

The main distribution of polar cod was found in the north-eastern parts of the survey area which is typical (Fig.7.2.1.1), and similar as last year, concentrations were high. Similar as last year, polar cod were also quite abundant west of 35°E. In 2020, the distribution area of the polar cod was much covered than in 2021, so the biomass was larger. Overall, polar cod abundance in 2021 was quite high.

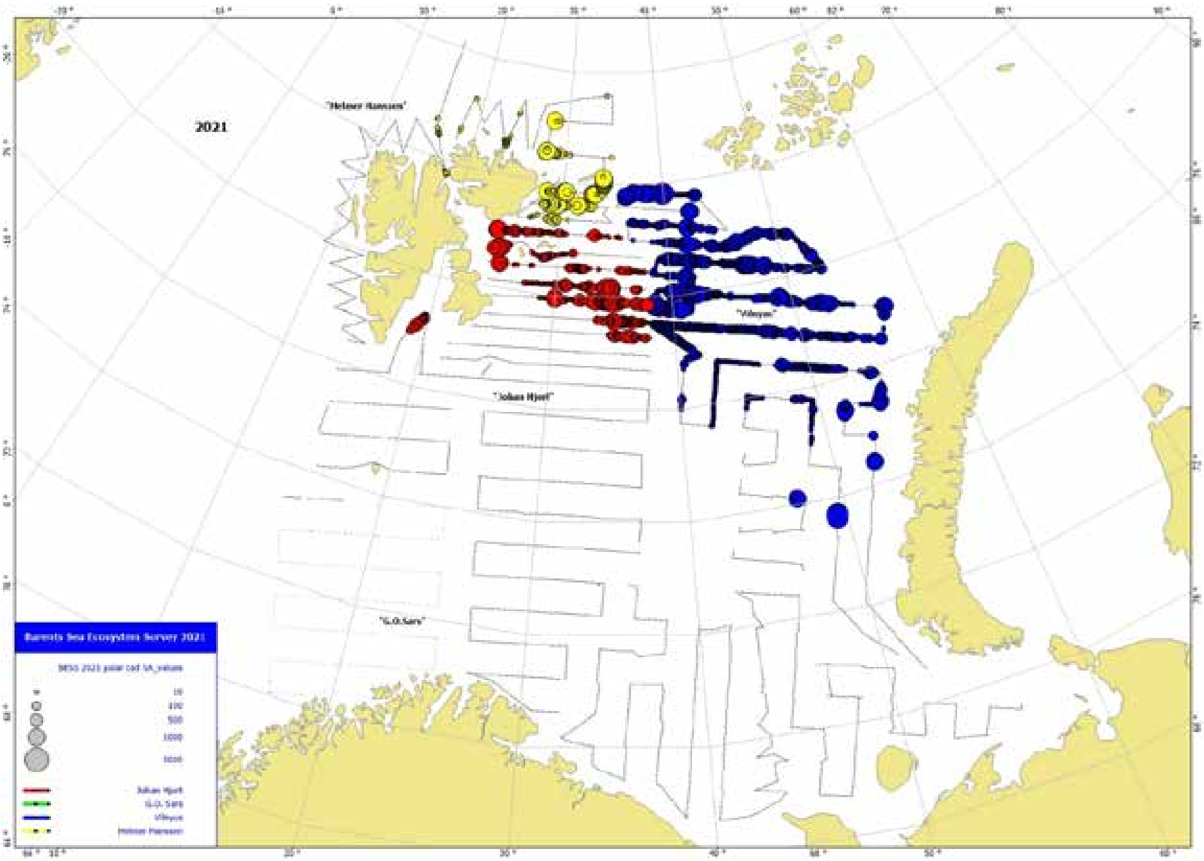


Figure 7.2.1.1 *Geographical distribution of polar cod (*Boreogadus saida*) in autumn 2021 based on acoustic data. Circle sizes correspond to s_A values (m^2/nm^2) per nautical mile.*

7.2.2. Abundance estimation

The stock abundance estimate by age, number and weight in 2021 is given in Table 7.2.2.1 and the time series of abundance estimates are summarized in Table 7.2.2.2.

The total abundance of polar cod in 2021 is lower than the very high abundance from last year, but still well above average and the highest since 2016 except for the estimate from last year. The 2-year-olds (2019 year-class) dominate the biomass. This was expected given the record high abundance of 1-year-olds last year. 1-year-olds (2020 year-class) also had higher estimated abundance than the long-term average.

Table 7.2.2.1. *Barents Sea polar cod. Summary of results from the acoustic estimate in August-September 2021.*

Length (cm)	Age group/year class					Sum (10^9)	Biomass (10^3 t)	Mean weight (g)
	1	**2**	**3**	**4**	**5**			
	2020	**2019**	**2018**	**2017**	**2016**			
7-8	0.003					0.003	0.01	2.70
8-9	2.75	0.09				2.84	11.57	4.07
9-10	10.34	0.22	0.04			10.60	60.25	5.68
10-11	16.60	2.18	0.16			18.94	139.00	7.34
11-12	10.77	6.13	0.01	).0005		16.92	160.17	9.47
12-13	3.30	9.08	0.03	0.001		12.42	158.40	12.76
13-14	0.86	8.25	0.11	0.04		9.26	149.78	16.17
14-15	0.54	6.74	0.24	0.02		7.54	157.51	20.89
15-16	0.13	5.25	0.21			5.59	138.04	24.70
16-17	0.02	3.33	0.34	0.01		3.70	122.98	33.20
17-18	0.01	1.43	0.32	0.01		1.77	71.52	40.32
18-19		0.79	0.16	0.03		0.98	47.06	48.19
19-20		0.32	0.10	0.04		0.46	25.72	55.42
20-21		0.11	0.16	0.01		0.29	18.37	63.97
21-22		0.05	0.12	0.008		0.18	13.39	73.86
22-23		0.02	0.15	0.002		0.17	14.31	84.46
23-24			0.02	0.003		0.02	2.31	98.92
24-25			0.01	0.003		0.01	1.13	111.25
25-26		0.01	0.01			0.02	2.20	130.43
26-27					0.01	0.01	1.59	125.37
27-28								
28-29					0.01	0.01	1.75	187.00
29-30								
30-31								
31-32					0.01	0.01	2.00	182.60
TSN (10^9)	45.34	44.02	2.19	0.18	0.03	91.76		
TSB (10^3 t)	375.46	819.87	90.42	7.96	5.34		1299.05	
Mean length (cm)	10.44	13.49	16.67	17.14	28.4	12.31		
Mean weight (g)	8.28	18.63	41.29	44.22	161.8			14.16

Target strength estimation based on formula: TS= 21.8 log (L) – 72.7

Table 7.2.2.2. *Barents Sea polar cod. Summary of acoustic estimates by age in autumn 1986- 2021. TSN and TSB are total stock numbers (10^9) and total stock biomass (10^3 tones) 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	13.540	154.9	1.777	41.7	0.236	8.6	0.060	2.6	15.613	207.8
1990	3.834	39.3	2.221	56.8	0.650	25.3	0.094	6.9	6.799	127.3
1991	23.670	214.2	4.159	93.8	1.922	67.0	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	37.790	594.9
1993	16.269	131.6	18.919	367.1	2.965	103.3	0.147	7.7	38.300	609.7
1994	27.466	189.7	9.297	161.0	5.044	154.0	0.790	35.8	42.597	540.5
1995	30.697	249.6	6.493	127.8	1.610	41.0	0.175	7.9	38.975	426.2
1996	19.438	144.9	10.056	230.6	3.287	103.1	0.212	8.0	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	23.0	102.435	839.5
1999	59.434	399.6	22.760	426.0	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	0.840	48.4	69.262	1347.8
2001	77.144	709.0	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	6.350	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	0.510	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	1803.0
2006	16.190	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	3.230	145.8	0.315	19.8	58.807	1230.1
2008	41.693	421.8	18.114	522.0	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	0.336	16.6	44.090	889.3
2010	27.285	234.2	18.257	543.1	12.982	594.6	1.253	58.6	59.777	1430.5
2011	34.460	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	0.119	8.0	20.457	318.9
2013	2.216	18.1	4.317	102.2	5.243	210.3	0.180	9.9	11.956	340.5
2014	0.687	6.5	4.439	110.0	3.196	121.0	0.080	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	6.380	139.1	0.207	6.9	0.023	0.7	102.529	939.4
2017	13.810	121.8	8.269	200.8	1.112	34.3	0.003	0.1	23.195	357.1
2018**	1.900	16.4	0.980	23.1	0.240	9.4	0.014	0.6	3.124	49.6
2019**	6.109	49.8	1.217	30.3	0.214	6.3	0.014	0.8	7.555	87.2
2020	115.139	988.3	20.133	386.8	8.217	299.3	0.647	42.8	144.171	1720.8
2021	45.340	375.5	44.020	819.9	2.190	90.4	0.210	13.3	91.760	1299.0
Average	32.160	259.6	14.360	321.6	4.520	170.0	0.470	25.7	51.530	778.4

* data partly recovered by VPA

** incomplete survey coverage

7.3 Herring (*Clupea harengus*)

Geographical distribution

Young Norwegian spring spawning herring (NSSH) were distributed mostly in the south-western parts of the Barents Sea in 2021 (Figure 7.3.1.1), and only very small amounts of herring were recorded in the eastern parts of the Barents Sea.

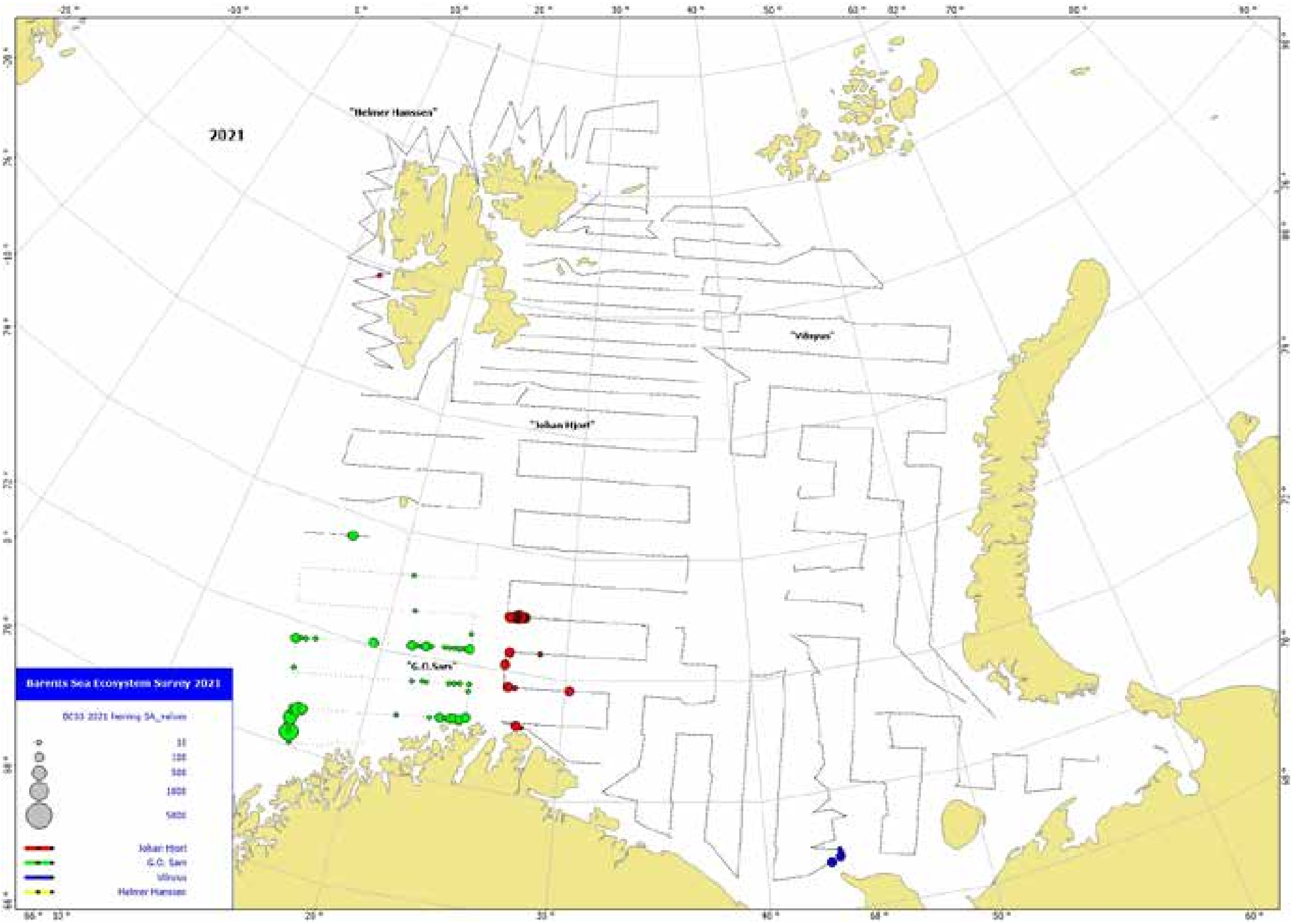


Figure 7.3.1.1 *Geographical distribution of herring (*Clupea harengus*) in autumn 2021 based on acoustic recordings. Circle sizes correspond to s_A values (m^2/nm^2) per nautical mile.*

7.2.2 Abundance estimation

The estimated total number and biomass of NSSH in the Barents Sea in the autumn 2021 is shown in table 7.3.2.1, and the time series of abundance estimates is summarized in Table 7.3.2.2. Total numbers in 2021 was estimated at 2.61 billion individuals (Table 7.3.2.1). This is below the long-term average (Table 7.3.2.2). Abundance of all age groups were below the long-term average, and the abundance of 2-year-olds was the lowest on record as expected from the lack of 1-year-olds (2019 year-class) in the survey last year. Still, the very strong 2016 year-class are dominating the biomass estimate.

Table 7.3.2.1. *NSS herring. Acoustic estimate in the Barents Sea in August-October 2021*

Length, (cm)	Age/year class						Sum (10^9)	Biomass (10^3 t)	Mean weight (g)
	2020	2019	2018	2017	2016	2015+			
	1	2	3	4	5	6+			
13-14	0.07						0.07	1.15	16.00
14-15	0.05						0.05	0.81	18.00
15-16	0.08						0.08	1.95	24.50
16-17	0.15						0.15	4.69	30.42
17-18	0.38						0.38	13.95	37.00
18-19	0.47						0.47	20.36	43.33
19-20	0.06	0.01					0.06	3.24	51.79
20-21	0.15	0.01					0.16	9.23	56.77
21-22		0.04	0.02				0.06	4.21	69.62
22-23		0.005	0.003				0.01	0.60	77.57
23-24		0.06	0.09				0.15	14.88	100.26
24-25			0.14				0.14	14.73	107.48
25-26			0.001	0.001			0.002	0.27	124.73
26-27			0.11	0.05			0.16	21.40	133.01
27-28				0.04	0.04		0.09	13.43	151.50
28-29				0.09			0.09	16.38	178.75
29-30					0.13		0.13	24.91	185.25
30-31						0.002	0.002	0.33	221.00
31-32					0.04		0.04	11.04	249.00
32-33					0.09	0.04	0.13	41.97	315.67
33-34					0.09	0.04	0.13	43.57	327.67
34-35									
35-36						0.04	0.04	12.01	271.00
TSN (10^9)	1.41	0.12	0.36	0.19	0.40	0.13	2.61		1.41
TSB (10^3t)	80.79	10.13	39.49	30.40	100.56	13.74		275.11	
Mean length (cm)	17.72	22.20	24.37	27.19	30.76	33.80	22.48		
Mean weight (g)	38.74	85.41	109.90	159.43	251.17	303.84			105.38

Target strength estimation based on formula: TS= 20.0 log (L) – 71.9

Table 7.3.2.2. *NSS herring. Summary of acoustic estimates by age in autumn 1999-2021. TSN and TSB are total stock numbers (10^9) and total stock biomass (10^3 tons) 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	0.986	31.0	0.051	2.0			49.795	749.0
2000	14.731	383.0	11.499	560.0					26.230	943.0
2001	0.525	12.0	10.544	604.0	1.714	160.0			12.783	776.0
2002	**No data**									
2003	99.786	3090.0	4.336	220.0	2.476	326.0			106.597	3636.0
2004	14.265	406.0	36.495	2725.0	0.901	107.0			51.717	3252.0
2005	46.380	984.0	16.167	1055.0	6.973	795.0			69.520	2833.0
2006	1.618	34.0	5.535	398.0	1.620	211.0			8.773	643.0
2007	3.941	148.0	2.595	218.0	6.378	810.0	0.250	46.0	13.164	1221.0
2008	0.030	1.0	1.626	77.0	3.987*	287*	3.223*	373*	8.866*	738*
2009	1.538	48.0	0.433	52.0	1.807	287.0	1.686	393.0	5.577	815.0
2010	1.047	35.0	0.315	34.0	0.234	37.0	0.428	104.0	2.025	207.0
2011	0.095	3.0	1.504	106.0	0.006	1.0			1.605	109.0
2012	2.031	36.0	1.078	66.0	1.285	195.0			4.394	296.0
2013	7.657	202.0	5.029	322.0	0.092	13.0	0.057	9.0	12.835	546.0
2014	4.188	62.0	1.822	126.0	6.825	842.0	0.162	25.0	13.011	1058.0
2015	1.183	6.0	9.023	530.0	3.214	285.0	0.149	24.0	13.569	845.0
2016	7.760	131.0	1.573	126.0	3.089	389.0	0.029	6.0	12.452	652.0
2017	34.950	820.0	2.138	141.0	3.465	412.0	0.982	210.0	41.537	1583.0
2018	**No data**									
2019	13.650	172.0	0.209	15.1	6.000	756.0	1.600	487.0	21.460	1430.0
2020			0.231	13.0	1.816	189.0	11.59*	2796*	13.636*	2998*
2021	1.410	80.8	0.120	10.1	0.360	39.5	0.720	144.7	2.610	275.1
Average	15.280	368.5	5.390	353.8	2.610	307.2	1.740	384.8	23.440	1219.3

* in mix with Kanin herring in the south-eastern part of the coverage 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 were observed in the western part of the Barents Sea, in particular along the continental shelf slope (Figure 7.4.1.1).

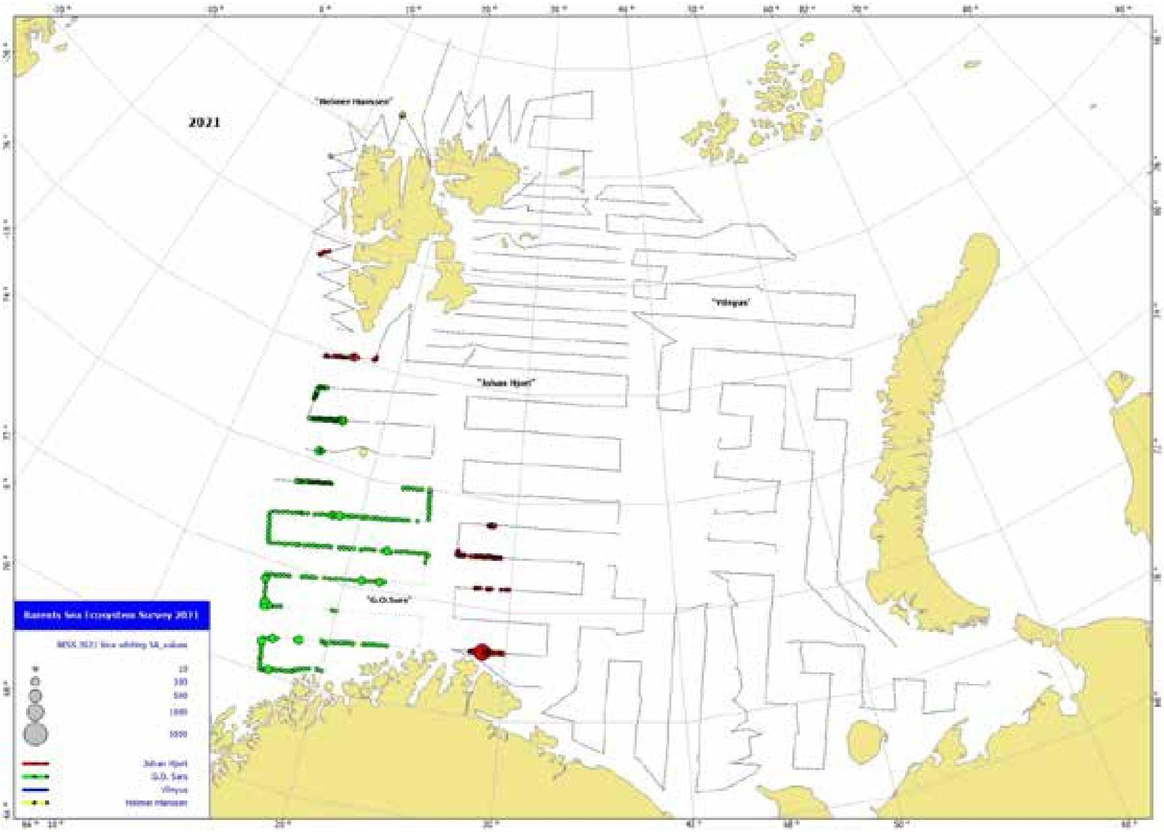


Figure 7.4.1.1. *Geographical distribution of blue whiting (*Blue whiting*) in autumn 2021 based on acoustic recordings. Circle sizes correspond to s_A values (m^2/nm^2) per nautical mile.*

7.4.2 Abundance by size and age

The estimated total number and biomass of blue whiting in the Barents Sea in the autumn 2021 is shown in table 7.4.2.1, and the time series of abundance estimates is summarized in Table 7.4.2.2.

From 2004-2007 estimated biomass of blue whiting in the Barents Sea was between 200 000 and 350 000 tons (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, but the last four years it has been lower than average. This year estimated biomass was similar to the estimates from 2018 and 2019.

The 2020 year class (1-year olds) dominated in both abundance and biomass and the abundance is above the long term average. The abundance of the other age groups is below average (Table 7.4.2.1).

Table 7.4.2.1 *Blue whiting. Acoustic estimate in the Barents Sea in August-October 2021.*

Length (cm)	Age/year class												Sum 10^6	Biomass 10^3 t	Mean weight (g)
	0	1	2	3	4	5	6	7	8	9	10	16			
	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2006			
16-17	0.0	0.1											0.1	0.0	20.0
17-18	1.6	10.1											11.8	0.3	26.2
18-19	7.7	47.4											55.1	1.7	31.1
19-20	5.0	23.3											128.3	4.8	37.6
20-21		30.9											130.9	5.9	44.8
21-22		67.8	1.8										69.6	3.7	52.9
22-23		22.4	4.4										26.8	1.7	61.5
23-24			15.6										15.6	1.1	72.8
24-25		3.7	11.8	7.0									22.4	1.8	82.4
25-26			11.6	4.8	3.4								19.8	1.9	95.4
26-27			10.2	5.2			2.1						17.5	1.9	109.9
27-28			2.1	10.3									12.4	1.5	122.5
28-29				7.4	3.9								11.4	1.6	140.2
29-30				0.4	2.6	4.3	3.7						11.0	1.7	154.2
30-31				4.2	0.8		3.6	1.2					9.8	1.7	172.7
31-32							5.7	3.2			1.8		10.7	2.0	186.5
32-33						0.7	3.1	8.0	0.3				12.1	2.5	209.7
33-34						1.9	2.8	3.7	1.2	0.8			10.4	2.4	227.2
34-35						0.7	1.6	0.6	1.2				4.0	1.0	255.6
35-36							0.3	0.4	0.9	1.2			2.8	0.7	262.9
36-37										0.4			0.4	0.1	313.8
37-38							0.0	0.2		0.0		0.5	0.7	0.2	325.8
38-39															
39-40											0.3		0.3	0.1	350.0
41-42												0.0	0.0	0.0	431.0
TSN 106	14.3	405.8	57.5	39.3	10.7	7.6	22.9	17.3	3.6	2.4	2.1	0.5	583.9		
TSB 103 t	0.4	17.2	5.0	4.7	1.4	1.4	4.2	3.7	0.8	0.5	0.4	0.2		40.4	
Mean length (cm)	18.7	20.0	24.4	26.8	27.7	31.0	31.0	32.3	33.9	34.4	32.5	37.4			
Mean weight (g)	35.5	43.5	86.2	20.1	33.1	87.6	84.2	213.3	238.4	249.1	203.4	320.1			69.3

Target strength estimation based on formula: TS=20 log (L) - 65.2

Table 7.4.2.2 *Blue whiting. Acoustic estimates by age in autumn 2004-2021. TSN and TSB are total stock numbers (10^6) and total stock biomass (10^3 tons).*

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		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
2020	110	5	19	2	11	1	56	11	196	18
2021	406	17	58	5	39	5	67	13	584	40
Average	337	17	248	21	309	29	357	87	1169	113

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

Note:«+» <0.5

Table 7.4.2.3 *Summary of stock size estimates for Blue whiting in 2020-2021.*

Year class		Age	Numbers (10^6)		Mean weight (g)		Biomass (10^3 t)	
2020	2019	1	405.8	110.1	43.5	42.5	17.2	4.7
2019	2018	2	57.5	19.0	86.2	83.6	5.0	1.6
2018	2017	3	39.3	10.9	120.1	92.0	4.7	1.0
2017	2016	4+	67.0	56.1	190.7	197.6	12.7	11.1
Total stock in:								
2021	2020	Total	583.9	196.1	69.3	93.6	40.4	18.4

8 COMMERCIAL DEMERSAL FISH

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

This section provides data on the abundance and distribution for the most abundant commercial demersal fish species. Indices (number and biomass) calculated using Biofox for these species except cod and haddock are presented in Table 8.1 and 8.2. Abundance indices by age based on the BESS data are used in annual assessments of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) and are given in Table 8.3 and 8.4. AFWG also uses length-based indices from this survey for deep-water redfish (*Sebastes mentella*), Golden redfish (*S. norvegicus*) and Greenland halibut (*Reinhardtius hippoglossoides*) but they are calculated by other methods than Biofox.

Table 8.1. *Abundance (N, 10^6 individuals) and species biomass (B, 10^3 tonnes) of demersal species assessed by AFWG (except cod and haddock and not including 0-group).2018 * poor coverage in the eastern Barents Sea, indices only calculated for saithe and redfish. Biofox calculations.*

	Saithe		Golden redfish		Deep-water redfish		Greenland halibut	
Year	N	B	N	B	N	B	N	B
2004	36	40	13	9	263	104	182	39
2005	31	26	23	11	330	137	335	56
2006	28	49	16	16	526	219	430	77
2007	70	98	20	11	796	183	296	86
2008	3	7	42	17	864	96	153	76
2009	33	29	12	11	1003	213	191	90
2010	5	9	22	4	1076	112	186	150
2011	9	10	14	5	1271	105	175	88
2012	14	13	32	8	1587	196	209	86
2013	18	33	75	20	1608	256	160	94
2014	3	6	45	13	927	208	43	53
2015	105	153	9	5	894	214	79	52
2016	58	54	34	24	1527	319	82	40
2017	282	193	34	18	1705	212	134	74
2018*	30	24	73	21	1298	260		
2019	58	80	27	21	1126	313	166	61
2020	291	301	26	8	1086	291	276	55
2021	130	151	21	14	1701	191	141	56
Mean	67	71	30	13	1088	202	190	73

Table 8.2. *Abundance (N, 10^6 individuals) and species biomass (B, 10^3 tonnes) of abundant demersal species not assessed by AFWG (not including 0-group). 2018 * poor coverage in the eastern Barents Sea, indices not calculated. Biofox calculations.*

	Plaice		Long rough dab		Atlantic wolffish		Spotted wolffish		Northern wolffish	
Year	N	B	N	B	N	B	N	B	N	B
2004	53	43	2951	306	15	7	12	31	3	26
2005	19	11	2753	272	16	6	11	26	3	26
2006	36	19	3705	378	26	11	12	46	2	19
2007	120	55	5327	505	42	11	12	42	3	25
2008	57	29	3942	477	25	14	13	51	3	22
2009	21	13	2600	299	20	8	9	47	3	31
2010	34	21	2520	356	17	17	7	37	3	25
2011	36	26	2507	322	20	13	9	47	6	42
2012	21	13	4563	584	22	9	13	83	8	45
2013	36	29	4932	565	27	30	13	84	12	52
2014	170	121	3046	413	12	12	8	51	6	34
2015	107	79	3624	438	33	37	12	86	9	63
2016	37	29	3369	402	40	24	13	40	8	51
2017	17	19	4604	538	30	29	14	63	8	63
2018*										
2019	146	101	3627	472	37	20	15	51	13	76
2020	94	37	3443	454	44	27	22	55	13	65
2021	195	106	3688	396	42	28	17	37	7	59
Mean	71	44	3600	422	28	18	12	52	6	43

Table 8.3 *Bottom trawl indices (10^6 individuals) for cod calculated with Biofox. The indices are used in stock assessment. *adjusted for lack of coverage in the northern (2014) and eastern (2018) Barents Sea– bold: indices not used for assessment due to lack of survey coverage.*

Year/age	1	2	3	4	5	6	7	8	9	10	11	12+
2004	330.6	329.7	147.7	421.5	150.2	79.8	40.2	10.1	2.2	0.5	0.1	0.2
2005	440.7	146.6	216.6	55.8	100.9	28.0	15.6	5.7	1.2	0.5	0.1	0.1
2006	479.0	509.7	186.1	205.6	59.9	69.8	17.6	8.1	2.6	0.6	0.2	0.0
2007	333.3	505.4	586.2	159.2	79.1	24.6	26.9	6.0	2.2	0.9	0.1	0.2
2008	130.9	372.6	652.6	483.4	132.3	51.1	12.8	17.5	3.3	0.9	0.2	0.4
2009	569.7	93.5	202.3	280.6	289.6	101.7	31.9	12.7	7.3	2.6	0.8	0.5
2010	310.3	84.2	56.8	177.0	397.2	424.9	142.7	38.5	10.5	6.8	1.6	0.6
2011	509.8	160.0	123.6	101.5	240.2	300.4	178.4	32.3	7.7	1.8	1.3	0.9
2012	1454.3	255.9	229.1	146.4	70.0	150.8	165.2	84.5	12.7	4.4	1.6	2.1
2013	914.2	659.0	249.1	183.6	125.7	63.2	118.2	130.2	53.8	9.1	3.3	2.5
2014	**308.2**	**155.1**	**190.0**	**108.6**	**93.9**	**52.8**	**30.4**	**50.2**	**36.3**	**12.1**	**3.4**	**2.4**
2014 *	**339.0**	**184.0**	**226.3**	**122.2**	**103.4**	**67.7**	**42.1**	**81.3**	**78.9**	**28.1**	**4.7**	**2.8**
2015	725.3	154.0	174.4	225.2	141.3	72.6	48.6	26.2	35.3	26.6	7.9	2.7
2016	350.8	341.3	77.2	93.7	121.6	70.1	44.4	27.2	13.8	13.2	5.4	3.0
2017	757.5	260.6	375.0	141.5	104.9	120.9	62.6	28.0	11.2	6.4	4.4	7.2
2018*	**2100.3**	**413.8**	**183.6**	**148.9**	**60.0**	**37.6**	**57.1**	**20.2**	**14.4**	**5.8**	**3.6**	**6.3**
2019	560.2	475.2	416.6	232.3	215.1	76.6	42.2	44.4	16.1	4.9	2.2	2.9
2020	66.5	104.7	133.7	134.3	98.6	79.6	31.6	15.7	11.4	2.9	1.1	1.1
2021	61.2	51.8	84.0	100.0	80.3	46.2	33.6	12.5	4.7	5.0	2.4	1.4

Table 8.4 *Bottom trawl indices (10^6 individuals) for haddock calculated with Biofox. The indices are used in stock assessment. * indices not used for assessment due to lack of survey coverage*

Year/age	1	2	3	4	5	6	7	8	9	10	11	12+
2004	189.0	268.5	123.4	70.3	69.1	31.5	3.0	1.7	0.0	0.1	0.0	0.1
2005	603.8	114.2	324.6	89.5	30.4	32.2	15.0	0.5	0.7	0.2	0.1	0.2
2006	2270.2	929.1	107.5	124.6	41.6	19.0	17.5	7.3	0.8	0.5	0.1	0.1
2007	988.4	1818.9	1282.9	88.5	90.4	19.2	5.9	7.1	1.9	0.9	0.2	0.2
2008	322.0	1291.9	1154.9	406.0	43.1	35.5	4.9	2.5	2.3	0.3	0.0	0.0
2009	134.8	143.8	650.7	619.1	305.9	21.0	6.5	0.9	0.5	0.0	0.0	0.0
2010	274.4	65.1	184.0	865.3	666.4	147.7	15.8	2.7	0.0	0.1	0.1	0.3
2011	105.3	113.6	40.4	73.8	392.9	301.4	37.4	3.0	0.3	0.1	0.0	0.2
2012	591.1	41.5	92.5	20.3	67.6	214.1	152.0	12.7	0.3	0.2	0.0	1.5
2013	155.9	223.0	25.8	65.2	19.6	50.8	150.1	76.4	7.0	0.4	0.0	0.2
2014	264.8	75.1	261.6	40.8	70.2	25.8	60.5	85.8	18.0	1.4	0.2	0.0
2015	320.0	145.2	42.1	213.6	25.1	37.1	20.6	47.9	33.8	8.6	0.2	0.2
2016	793.8	144.9	209.3	34.4	184.1	48.0	56.8	40.4	65.8	47.5	11.8	0.9
2017	935.8	189.3	70.3	70.3	11.5	20.5	4.0	4.0	5.4	4.4	4.8	0.7
2018*												
2019	379.4	585.3	897.0	160.7	38.1	15.1	5.3	5.0	1.9	2.1	2.1	5.6
2020	26.8	57.8	204.1	341.4	58.8	4.9	2.0	0.8	0.2	0.7	0.1	0.5
2021	107.8	35.9	129.6	346.8	329.0	32.3	5.4	0.9	0.3	0.6	0.4	0.1

8.1 Cod (*Gadus morhua*)

At the time of the 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. 8.1.1), except in some station in the north-eastern part of Svalbard (Spitsbergen), and the stations furthest northeast.

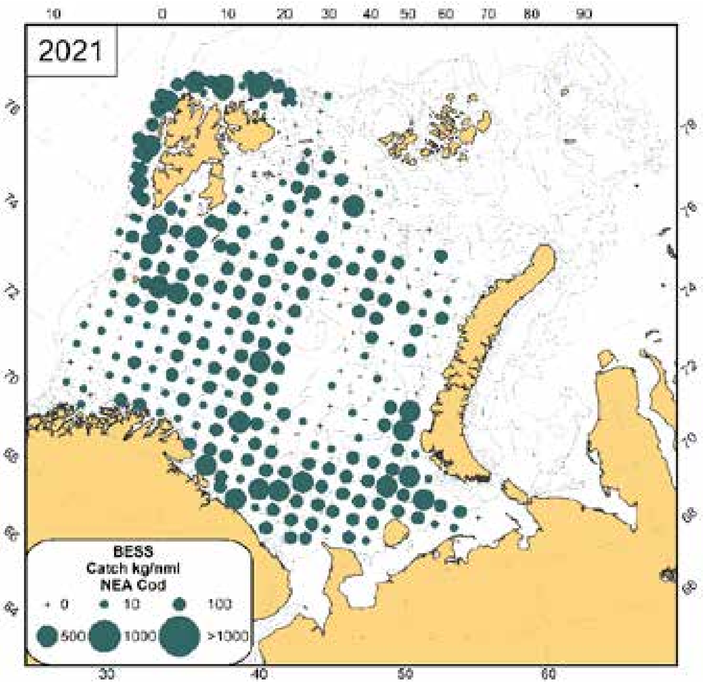


***Figure 8.1.1** Distribution of cod (*Gadus morhua*), August-October 2021*

3.2 Haddock (*Melanogrammus aeglefinus*)

Within the area surveyed, the haddock distribution in 2021 was similar to distribution in 2020 and concentrated in the Atlantic water masses. Main concentrations of haddock were found along the Murman coast (Fig.8.2.1).

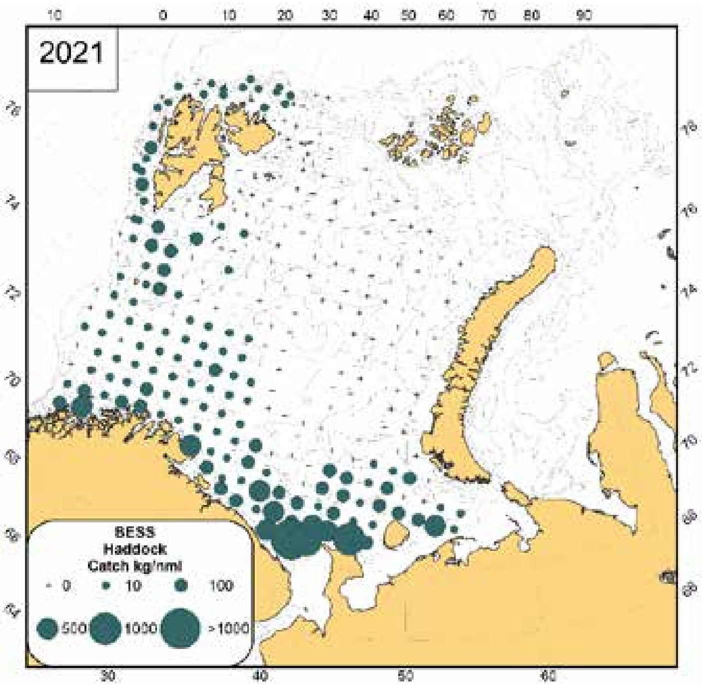


Figure 8.2.1 *Distribution of haddock (*Melanogrammus aeglefinus*), August-October 2021*

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. 8.3.1). High catch rates were found in the south-west. The abundance and biomass in 2021 was above the mean from 2004-2021, but lower than the indices in 2020 (Table 8.1).

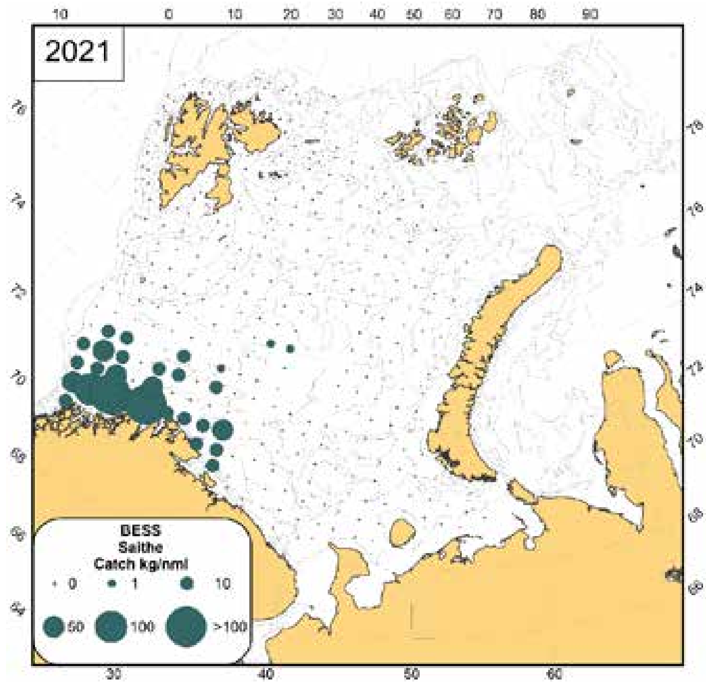


Figure 8.3.1 *Distribution of saithe (*Pollachius virens*), August-October 2021*

8.4 Greenland halibut (*Reinhardtius hippoglossoides*)

BESS covers mainly an area where young Greenland halibut is found, including the nursery area in the northern most part. The adult component of the stock is mainly distributed outside the ecosystem survey area, i.e. on the western slope. However, in recent years larger Greenland halibut has increasingly been registered in the deep-water central parts of Barents Sea.

As in previous years, 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 was similar. The main concentrations of G. halibut were observed around Svalbard (Spitsbergen), and in the Bear Island Trench.

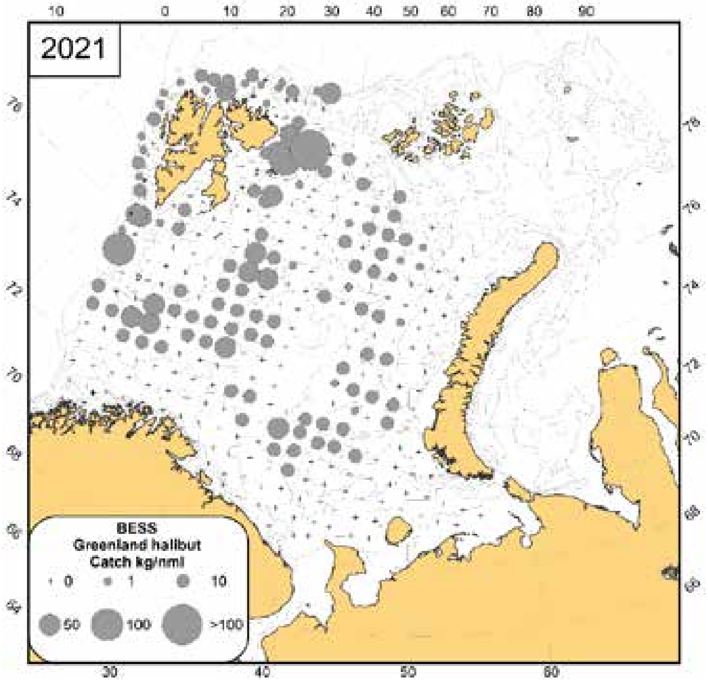


Figure 8.4.1 *Distribution of Greenland halibut (*Reinhardtius hippoglossoides*), August-October 2021*

8.5 Golden redfish (*Sebastes norvegicus*)

In 2021, abundance for golden redfish was concentrated along the coast of the Troms region in Norway and along the Murman coast with greater abundances off the Norwegian coast than in 2020 (Fig. 8.5.1). In the north, the centre of abundance was further south and was similar to 2020, west of Svalbard (Spitsbergen) rather than north-west as in 2019.As in earlier years observations in the eastern Barents Sea, were few and of low abundance. The abundance index was lower than in 2020, and lower than the mean or 2004-2021, whereas the biomass index was similar to the mean 2004-2021, and higher than in 2020 (Table 8.1)

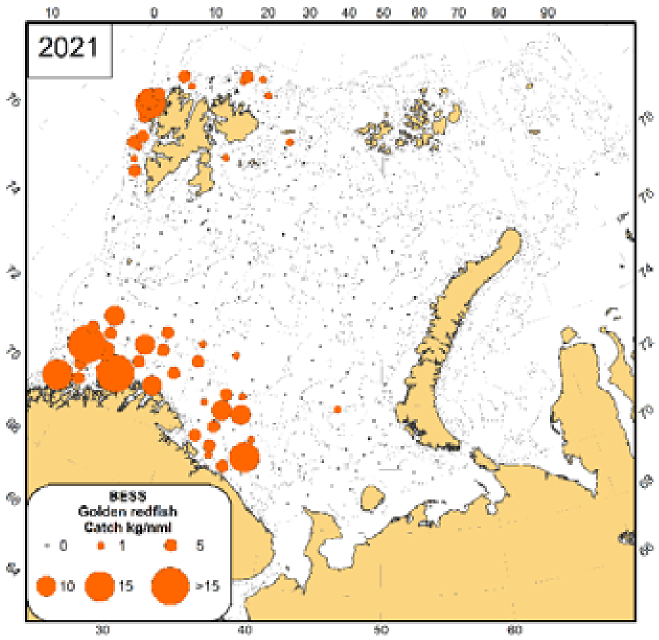


Figure 8.5.1 *Distribution of golden redfish (*Sebastes norvegicus*), August-October 2021*

8.6 Deep-water redfish (*Sebastes mentella*)

Observations of deep-water redfish were very much like the previous year, except west and south-west of Spitsbergen where catches were considerably more common and also higher than prior to 2020. As in previousyears, deep-water redfish were only absent from an area north of Bear Island and the south- eastern part of the Barents Sea. (Fig. 8.6.1). The catches in the area south and south-east of Bear Island and along the Bear Island Trench, were lower than in 2020.

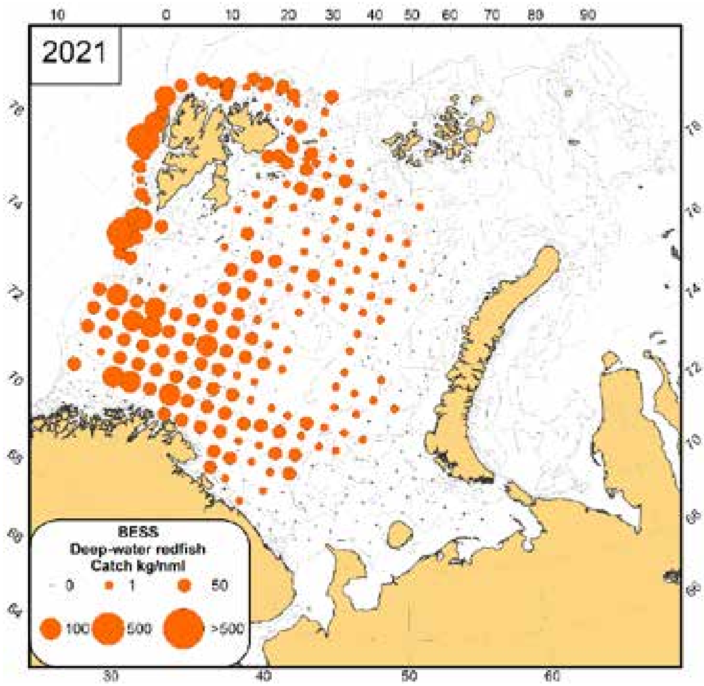


***Figure 8.6.1** Distribution of deep-water redfish (*Sebastes mentella*), August-October 2021*

8.7 Long rough dab (*Hippoglossoides platessoides*)

As usual, long rough dab were found in the entire area surveyed (Fig. 8.7.1) and the distribution is comparable with 2020. The abundance (N) was somewhat higher than in 2020 and the average for 2004-2021, whereas the biomass was lower (Table 8.1)

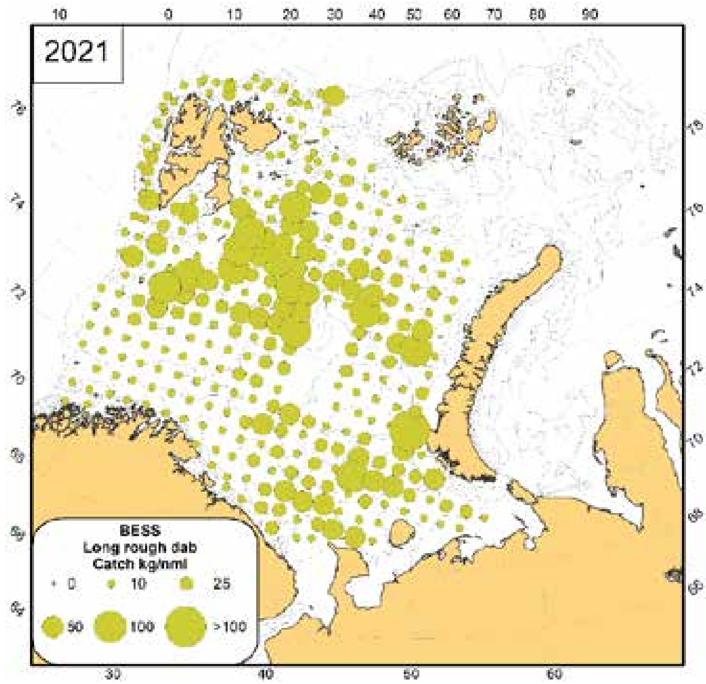


Figure 8.7.1 *Distribution of long rough dab (*Hippoglossoides platessoides*), August-October 2021*

8.8 Plaice (*Pleuronectes platessa*)

Almost the entire Barents Sea distribution area of plaice was covered in 2021 except coastal waters in the Russian Economic Zone. (Fig. 8.8.1). Abundance and biomass indices in 2021 were significantly higher than in 2020 and higher than the average 2004-2021 (Table 8.1).

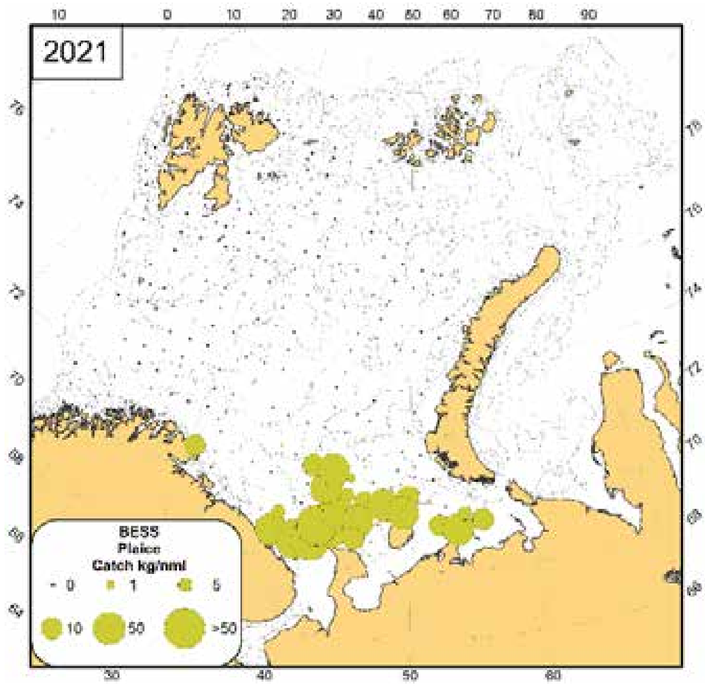


Figure 8.8.1 *Distribution of plaice (*Pleuronectes platessa*), August-October 2021*

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 2020 (Fig 8.9.1) was generally similar to 2021, but higher than the average 2004-2021.

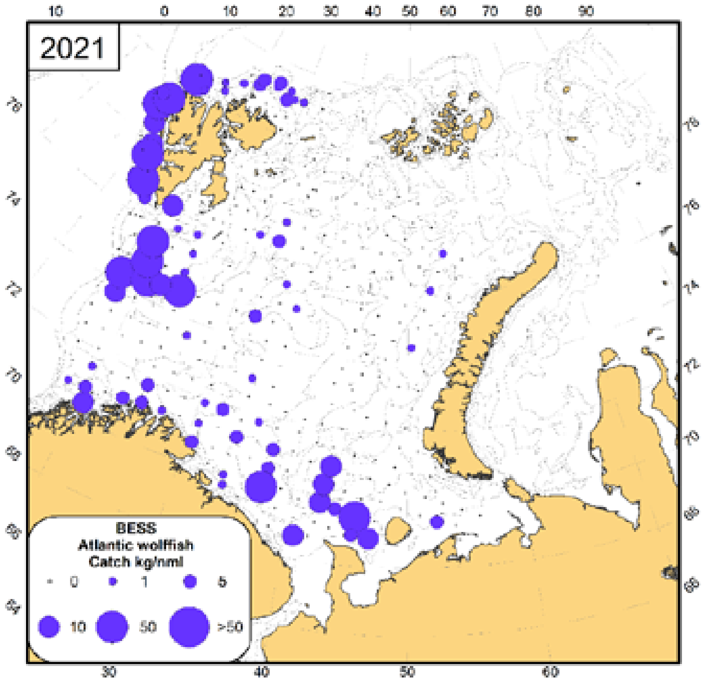


Figure 8.9.1 *Distribution of Atlantic wolffish (*Anarhichas lupus*), August-October 2021*

8.10 Spotted wolffish (*Anarhichas minor*)

Spotted wolffish is the most valuable commercial wolffish species. In 2021 the abundance and biomass of spotted wolffish was somewhat lower than in 2020 and the distribution similar (Fig. 8.10, Table 8.1). Abundance (N) was higher than the mean from 2004-2021, whereas the biomass index was lower.

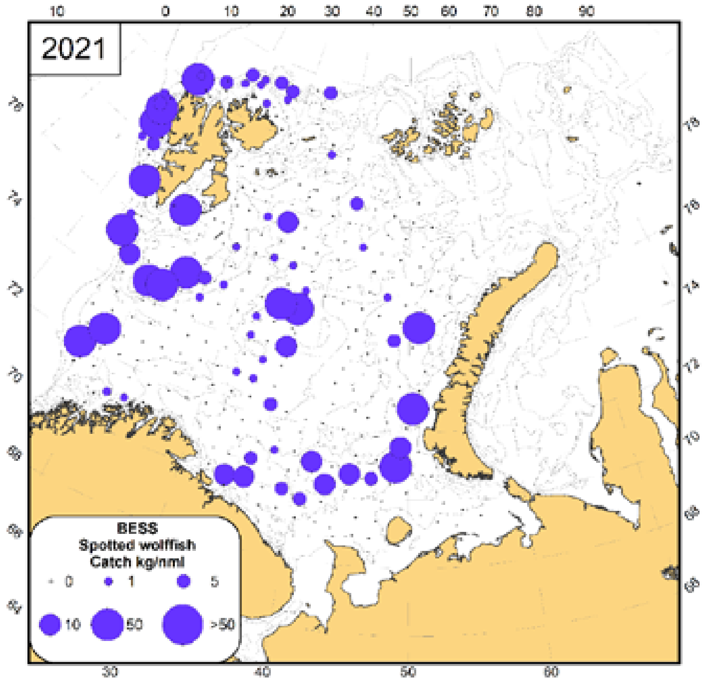


***Figure 8.10.1** Distribution of spotted wolffish (*Anarhichas minor*), August-October 2021*

8.11 Northern wolffish (*Anarhichas denticulatus*)

In 2021 the distribution of northern wolffish was almost the same as in previous years (Fig. 8.11.1). The abundance and biomass were lower than in 2020, and somewhat higher than the mean 2004-2021 (Table 8.1).

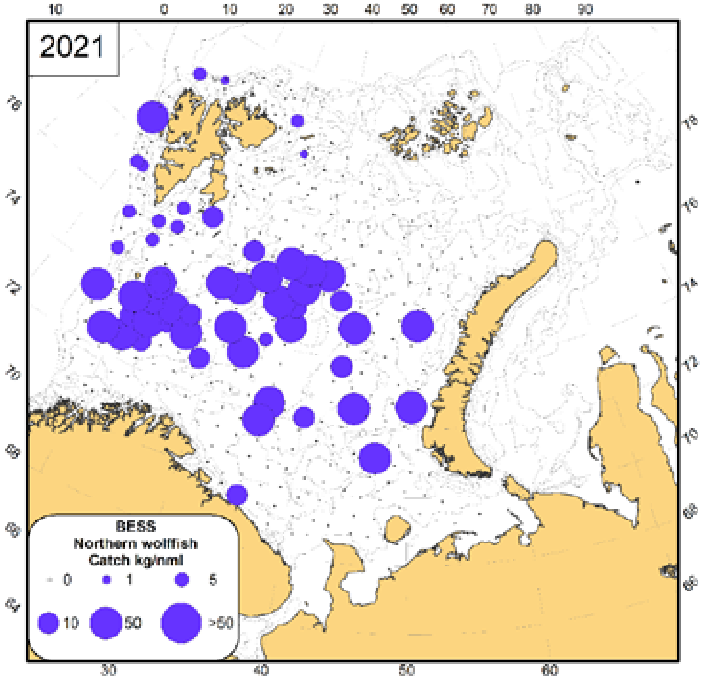


***Figure 8.11.1** Distribution of northern wolffish (*Anarhichas denticulatus*), August-October 2021*

9 FISH BIODIVERSITY

9.1 Small non-target fish species

Text: E. Eriksen, T. Prokhorova, and A. Dolgov
Figures: D. Prozorkevich

Despite the distribution and biology of the non-commercial fish species and their role in the Barents Sea ecosystem being investigated since mid-1990s (e.g. Dolgov, 1995; Wienerrother et al., 2011; Wienerrother et al., 2013 etc), their distribution patterns, abundance and biomass is poorly studied. Since 2012 abundance and biomass of pelagically distributed juveniles of fish species from the families Agonidae, Ammodytidae, Cottidae, Liparidae, Myctophidae and Stichaeidae (called "small fishes" here) were calculated presented in the Survey report.

Abundance and biomass estimates were calculated by different software during the last for decades: SAS (for the new 23 fisheries subareas, 1980-2017), MatLab (for the new 15 WGIBAR-subareas (Fig. 6.2, 1980-2018, WGIBAR, 2018) and R (for the new 15 WGIBAR-subareas (Fig. 9.1.1, 2003-2021). Due to software upgrading (led to challenges with script running in SAS) and personal resource limitation (MatLab), we decided to developed R-scripts (R is free software) for estimation of abundance and biomass indices. Two data sets (abundance and biomass indices calculated by R and SAS) were analyzed for similarities, and were found highly significant (for Agonidae r=0.99, Ammodytidae r=0.98, Liparidae r=0.95 and Cottidae r=0.92), and less significant for Stichaeidae r=0.69). Here, we presented time series for abundance and biomass indices calculated in SAS (1990-2002) and in R (2003-2021), and spatial abundance and biomass indices calculated in R for 2003-2021. Time series for Myctophidae needs more work with database and indices calculation due to non-significant correlation (r= 0.27) between old and new indices.

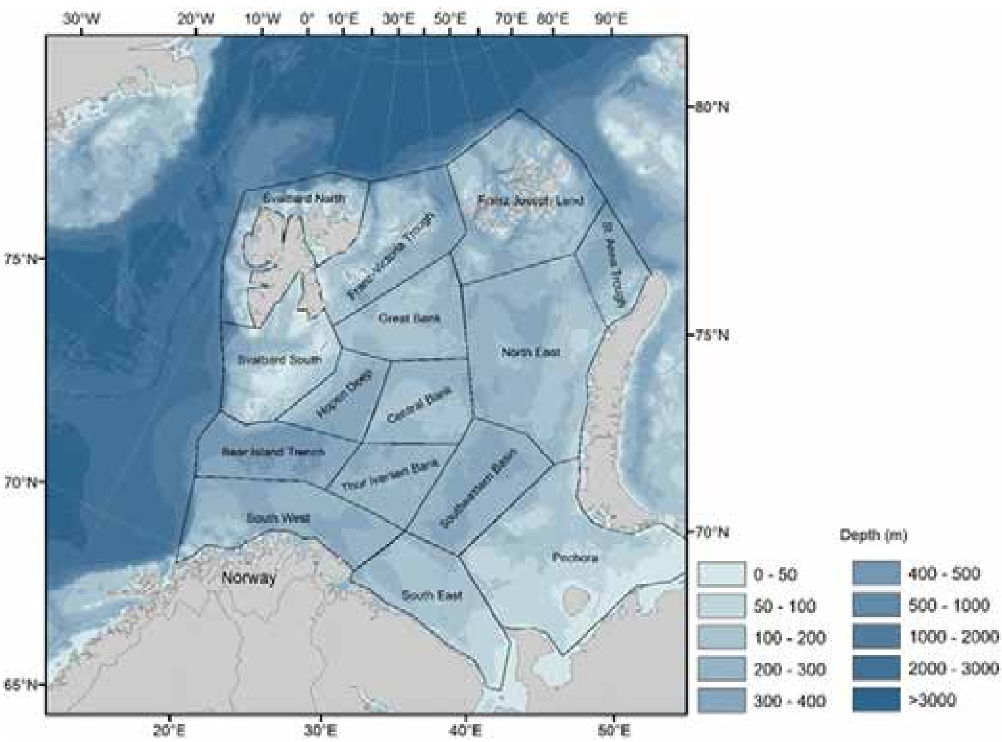


Figure 9.1.1. *Map showing subdivision of the Barents Sea into 15 WGIBAR-subareas (regions) used to calculate estimates of 0-group abundance and biomass based on the BESS.*

In 2021, the total biomass of small fishes (764 tonnes for all these families) was the lowest since 2008 (Table 9.1.1). Total biomass of small fish was dominated by speceis from families Stichaeidae, Liparidae and Ammodytidae.

Composition of small fish biomasses varied between polygons, the south-eastern and south-western polygons dominated by Ammodytidae, the northern and central polygons dominated by Stichaeidae and Liparidae (Fig. 9.1.2).

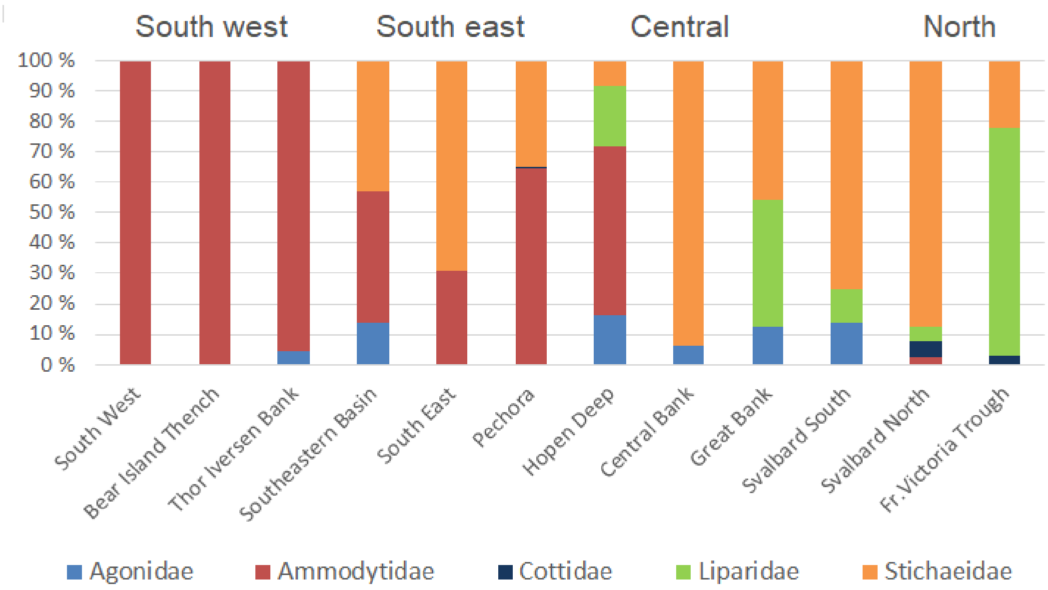


Figure 9.1.2. *Spatial distribution of small-fish biomasses in the WGIBAR-subareas (polygons) in August-September 2021.*

Table 9.1.1. *Abundance indices (AIc, in millions) and biomass (B, in tonnes) of pelagic juveniles of species from families Agonidae, Ammodytidae, Liparidae, Cottidae and Stichaeidae. Long term mean (LTM) for the period 1990-2021 is also presented. Time series for abundance and biomass indices calculated in SAS (1990-2003) and in R (2004-2021).*

Year	Agonidae		Ammodytidae		Cottidae		Liparidae		Myctophidae		Stichaeidae		Total biomass, tonnes
	AIc	B	AIc	B	AIc	B	AIc	B	AIc	B	AIc	B	
1990	37	11	2099	1050	195	58	0	0	40	18	830	415	1552
1991	179	54	1733	866	2799	840	404	141	6	3	1565	783	2686
1992	85	25	1367	683	230	69	36	12	293	132	456	228	1150
1993	10	3	3425	1712	71	21	15	5	1536	691	0	0	2433
1994	808	242	33168	16584	3992	1198	11	4	13	6	0	0	18034
1995	39	12	4562	2281	93	28	2	1	40	18	3	2	2341
1996	117	35	7791	3895	310	93	35	12	274	123	0	0	4159
1997	32	9	3393	1697	282	85	184	65	12	5	1591	796	2656
1998	112	33	471	236	289	87	99	35	14	6	805	403	799
1999	388	116	1630	815	2460	738	865	303	12	5	1062	531	2508
2000	336	101	8549	4274	887	266	464	163	219	98	2129	1065	5967
2001	75	23	1052	526	206	62	97	34	153	69	681	340	1053
2002	20	6	3259	1630	37	11	46	16	17	8	0	0	1670
2003	27	12	389	140	435	216	24	21	0	0	1592	851	1241
2004	256	80	115	221	451	193	315	1214	79	43	1211	598	2350
2005	346	103	13848	18336	1025	620	3715	7216	12	5	1308	796	27075
2006	546	114	21872	11879	923	599	5654	2699	0	0	9234	3255	18546
2007	308	86	200	322	602	290	3544	1298	1	1	1629	864	2861
2008	125	44	258	247	18	12	53	88	40	25	348	185	601
2009	481	71	10579	2736	3188	836	953	274	274	132	4943	2688	6737
2010	275	67	380	168	167	87	280	138	6	6	4952	1539	2004
2011	140	52	955	507	311	144	915	426	4	2	4532	3015	4147
2012	189	64	9067	5033	259	163	1355	741	0	0	9638	4195	10197
2013	8	2	2121	2871	54	32	37	18	0	0	187	73	2996
2014	30	10	787	447	11	6	13	4	0	0	1336	650	1116
2015	65	27	2313	3211	931	527	442	196	0	0	3966	1953	5913
2016	115	40	10850	4129	720	417	2606	815	0	0	2144	968	6371
2017	29	11	2817	6993	4	12	881	153	0	0	553	275	7445
2018	633	259	1449	580	2675	2174	4010	2124	0	0	1382	819	5955
2019	742	220	591	394	1505	646	926	270	0	0	5543	2208	3737
2020	596	129	1934	20950	458	198	4859	2065	0	0	616	404	23747
2021	99	20	410	294	28	17	878	295	0	0	926	434	1059
LTM	**227**	**65**	**4795**	**3616**	**800**	**336**	**1054**	**651**	**95**	**44**	**2036**	**948**	**5660**

Agonidae were represented by atlantic poacher *Leptagonus decagonus*. *L. decagonus* was distributed mostly in the north-western area (Figure 9.1.3). The estimated indices in 2021 showed that their total abundance ($99*10^6$ individuals) and biomass (20 tonnes) was the lowest since 2018 and was lower than long term mean values ($227*10^6$ individuals and 65 tonnes (Table 9.1.1).

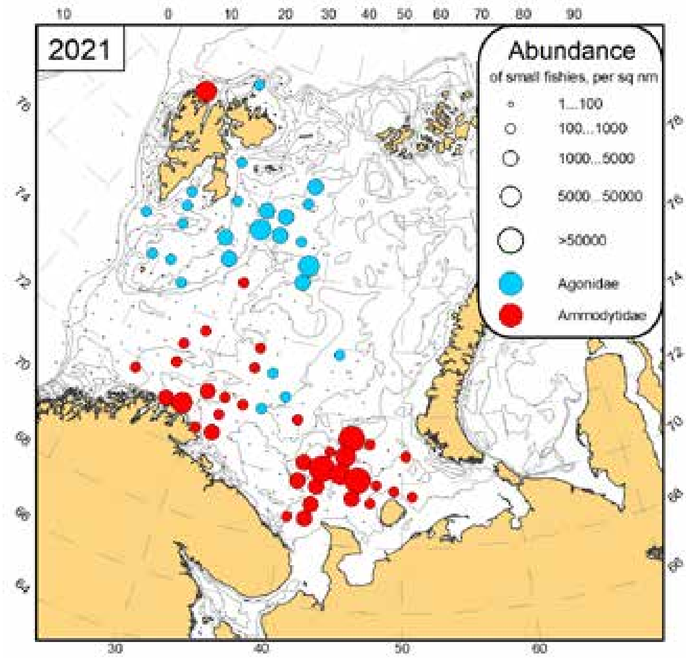


***Figure 9.1.3**. Spatial distribution of Agonidae and Ammodytidae in August-September 2021.*

Abundance and biomass of Agonidae were calculated in R for the period of 2003-2021 for 15 WGIBAR-polygons (Fig. 9.1.1). The highest densities of Agonidae were found in the North East during 2004-2007, 2009, and 2011, in the Great Bank in the 2013, 2016-2017 and in 2021, and in the Central Bank 2008, 2015, 2018-2020 (Fig. 9.1.4).

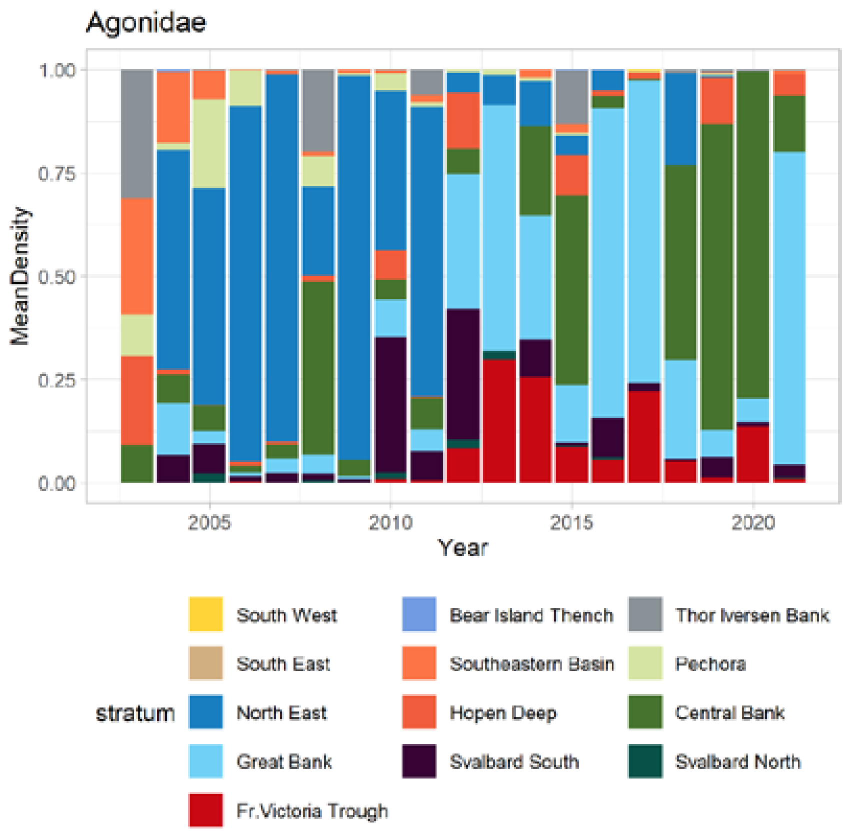


***Figure 9.1.4**.* Spatial distribution of mean polygon densities of Agonidae in August-September 2004-2021.

Ammodytidae were represented by sandeel *Ammodytes marinus* and were observed in the south-central and south-eastern areas (Figure 9.1.3). In 2021, estimated abundance and biomass was half of the than long-term mean and was 410*10^6 individuals and 294 tonnes, respectively (Table 9.1.1).

Total abundance and biomass of Ammodytidae calculated in R for the period of 2003-2021 for 15 WGIBAR-polygons (Fig. 9.1.1). The highest densities of Ammodytidae were found in the Pechora during 2003, 2009, 2011, 2013, 2021, in the Thor Iversen Bank during 2004, 2008, 2012, in the South East during 2005-2006, in the Bear Island Trench during 2007, 2014, 2018, in the Svalbard South during 2015-2017, 2020, and in the Svalbard North during 2019 (Fig. 9.1.5).

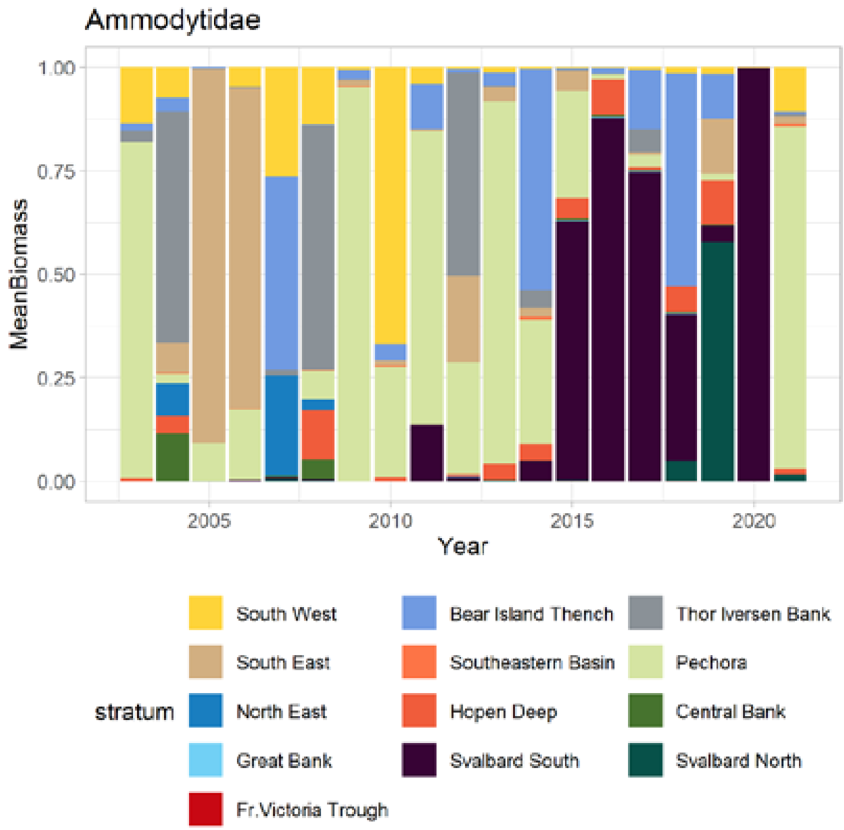


Figure 9.1.5. *Spatial distribution of mean polygon densities of Ammodytidae in August-September 2004-2021.*

Stichaeidae were represented by snakeblenny *Lumpenus lampraetaeformis*, daubed shanny*Leptoclinus maculatus*, and stout eelblenny*Anisarchus medius* (Figure 9.1.6). In 2021, Stichaeidae were observed in the two separated ares in the north west and in the south east. In 2021, total abundance (926*10^6 ind.) and biomass (434 tonnes) of Stichaeidae was higher than in 2020, but lower than the long-term mean values of 2,036*10^6 (abundance) and 948 tonnes (biomass) (Table 9.1.1).

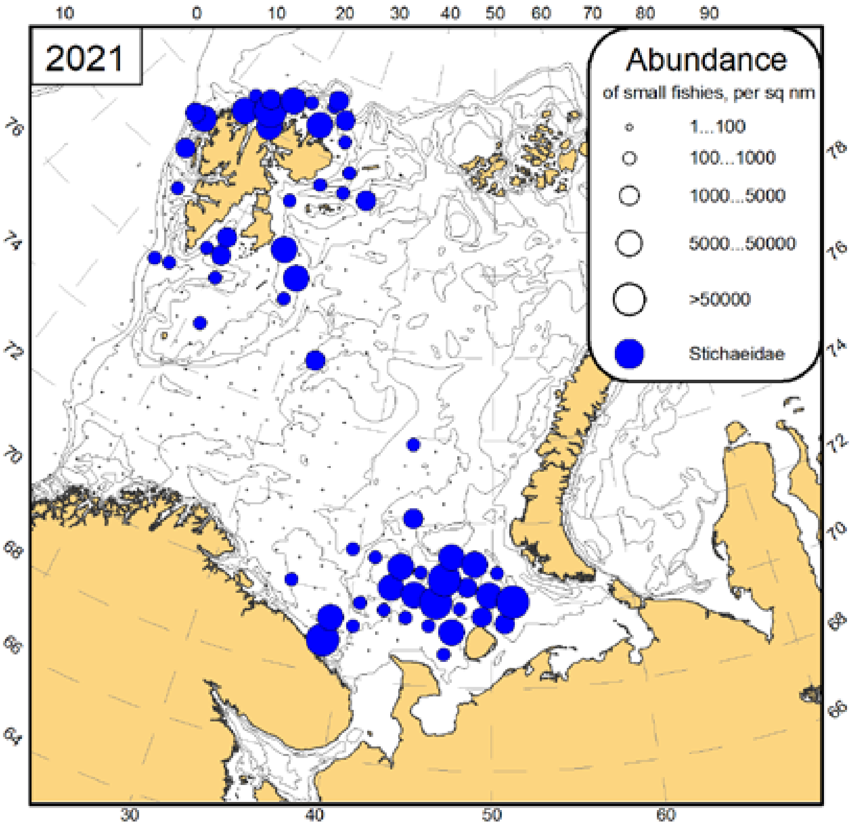


Figure 9.1.6. *Spatial distribution of Stichaeidae in August-September 2021.*

Total abundance of Stichaeidae calculated in R for the period of 2003-2021 for 15 WGIBAR-polygons (Fig. 9.1.1). The highest densities of Stichaeidae were found in the Svalbard North and Svalbard South during almost all years (Fig. 9.1.7). Other polygons contributed to the total abundance in lesser degree.

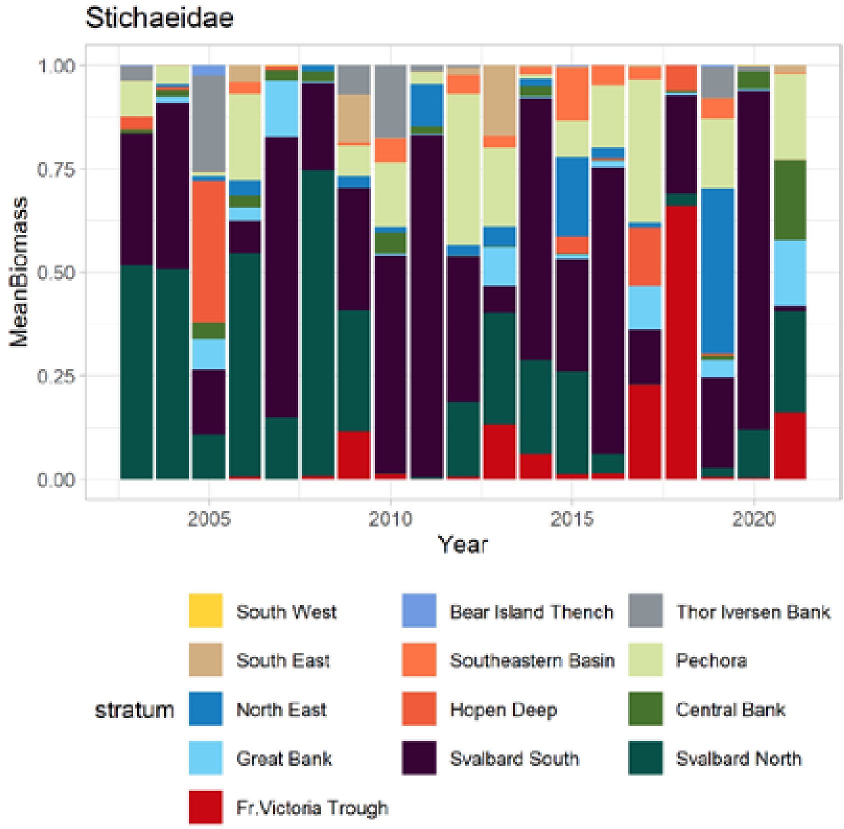


Figure 9.1.7. *Spatial distribution of mean polygon densities of Stichaeidae in August-September 2004-2021.*

Cottidae were mostly represented by shorthorn sculpin *Myoxocephalus scorpius*, bigeye sculpin *Triglops nybelini*, ribbed sculpin *Triglops pingelii* and moustache sculpin*Triglops murrayi*. In 2021, Cottidae were found in the restricted areas in the north west and in the south east, and their distribution was smaller than previous years (Figure 9.1.8). Total abundance ($28*10^6$) and biomass (17 tonnes) was very low and was more 20 times lower than the long term mean values of $800*10^6$ (abundance) and 336 tonnes (biomass) (Table 9.1.1).

Total abundance of Cottidae calculated in R for the period of 2003-2021 for 15 WGIBAR-polygons (Fig. 9.1.1). The highest densities of Cottidae were found in the Svalbard North in 2003-2008 and 2008, in the Great Bank in 20018-2019, and in the Fr. Victoria Trough during almost all years (Fig. 9.1.9). Other polygons contributed to the total abundance in lesser degree.

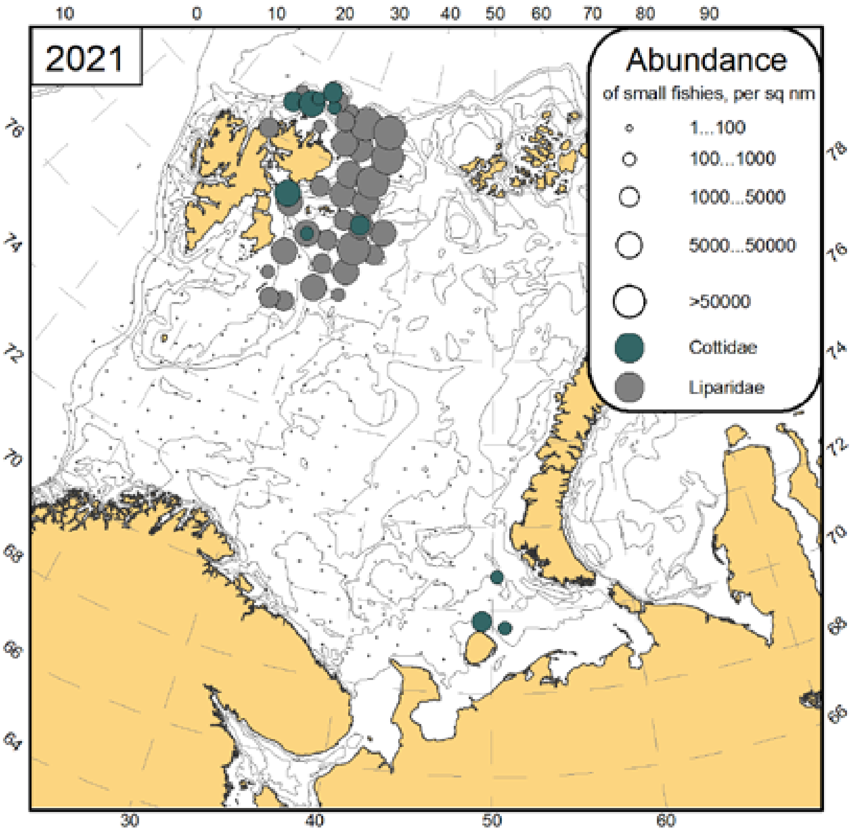


Figure 9.1.8. *Spatial distribution of Cottidae and Liparidae in August-September 2021.*

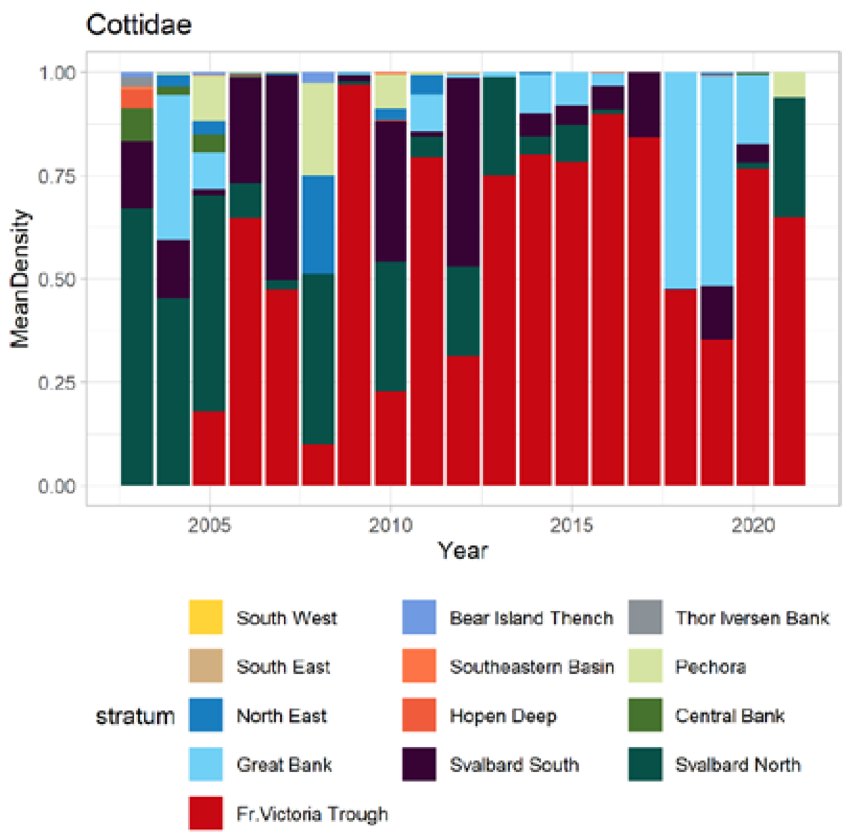


Figure 9.1.9. *Spatial distribution of mean polygon densities of Cottidae in August-September 2004-2021.*

Liparidae were represented by gelatinous snailfish *Liparis fabricii* and nebulous snailfish *Liparis bathyarcticus.* In 2021, Liparidae distributed (Figure 9.1.8) east and north-east for Svalbard (Spitsbergen). In 2021, estimated abundance and biomass were 878*10^6 and 295 tonnes, respectively. That is lower than the long-term mean values (1054*10^6 and 651 tonnes) (Table 9.1.1).

Total abundance of Liparidae calculated in R for the period of 2003-2021 for 15 WGIBAR-polygons (Fig. 9.1.1). The highest densities of Liparidae were found in the Great bank in 2004-2005, 2007 and 2019, and in the Fr. Victoria Trough during almost all years (Fig. 9.1.10). Other polygons contributed to the total abundance in lesser degree.

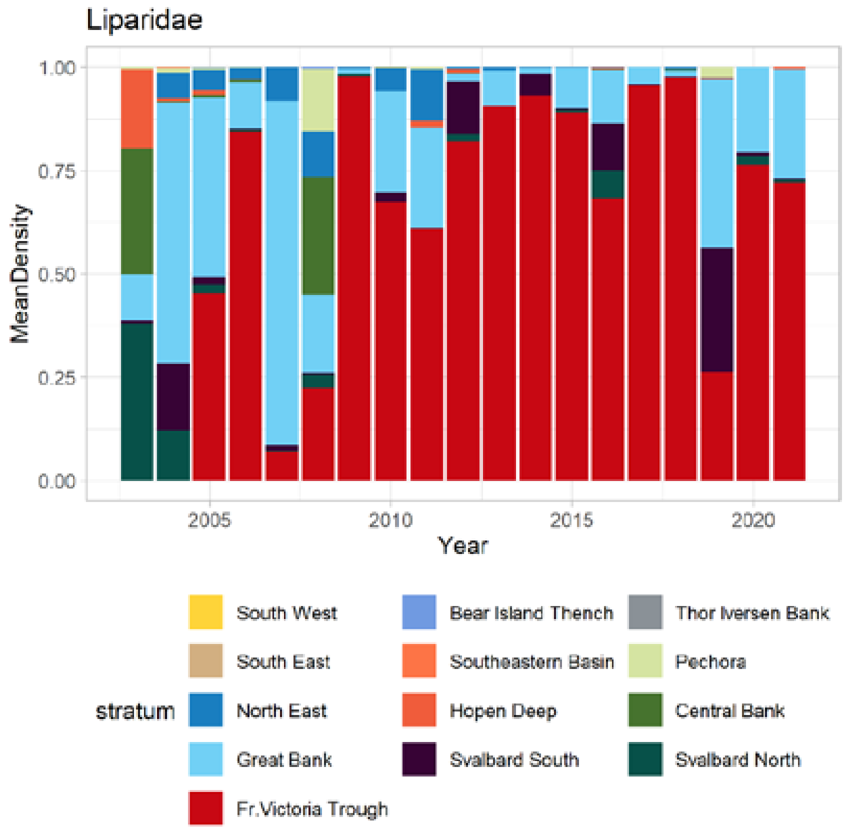


Figure 9.1.10. *Spatial distribution of mean polygon densities of Liparidae in August-September 2004-2021.*

9.2 Fish biodiversity in the demersal compartment

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

Norway pout (*Trisopterus esmarkii*). The distribution of Norway pout in 2021 was approximately the same as in 2020, except their absence in the central-western part of the area in 2021 (Fig. 9.2.1). The highest concentrations of this species were traditionally found in the south-western part of the Barents Sea. The maximum catch of Norway pout in 2021 (79.2 kg/nautical mile) was higher than in 2020 (51.0 kg/nautical mile), but the average catch (0.2 kg/nautical mile) was less than in 2020 (0.4 kg/nautical mile). Total abundance and biomass (330.6 million individuals and 11.6 thousand tonnes respectively) of Norway pout was lower than in 2020 (515.2 million individuals and 14.6 thousand tonnes) and was the lowest since 2006 (Table 9.2.1).

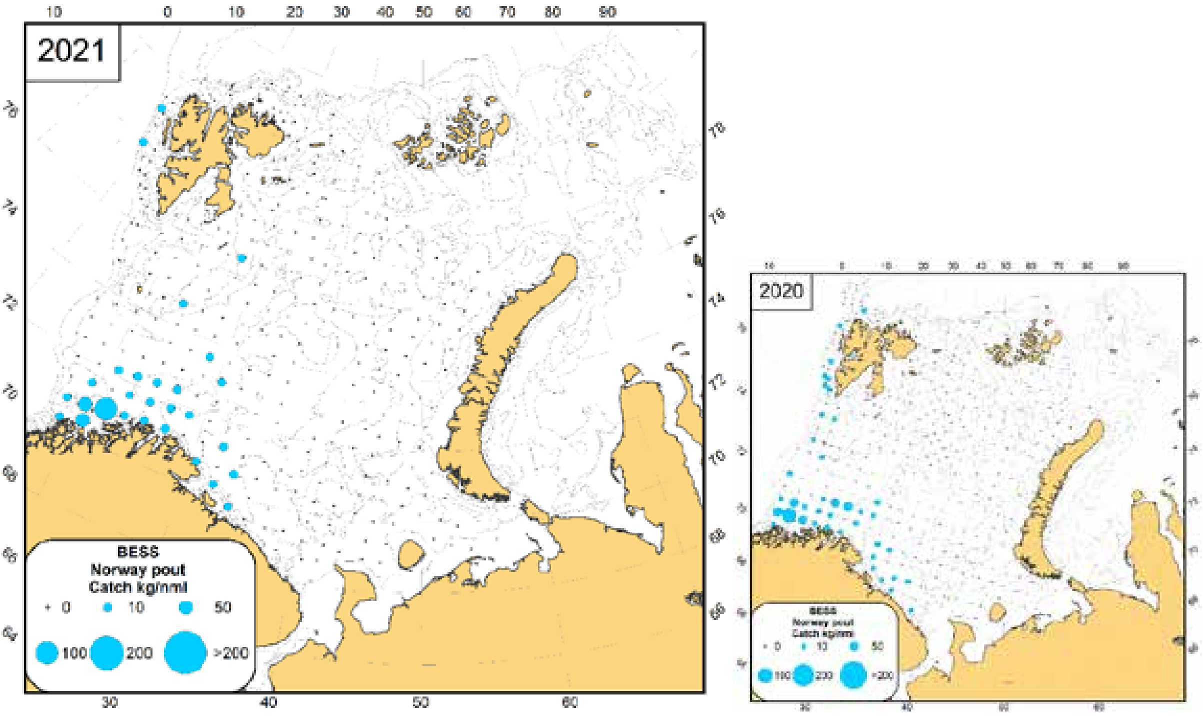


Figure 9.2.1 *Distribution of Norway pout (*Trisopterus esmarkii*), August-September 2021*

Norway redfish (*Sebastes viviparus*). In 2021 Norway redfish was distributed in the same area as in 2020 (Fig. 9.2.2). This species occurred in the south-western area of the survey along the Norwegian coast and in the south-western part of Svalbard (Spitsbergen). Several redfish individuals were also caught in the south-central part of the Barents Sea and off the south-eastern part of Svalbard (Spitsbergen) Archipelago. The maximum catch of Norway redfish in 2021 (178.8 kg/nautical mile) was higher than in 2020 (124.4 kg/nautical mile), but the average catch (0.5 kg/nautical mile) was less than in 2020 (0.8 kg/nautical mile). Total abundance and biomass of this species in 2021 ($131.6*10^6$ individuals and 19.1 thousand tonnes) were less than in 2020 ($155.7*10^6$ individuals and 22.6 thousand tonnes) (Table 9.2.1).

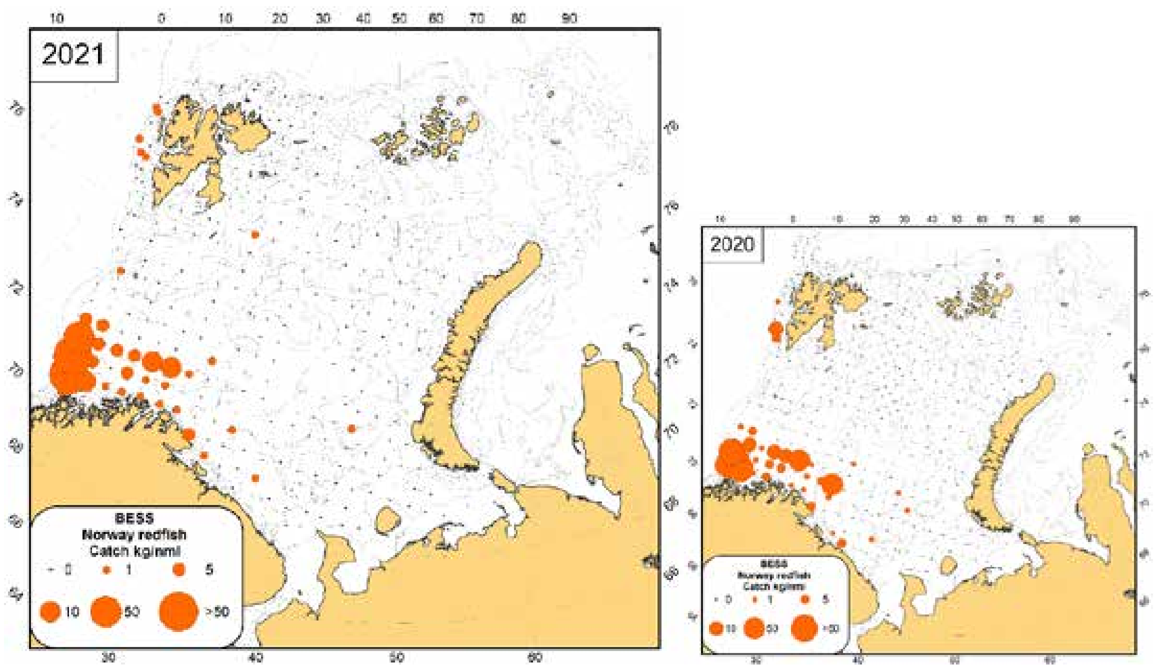


Figure 9.2.2 *Distribution of Norway redfish (*Sebastes viviparus*), August-September 2021*

Table 9.2.1 Total abundance (N, $*10^6$ individuals) and biomass (B, thousand tonnes) of Norway pout and Norway redfish in the Barents Sea in August-October 2006-2021 based on demersal trawls (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
2020	515.2	14.6	155.7	22.6
2021	330.6↓	11.6↓	131.6↓	19.1↓

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 is widely found in the Barents Sea except the most north-eastern areas, while Arctic skate belongs to the Arctic zoogeographic group and is found in the cold waters of the northern area.

In 2021 thorny skate was distributed in the wide area from the north-western to the south-western and south-eastern Barents Sea where warm Atlantic and Coastal Waters dominated (Figure 9.2.3). Thorny skate was observed in 15.9 % of the bottom stations, half as often as in 2020 (32.5 %). Thorny skate was distributed within a depth of 51-613 m, and the highest biomass occurred at depth 51-300 m (81.7 % of total biomass). The mean catch and the average catch in 2021 (0.6 individuals per nautical mile and 0.4 kg per nautical mile) were the lowest in the years 2014-2021 (Table 9.2.2). The estimated total biomass and abundance of thorny skate in 2021 ($30.7*10^6$ individuals and 27.6 thousand tonnes) were also low, and approximately at the same level as in 2016.

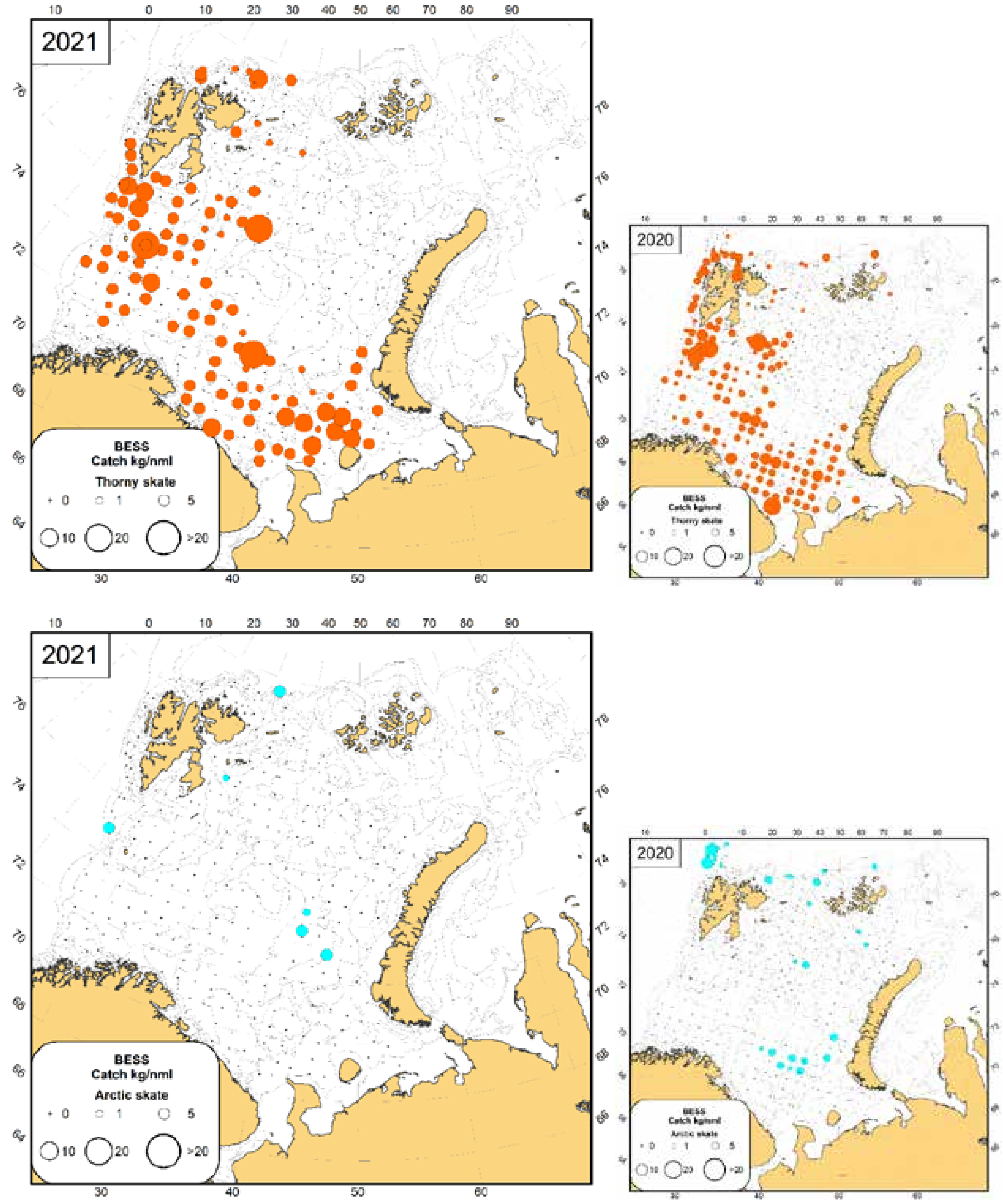


Figure 9.2.3 *Distribution of thorny skate (*Amblyraja radiata*) and Arctic skate (*Amblyraja hyperborea*), August-September 2021*

Table 9.2.2 *Mean catches (abundance N, individuals per nautical mile and biomass (B, kg per nautical mile) and total abundance (N, million individuals) and biomass (thousand tonnes) of thorny skate during BESS 2014-2021*

Year	Mean catch		Total abundance	
	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
2020	0.8	0.7	31.7	31.1
2021	0.6↓	0.4↓	30.7↓	27.6↓

* – 2018 is not included due to the poor survey coverage

Arctic skate was observed only in the 6 bottom stations in 2021 (Figure 9.2.3). This species was distributed at depth of 267-791 m. The mean catch (in terms of biomass and abundance) of Arctic skate in 2021 (0.02 individuals per nautical mile and 0.01 kg per nautical mile) were the lowest for the years 2014-2021 (Table 9.2.3). The estimated total biomass and abundance of Arctic skate in 2021 (0.7 million individuals and 0.6 thousand tonnes) was also the lowest observed (Table 9.2.3).

Table 9.2.3 *Mean catches (abundance N, individuals per nautical mile and biomass B, kg per nautical mile) and total abundance (N, million individuals) and biomass (thousand tonnes) of Arctic skate during BESS 2014-2021*

Year	Mean catch		Total abundance	
	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
2020	0.12	0.11	1.8	1.8
2021	0.02↓	0.01↓	0.7↓	0.6↓

* – 2018 was not included due to the poor survey 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 also observed in the Barents Sea during the ecosystem survey in 2021 (Figure 9.3.1). For example, Arctic flounder *Liopsetta glacialis* occurs in brackish waters, rarely found deeper than about 20 m. In the survey area this species was found in the shoal regions in the south-eastern area.

Black seasnail *Paraliparis bathybius* generally lives at depths below 600 m and temperature below 0 °, and was found in deepwater area on the slope in the north of the Barents Sea. Grey gurnard *Eutrigla gurnardus* which is known in the eastern Atlantic from Marocco northward to Island and Norway, again was caught on the south-western border of the survey area.

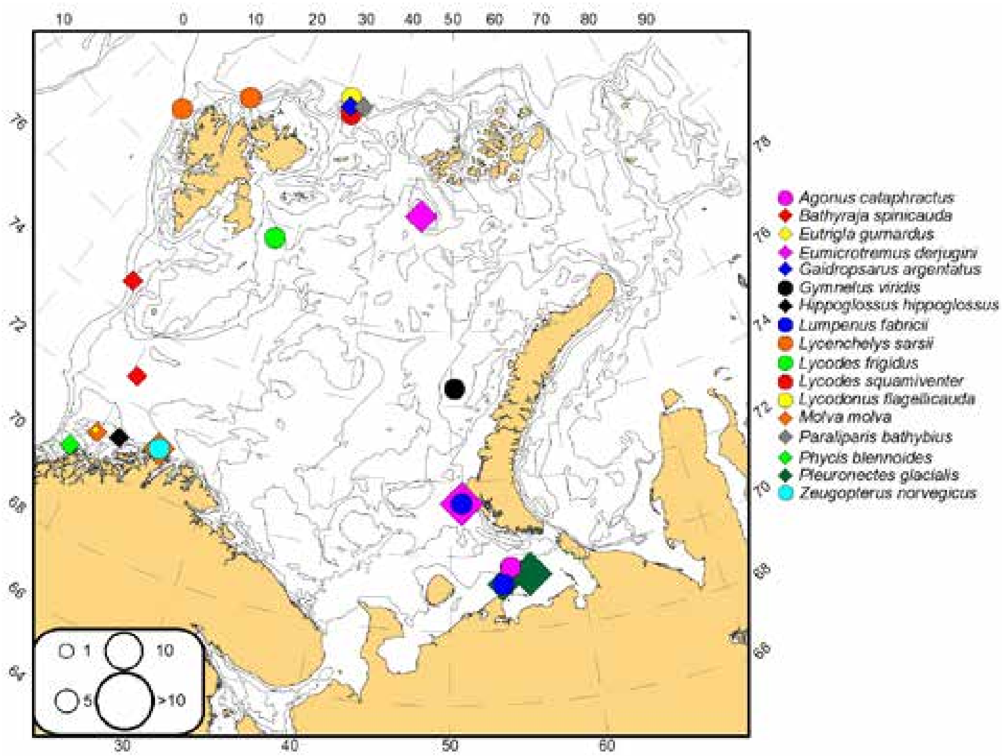


Figure 9.3.1 *Distribution of species which are rare in the Barents Sea and which were found in the survey area in 2021*

9.4 Zoogeographic groups

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

During the 2021 ecosystem survey in total 90 fish species from 29 families were recorded in the catches, and some specimens were only identified to genus or family level. The highest number of species belongs to the families Zoarcidae (14 species), Gadidae (10 species) and Pleuronectidae (10 species). 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). Among the analyzed species most belong to the Arctic (29.9 %), mainly boreal (26.1 %) and boreal (20.9 %) zoogeographic groups.

The median and maximum catches of non-commercial fish from different zoogeographic groups are shown in Tables 9.4.1, 9.4.2.

Widely distributed (only ribbon barracudina *Arctozenus risso* represents this group), **south boreal** (e.g. grey gurnard *Eutrigla gurnardus*, silvery pout *Gadiculus argenteus*, greater forkbeard *Phycis blennoides*) and **boreal** (e.g. lemon sole *Microstomus kitt*, stout eelblenny *Anisarchus medius*, silvery lightfish *Maurolicus muelleri*) species were mostly found in the central, southwestern and western part of the survey area where warm Atlantic and Coastal Waters dominate (Figure 9.4.1). The median and maximum catches of species of the widely distributed and south boreal zoogeographic group in 2021 were less than in 2020 (Table 9.4.1, 9.4.2). The median and maximum catches of species of the boreal zoogeographic group in 2021 were the highest since 2013.

Mainly boreal species (e.g. lesser sandeel *Ammodytes marinus,* snakeblenny *Lumpenus lampretaeformis*, greater eelpout *Lycodes esmarkii*) were widely found throughout the survey area (Figure 4.2.1). The catches of species belonging to the mainly boreal group (median and maximum) in 2021 were higher than in 2020, but still lower than during the period of 2013-2019 (Table 9.4.1, 9.4.2).

Arctic-boreal species (e.g. Atlantic poacher *Leptagonus decagonus*, ribbed sculpin *Triglops pingelii*) were found in the central and northern part of the Barents Sea (Figure 9.4.1). The median and maximum catches of species of the Arctic-boreal zoogeographic group in 2021 were the lowest since 2013 (Table 9.4.1, 9.4.2).

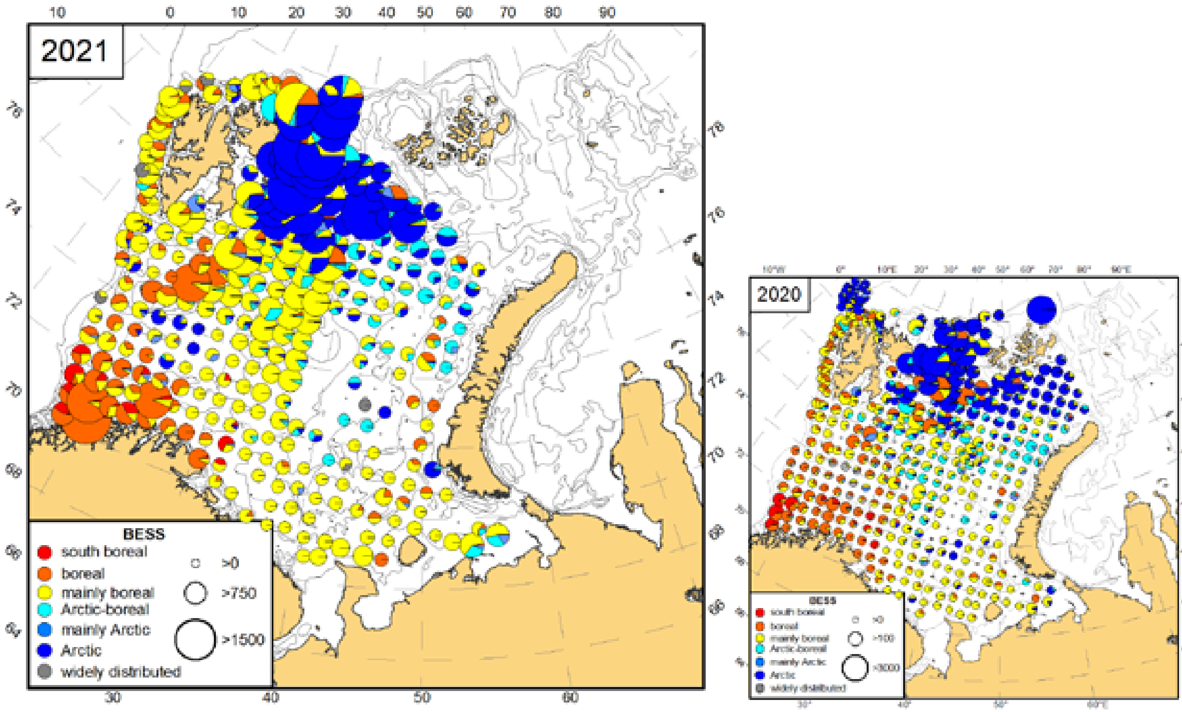


Figure 9.4.1 *Distribution of non-commercial fish species from different zoogeographic groups during the ecosystem survey 2021. The size of circles corresponds to total abundance (individuals per nautical mile, only bottom trawl stations were used, both pelagic and demersal species are included)*

Mainly Arctic (e.g. Arctic flounder *Liopsetta glacialis*, Atlantic spiny lumpsucker *Eumicrotremus spinosus*, slender eelblenny *Lumpenus fabricii*) and **Arctic** (e.g. Arctic alligatorfish *Aspidophoroides olrikii*, pale eelpout *Lycodes pallidus*, leatherfin lumpsucker *Eumicrotremus derjugini*) species were mainly found on the northern 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 and Novaya Zemlya Coastal Water. Median and maximum catches of mainly Arctic species in 2021 were lower than in 2020 (Table 9.4.1). Median and maximum catches of species of these two zoogeographic groups in 2021 were lower than in 2020 (Table 9.4.1, 9.4.2).

Table 9.4.1 *Median catch (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)*

Year	Widely distributed	South boreal	Boreal	Mainly boreal	Arctic-boreal	Mainly Arctic	Arctic
2013	0.2	0.8	7.1	48.9	25.4	10.2	70.8
2014[1]	0.1	0.9	8.7	36.4	8.6	1.7	7.4
2015	0.09	1.2	8.7	71.4	14	1.9	31.5
2016[2]	0.5	1.4	18.3	55.3	8.8	3.3	29.1
2017	0.2	3.2	15	53.7	19.3	4.9	78.5
2019[3]	0.02	2.6	14.2	54.3	15	7.2	108.5
2020	0.1	2.7	17.9	23.7	8.9	1.9	93.7
2021	0.06↓	1.3↓	23.0↑	47.7↑	7.5↓	1.7↓	70.1↓

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

Table 9.4.2 *Maximum catch (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)*

Year	Widely distributed	South boreal	Boreal	Mainly boreal	Arctic-boreal	Mainly Arctic	Arctic
2013	17.1	171.4	230.0	982.5	3326.9	656.3	3013.8
2014[1]	14.3	105.7	478.6	3841.4	371.6	60.9	386.4
2015	10.0	216.3	660.0	1587.1	1502.4	53.8	832.2
2016[2]	36.7	135.0	743.8	2962.5	283.8	123.2	808.6
2017	7.5	372.9	792.9	2945.0	571.3	282.5	2731.1
2019[3]	1.3	312.0	735.6	1406.1	297.5	828.8	2968.8
2020	11.0	357.0	1646.1	464.8	573.1	156.2	6770.6
2021	9.9↓	71.3↓	1788.2↑	751.3↑	268.0↓	80.8↓	2178.3↓

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

The median and maximum catches of species of the boreal zoogeographic group in 2021 were the highest since 2013, while those of the mainly boreal and Arctic-boreal zoogeographic group in 2021 were the lowest since 2013. There is no clear trend in the other zoogeographic groups during the period 2013-2021. Admittedly, differences in spatial survey coverage each year are not accounted. Additional analyzes using regular polygons can help to find some trends and their reasons.

10 COMMERCIAL SHELLFISH

10.1 Northern shrimp (*Pandalus borealis*)

Text by:D. Bakanev, C. Hvingel

Figures by: J. Zhak

During the survey in 2021 341 trawl hauls were completed – 275 of them contained northern shrimp. The biomass of shrimp varied from several grams to 129.1 kg/nml with an average catch of 6.2±0.7 kg nml (Table 10.1.1). Average values are reported with standard error (*SEM)*.

Table 10.1.1. *The catch characteristics of the Northern shrimp (include SEM) during BESS in 2005-2021*

Year	Total number of station	Number of station with shrimp	Mean catch, ind./nml	Mean catch, kg/nml
2005	224	169	1841±290	11.56±1.56
2006	637	480	1907±160	11.69±0.80
2007	551	426	1711±150	10.34±0.72
2008	431	329	1338±138	6.90±0.62
2009	378	310	1220±158	6.06±0.71
2010	319	238	1595±181	9.22±0.98
2011	391	304	1678±175	8.44±0.82
2012	443	325	1653±161	8.72±0.78
2013	487	388	1564±132	8.53±0.66
2014	165	101	933±113	5.05±0.61
2015	334	247	1039±103	5.61±0.52
2016	317	187	800±93	4.14±0.44
2017	339	281	1174±123	6.47±0.64
2018	217	160	1344±180	7.77±1.01
2019	323	254	1486±169	8.61±0.93
2020	461	317	820±106	4.51±0.52
2021	341	275	1137±118	6.22±0.69
Total	6134	4791	1367±150	7.64±0,77

As in previous years the densest concentrations of shrimp in 2021 were registered (Fig. 10.1.1) in central part of the Barents Sea and around Svalbard (Spitsbergen).

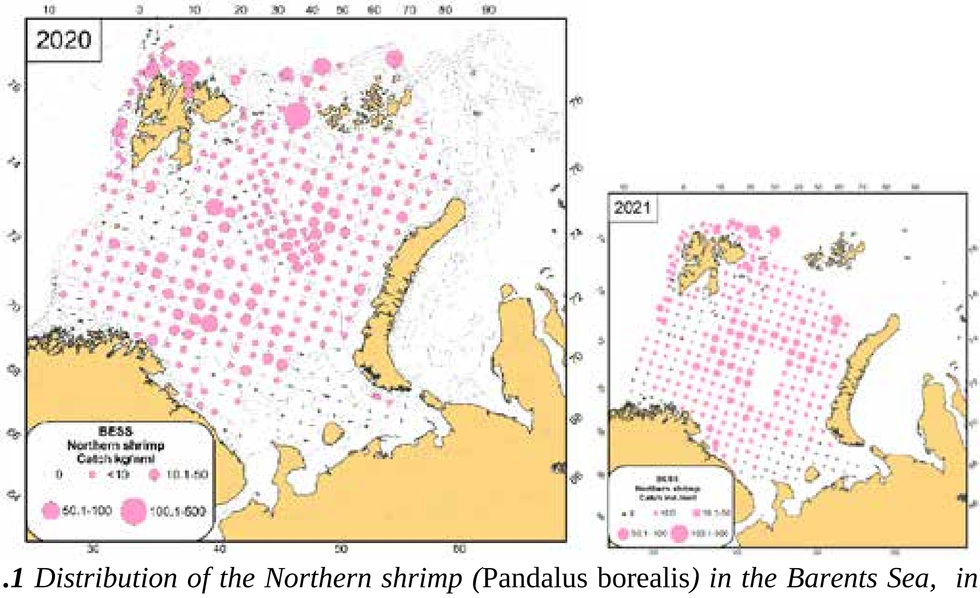


Figure 10.1.1 *Distribution of the Northern shrimp (*Pandalus borealis*) in the Barents Sea, in the Barents Sea in August-October 2020-2021*

Biological analysis of the northern shrimp was conducted in 2021 by Russian scientists in the eastern part of the survey area. As in 2020, the bulk of the population of the eastern Barents Sea shrimp was made up of smaller individuals, i.e males with a carapace length of 10-27 mm in addition to females with a carapace length of 17-30 mm (Fig. 10.1.2). In 2021 proportion of males and females was almost equal.

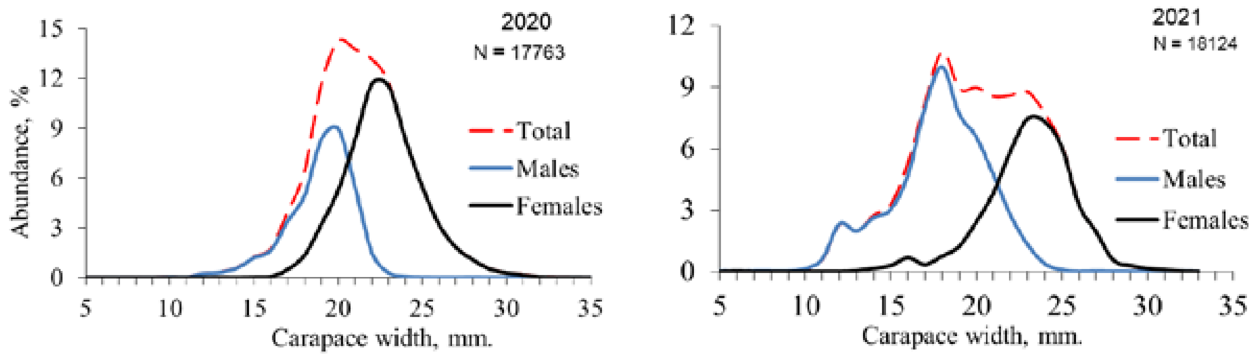


Figure 10.1.2. *Size and sex structure of catches of the Northern shrimp (*Pandalus borealis*) in the eastern Barents Sea 2020-2021*

10.2 Red king crab (*Paralithodes camtschaticus*)

Text by: N. Stesko, A.M. Hjelset, Figures by: J. Zakh

During BESS-2021 the red king crab was recorded in 26 of 341 trawl catches: in two stations in Norwegian water and in 24 stations in Russian part of survey (Table 10.2.1). Compared to 2020 in 2021 there was not recorded any expansion of red king crab range to north or east directions (Fig. 10.2.1). However, king crab's aggregations have shifted to eastward since first decade of the 21-th century.

Survey coverage of the red king crab distribution range in 2021 was close to that of the previous years (Table 10.2.1, Figure 10.2.1). In 2021, the largest aggregations of red king crab were observed in the northern part of the area where catches of that species were taken. Such results run counter to the data of the specialized trawl survey, which reported large yield to the north of the Kanin Peninsula. This situation might be accidental, as the ecosystem survey has a 25-30 nautical miles inter-haul spacing, and some compact and dense aggregations of crab may be missed.

Thus, it can be assumed that the observed interannual variations in red king crab distribution are primarily caused by the species migration activity.

Table 10.2.1. *The total catches of the red king crab during BESS 2005-2021.*

Year	Total number	Number of station	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
2020	461	22	233	547
2021	341	26	373	1186

* reduced coverage of the red king crab area

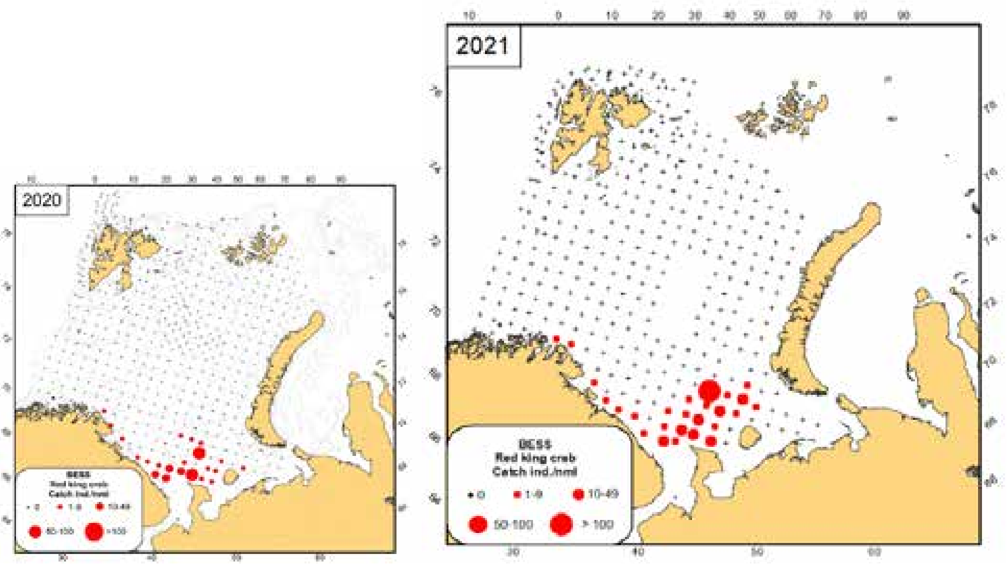
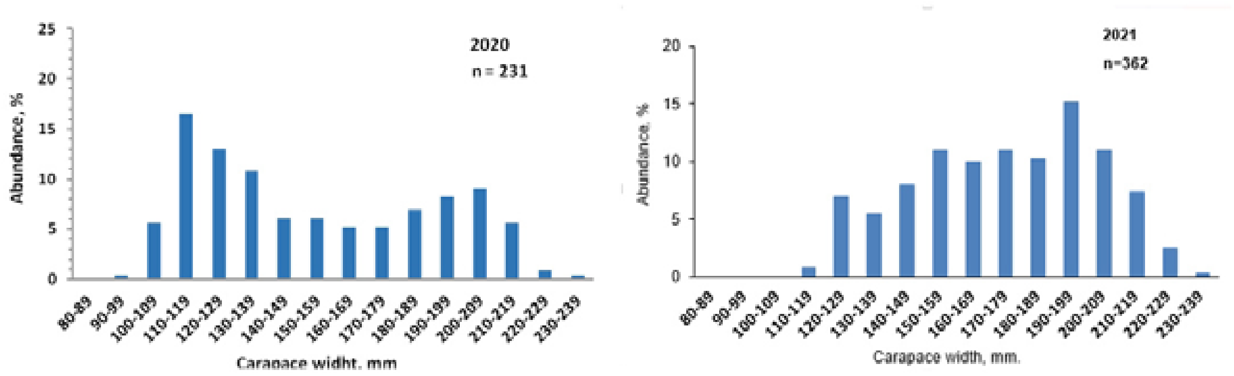


***Figure 10.2.1** Distribution of the red king crab (*Paralithodes camtschaticus*) in the Barents Sea in August-August-October 2020-2021*

The biomass of red king crab catches in 2021 varied from 1.0-616.4 kg/nm compared with 1.8-187.4 kg/nm in 2020. The average biomass was 24.9±23.8 compared with 26.9±9.0 kg/nm in 2020.

The abundance of crab in 2021 ranged from 1.2 to 449.4 ind./nm given an average crab abundance of 54.9±8.4 ind./nm (calculation doesn't include zero king crabs catches) compared with range 0.9-53.8 ind./nm and average 11.4±3.5 ind./nm. The size structure of the red king crab population in 2021 characterized by domination of commercial males with carapace width 150-210 mm. The quantity of non-commercial crabs caught in 2021 were reduced compared to 2020 (Fig. 10.2.2).



–

Figure 10.2.2 *Length distribution of the red king crab in the Barents Sea in August-Novembr 2020 and August-September 2021 (by BESS data).*

10.3 Snow crab (*Chionoecetes opilio*)

Text by: S. Bakanev, A. Stesko, A.M. Hjelset
Figures by: J. Zakh

In 2021 the snow crabs were recorded in 105 out of 341 trawl catches. Compared to previous year, the total catch of snow crab significantly decreased despite an increase in total number of stations (Table 10.3.1)

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. In 2019 and 2020 snow crab was not recorded in the water around Svalbard (Spitsbergen), however in 2021 it was caught on the South and the South-eastern part of Svalbard (Spitsbergen) area, but no more than 9 ind./nml.

In 2021, the north-eastern part of the Barents Sea was not covered by the survey, but the distribution of snow crab on that area is expected to be equal to 2020 (Fig. 10.3.1).

Within the survey area the biomass of snow crabs in 2021 varied from 0.001 to 18.3 kg/nm with an average 1.3±0.1 kg/nm compared with 0.003-40.8 kg/nm (3.7±0.3 kg/nm an average) in 2020 (Fig. 10.3.1, Table 10.3.1).

The abundance in 2021 ranged from 1 to 398 ind./nml with an average of 19.8±0.9 ind./nm compared with 11-520 ind./nml and 37.5±3.7 ind./nm in 2019 (Fig. 10.3.1, Table 10.3.1).

Size composition in 2021 were dominated by juvenile females and males with carapace width 20-40 mm . However, in males carapace width of 70-100 mm prevailed (Fig. 3.5.2.1). We could suppose annual increase in carapace width of juvenile crabs 20-30 mm up to middle size 30-40 mm, but generally its quite difficult to detect shifting of size composition due features of crabs catches in 2021 (Fig. 3.5.2.2).

Table 10.3.1. *The total and mean (per nautical mile) catches of snow crab during BESS in 2005-2021*

Year	Total number of stations	Number of stations with snow crab	Total catch, ind.	Total catch, kg	Mean abundance, ind./nm	Mean biomass, kg/nm
2005	649	10	14	2.5	1	0.3
2006	550	28	68	11	3	0.5
2007	608	55	133	18	3	0.4
2008	452	76	668	69	11	1.2
2009	387	61	276	36	6	0.8
2010	331	56	437	22	10	0.5
2011	401	78	6219	154	99	2.4
2012	455	116	37072	1169	395	12.6
2013	493	131	20357	1205	210	12.7
2014	304	78	12871	658	206	10.5
2015	335	89	4245	378	57	5.2
2016	317	84	2156	137	26	1.9
2017	376	159	25878	1422	147	10.0
2018*	217	61	19494	846	393	16.7
2019*	323	87	15523	608	145	6.6
2020	461	141	4403	436	38	3.7
2021	341	105	1705	110	20	1.2

* Some stations in the snow crab area were not surveyed in 2018 and 2019

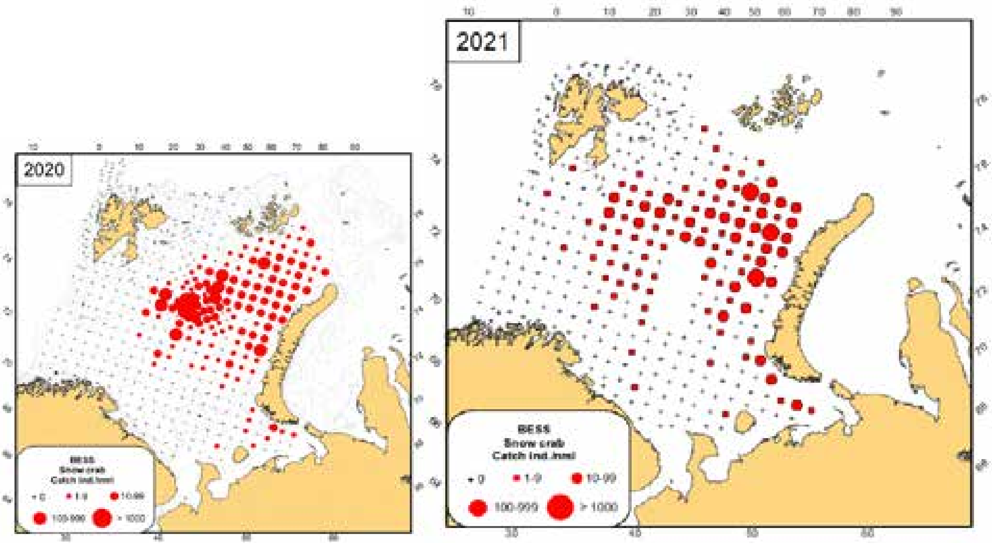


***Figure 10.3.1** Distribution of the snow crab (*Chionoecetes opilio*) in the Barents Sea in August-October 2020-2021*

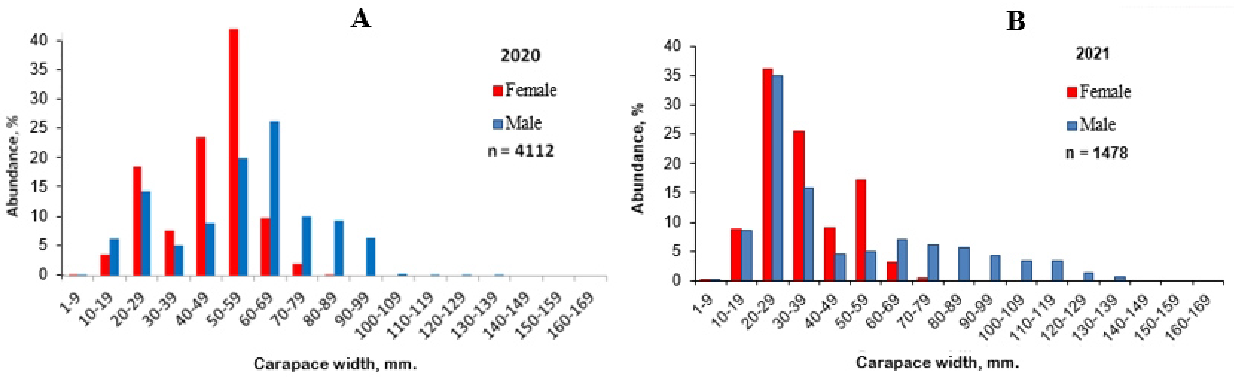


Figure 10.3.2 *Size and sex structure of the snow crab in the Barents Sea in August- November 2020 (A) and August-September 2021 (B) based on BESS data.*

10.4 Iceland scallop (*Chlamys islandica*)

Text by: D. Blinova, L.L. Jørgensen
Figures by: D. Blinova

The Iceland scallop was recorded in 88 of 254 trawl catches in 2021. The survey showed a wide distribution of scallops in the Barents Sea. The deepest record in 2021 was at 510 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). The disappearance of scallops to the west of Svalbard (Spitsbergen) reflects the peculiarity of this survey - one of the Norwegian ships did not identify these molluscs.

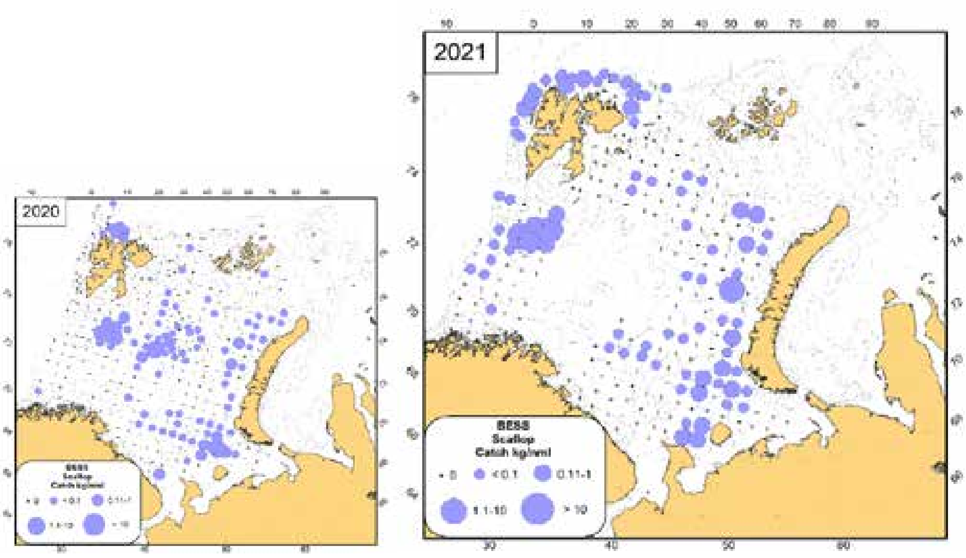


Figure 10.4.1 *Distribution of Iceland scallop (*Chlamys islandica*) in the Barents Sea, August-November 2020-2021*

The biomass of scallops in 2021 varied from 0.3 to 5010 g/haul (0.4-6500 g/nml). The average biomass is 177±39 g/haul (225±51 g/nml) (table 10.4). The abundance ranged from 1 to 625 ind./haul (1-811 ind./nml). The average abundance of scallops is 16±4 ind./haul (20±6 ind./nml).

Table 10.4 *Annual parameters of scallop population in the Barents Sea*

Year	Stations (% of total)	Abundance, ind./nml	Biomass, 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
2020	97 (23)	15±5	146±40
2021*	88 (35)	20±6	225±51

* - survey area was not complete

11 BENTHIC INVERTEBRATE COMMUNITY

Text by: N. Strelkova, L. L. Jørgensen
Figures by: A. Kudryashova

The list of benthic experts onboard Russian and Norwegian RVs is given in Table 1.
In 2021, megabenthos was recorded from 254 bottom trawl hauls across four R/Vs during the BESS in 2021. Megabenthos was processed to closest possible taxon with abundance and biomass recorded on all four ships. This was done by two benthic experts from "VNIRO", and by seven experts from IMR. Benthos was not processed on Part 1 of R/V "Johan Hjort" due to the absence of benthic experts onboard.

11.1 Species diversity

The total number of megabenthic taxa identified from the trawl-catch across all vessels is presented in Table 11.1.1. Detailed information about the taxonomic processing onboard the vessels are given in Table 11.1.2.

A total of 572 invertebrate taxa (384 identified to species level) was recorded in 2021.

Due to fewer stations, total number of benthic invertebrate animal taxa and species recorded in 2021 are slightly less that in 2020 (Table 11.1.1). However, the quality of taxonomic processing of the material in 2021 was not lower than in 2020 but slightly higher. In 2021 67.1 % of benthic invertebrate animals were identified to species level versus 65.6 % in 2020 (Table 11.1.2).

Table 11.1.1 *The measures obtained in BESS since 2005-2021. Pelagobenthic* Pandalus borealis *(Northern shrimp) are excluded from abundance and biomass values*

Year	Number stations	Total		Average abundance, ind./n.ml	Average biomass, kg/n.ml	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
2020	429	898168	10.7	1719.1	30.4	401	611
2021	254	212931	10.2	1076.6	50.6	384	572
Total	6221	15 542 617	242.2	2950.1*	48.2*	303*	452*

*The average long-term value

Table 11.1.2 *The taxonomic solution of megabenthos and assessment of the quality of taxonomic processing of invertebrates in the BESS 2021*

Research vessels	"G.O. Sars"	"Helmer Hanssen"	"Johan Hjort"	"Vilnyus"	**Total**
Number of processed hauls	45	42	23	144	**254**
Phylum	11	15	14	12	**16**
Class	24	26	24	22	**26**
Order	77	75	72	65	**90**
Family	158	149	150	103	**217**
Species	232	209	206	152	**384**
Total number of taxa	345	309	302	200	**572**
Percentage of species identification*	**67.2**	**67.6**	**68.2**	**76.0**	**67.1**

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

The taxonomic structure of the Barents Sea megafauna show a strong interannual stability. Despite different interannual area coverage, the quantitative distribution of taxa within phyla was very similar in 2020 and 2021 (Fig. 11.1.1). In 2021, Mollusca had the highest number of taxa (124 taxa) followed by Arthropoda (113 taxa), and Echinodermata (83 taxa). Among the mollusks, 58 % of taxa belonged to Gastropoda (72 taxa), 28 % – to Bivalvia (35 taxa), 9 % to Cephalopoda (11 taxa) and the remaining 5 % were distributed between Solenogastres, Polyplacophora and Scaphopoda. The Arthropoda phylum were primarily presented by Malacostraca (75 % of the taxa belonged to Decapods and Amphipods) and Pycnogonida (19 %). Among the Echinoderms the most diverse group was Asteroidea (47 % of taxa).

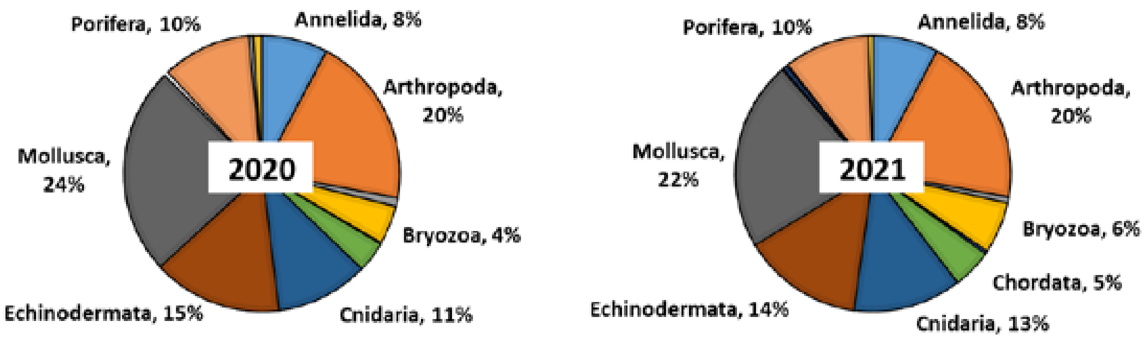


Figure 11.1.1 *The number of taxa given as % distribution of megabenthic phyla in the Barents Sea, September-November 2020 and August-September 2021*

The species density (number of taxa in the trawl catch) ranged from 1 to 94 with an average of 29.7±1.4 taxa per trawl-catch. At the significance level of 0.05, the differences between 2020 and 2021 data are statistically insignificant ($p = 0.143$).

The lowest diversity (less than 10-20 taxa per haul) was recorded in the south-eastern part of the survey area (Fig. 11.1.2). In the north-western sector of the sea, in the water around Svalbard

(Spitsbergen), the number of megabenthic taxa was the highest (up to 85 per station, and generally with 40-60 taxa per trawling (Fig. 11.1.2).

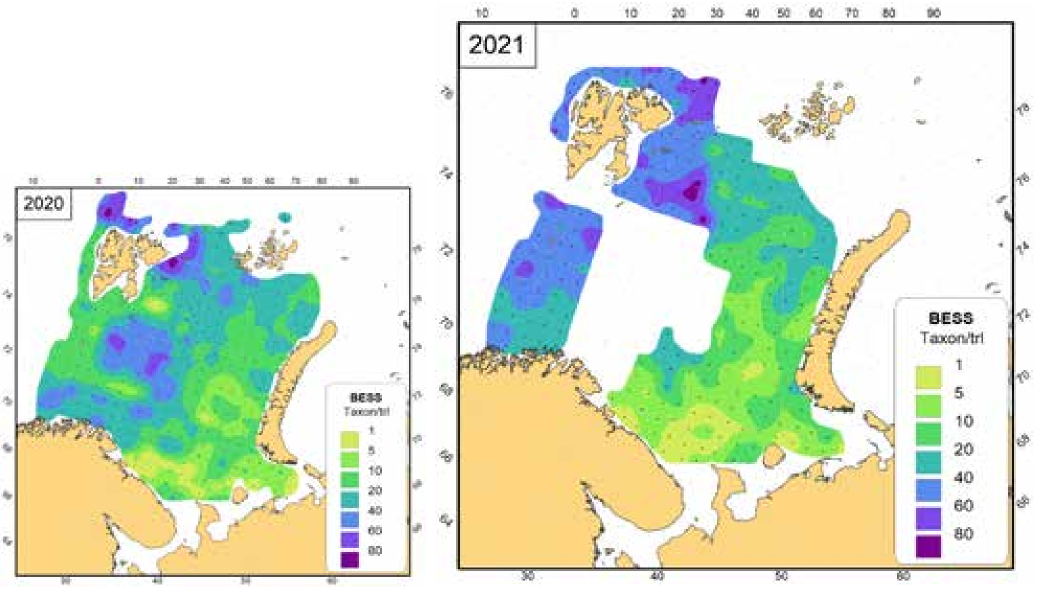


Figure 11.1.2 *The number of megabenthic taxa per trawl-catch in the Barents Sea in September-November 2020 and August-September 2021*

The ten species most frequently taken by trawl in the investigated part of the Barents Sea in 2021 were the decapod crustaceans *Sabinea septemcarinata* (taken by 70% of the trawl-hauls) and *Lebbeus polaris* (41%), sea stars *Ctenodiscus crispatus* (65%) and *Pontaster tenuispinus* (42%), the brittle stars *Ophiacantha bidentata* (49%), *Ophiopholis aculeate* (48%), *Ophioscolex glacialis* (39 %) and *Ophiura sarsii* (38%), scallop *Chlamys islandica* (35%).

New species records

During the BESS 2021, nine new species in the Norwegian part of the Barents Sea was recorded for the first time since 2005, when the ecosystem surveys started: bryozoans *Alcyonidium diaphanum*, polychaete worm *Aphrodita hastata*, crab *Atelecyclus rotundatus*, sea cucumber *Bathyplotes natan*, hydroid polyp *Laomedea angulata*, ascidians *Polycarpa pomaria* and *Synoicum incrustatum*, and soft corals of the Nephteidae family *Gersemia mirabilis* and *Pseudodrifa racemosa* (Fig. 11.1.3).

The sea spider *Cordylochele longicollis*, was recorded first time in BESS 2019 in the area of Fugløyabanken; in 2021 this species was recorded again but much further north – in the area to east of Svalbard (Spitsbergen). Most records of this species are lumped into *Cordylochele sp* and the distribution and frequency of *C. longicollis* is therefore uncertain.

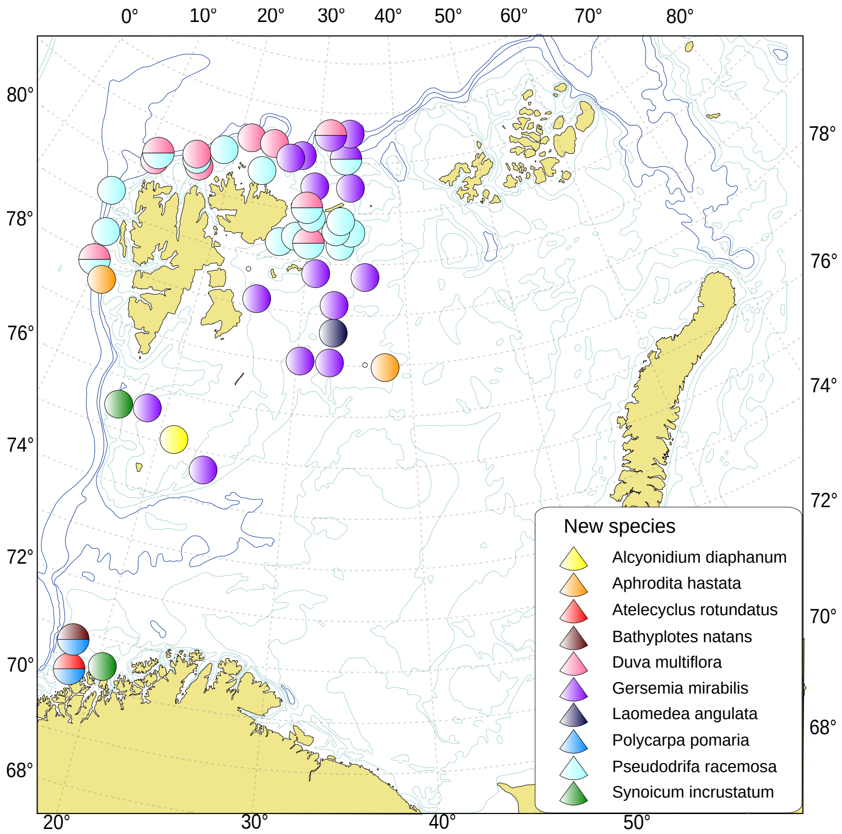


Figure 11.1.3 *Sites of finding of megabenthic species, first recorded in 2021 in the Barents Sea and adjacent water since 2005.*

A few individuals of the two species – *Atelecyclus rotundatus* (crab) and *Bathyplotes natans* (sea cucumber) was also recorded for the first time in the trawl fauna of the Barents Sea. This happen at two locations on Foley Bank at 207 and 212 m depth. This area is strongly influenced by warm Atlantic water of the North Cap Current. Records of these species may be a results of their spreading to the north due to long warming period.

The Ascidians *Synoicum incrustatum* and *Polycarpa pomaria* was first recorded in BESS 2021 in the areas of Fugløyabanken and in the Bear Island Bank. These species has also earlier been recorded in the water around Svalbard (Spitsbergen) by Gulliksen *et al*. (1999).

In north-western sector of BESS in the water around Svalbard (Spitsbergen) two new soft corals – *Gersemia mirabilis* and *Pseudodrifa racemosa* – was recorded in 17 and 15 stations, respectively. This was a result of using a new detailed identification guide of Nephteidae family on the Norwegian vessels during the BESS 2021. The obtained data show that this taxonomic group need a better revision across the entire Barents Sea.

New records of *Aphrodita hostata*, *Laomedea angulata* and *Alcyonidium diaphanum* in the north of the Norwegian survey area can be the result of non-standardized taxonomy, or very high qualification of benthic experts in 2021.

Unfortunately the BESS do not have the capacity to verify if these species are true new recordings, or if these recordings are due to unstandardised taxonomy. In the future all recorded species should be checked against a database, and if the species name does not exist, the species should be collected as a voucher for further taxonomy on land.

11.2 Abundance (number of individuals)

The number of megabenthos individuals in the trawl-catches (excluding the pelagobenthic species *Pandalus borealis*) ranged from 2 to 17113 (2-22204 ind./n.ml) with an average of 842±102 ind. per trawl-catch (1077±131 ind./n.ml). This is 37% less than in the previous year (Table 11.1), possibly caused by interannual difference in station coverage (Fig. 11.2.1).
The largest catch in number of individuals (17113 ind./trawl-catch), mainly consisted of colonial sea-squirt (Ascidiacea) *Kukenthalia borealis* (14870 ind./ trawl-catch), was obtained in the western part of the Barents Sea near Bear Island at the depth 157 m (Fig. 11.2.1). In 2020 the extra high abundance of sea-squirts (non-identified to species level) were recorded near the Bear Island. As in previous year, the lowest abundances (less than 50-100 ind. per haul) was recorded in the south-eastern part of the sea within the Russian part of the survey.

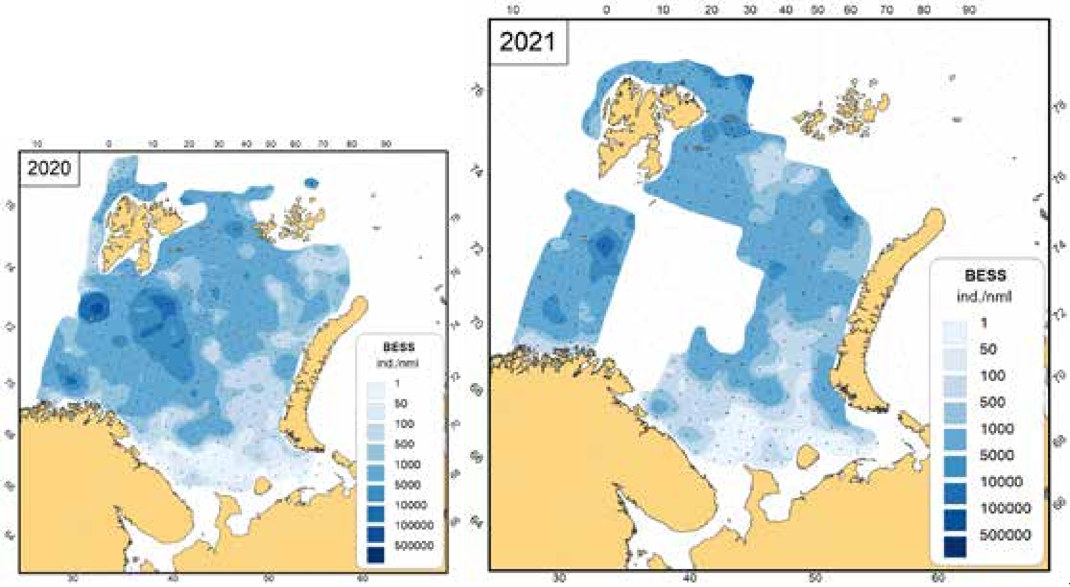


Figure 11.2.1
The number of individuals of megabenthos (excluding Pandalus borealis*) in the Barents Sea in September-November 2020 and August-September 2021*

In 2020 two extraordinary catches with high abundance of Ascidiacea (Chordata in Fig. 11.2.2) changed the usual distribution of abundance across the main megabenthic groups from echinoderms to a predominance of ascidians. In 2021 the percentage between the main groups of megabenthos taxa (in abundance) corresponds to the long-term pattern with the dominance of Echinodermata and Artropoda (mostly Crustacea) (Fig. 11.2.2).

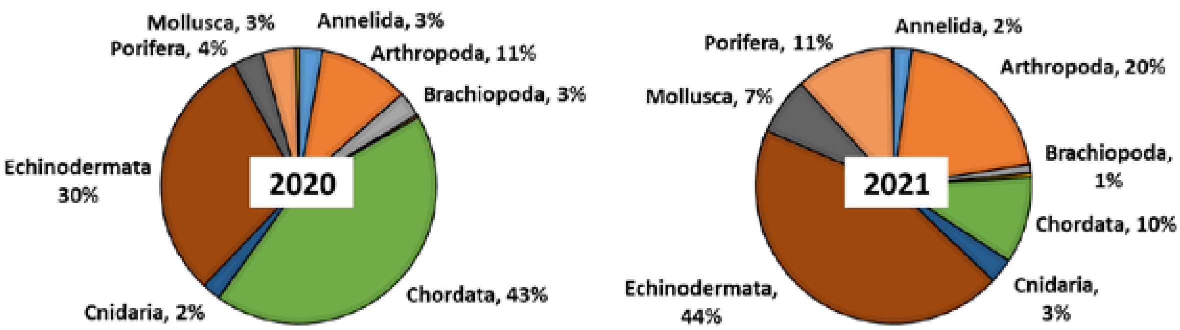


Figure 11.2.2 *Distribution of abundance (excluding* Pandalus borealis*) across the main megabenthic groups (%) in the Barents Sea, September-November 2020 and August-September 2021*

The ten most abundant species within the survey area (in the term of total number of ind./trawl catch during BESS 2021) were the sea stars *Ctenodiscus crispatus* (11.4 % of total abundance), sea-squirt *Kukenthalia borealis* (9.6 %), the brittle stars *Ophiacantha bidentata* (9.7 %), *Ophiopholis aculeata* (2.8 %), and *Ophiura sarsii* (1.5 %), shrimps *Sabinea septemcarinata* (8.5 %) and *Lebbeus polaris* (1.6 %), sea urchins of genera *Strongylocentrotus* (mainly *S. pallidus*) (8.0 %), sponges of genera *Thenea* (5.5 %), and bivalve *Bathyarca glacialis* (2.1 %).

11.3 Biomass

As in previous years, the main part of the total biomass was made up by Sponges, Echinoderms, and Crustaceans (total 98 %) in 2021 (Fig. 11.3.1). In 2021, biomass of Cnidaria and Chordata had almost disappeared compared to 2020.

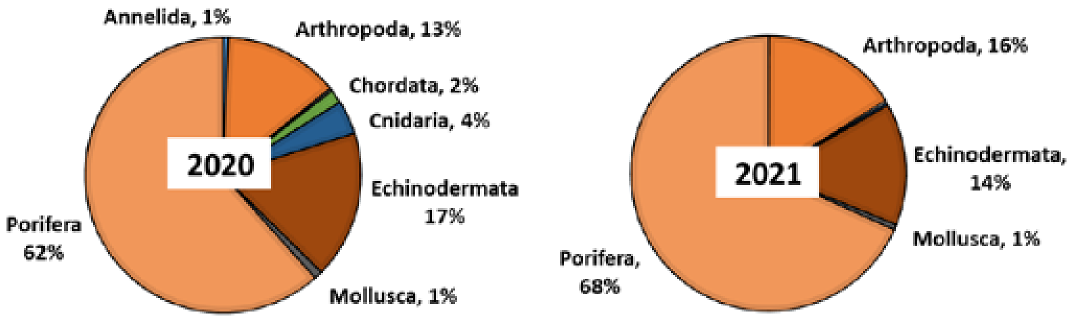


Figure 11.3.1 *Distribution of biomass (excluding* Pandalus borealis*) across the main megabenthic groups (%) in the Barents Sea, September-November 2020 and August-September 2021*

The megabenthos biomass taken by the trawl (excluding the semipelagic species *Pandalus borealis*) in 2021 variate from 0.003 to 1623 kg (0.004-2074 kg/n.ml) with an average of 40.0±10.3 kg per trawl-catch (50.6±12.9 kg/n.ml). This average is 66.4% more than in the previous year (table 11.1).

Totally (even with the lack of no stations visited in the central part of the Sea), biomass distribution in 2021 is very close to the pattern of previous year (Fig. 11.3.2).

Trawl catches with biomass of more the 1 t per trawl haul in 2021 was observed on three stations in the south-western part of the Barents Sea at 263-334 m depth (Fig. 11.3.2) and dominated by *Geodia* sponges (*G. barretti*, *G. atlanthica*, *G. macandrewii* and *G. phlegrae*). Other hot spots of biomass (more than 100 kg per trawling) was recorded in Spitsbergenbanken (dominated by see cucumber *Cucumaria frondosa*), north of Svalbard (Spitsbergen) (*Geodia* sponges), in the south-eastern part of the sea, north of Kanin Nos peninsula (*Paralithodes camtschaticus*) and in north-eastern sector of the sea (brittle stars of genera *Gorgonocephalus*, sea urchins of genera *Strongylocentrotus* and crabs *Chionoecetes opilio*)

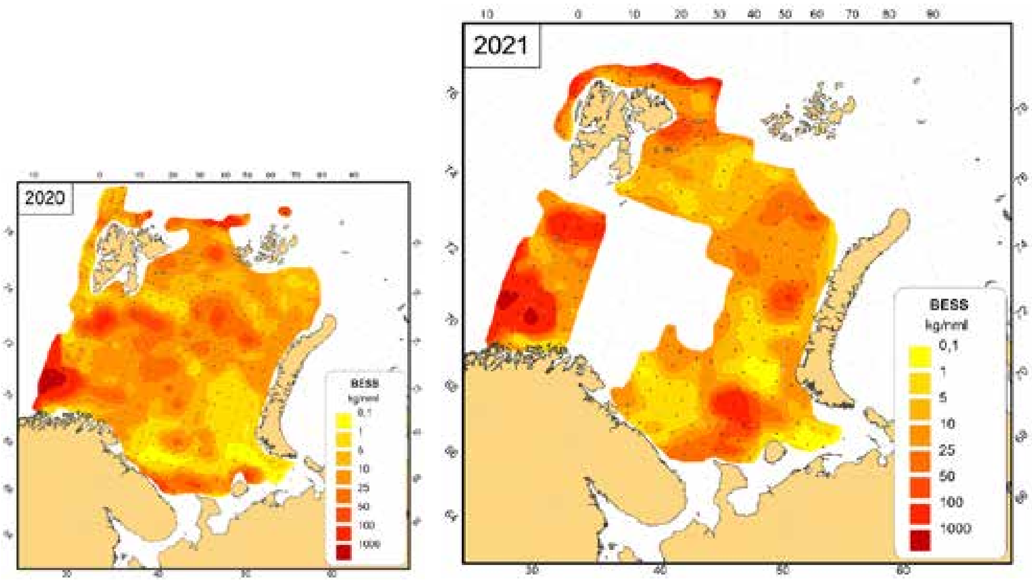


Figure 11.3.2 *Biomass distribution of megabenthos (excluding* Pandalus borealis*) in the Barents Sea in September-November 2020 and August-September 2021*

More than half of the megabenthic biomass (60 % of the total biomass of by-catches) belonged to the *Geodia* sponges (*G. barretti, G. atlanthica, G. macandrewii*, *G phlegrae*, and *G. hentcheli*). Other top-dominant species in biomass was crabs *Paralithodes camtschaticus* (11.1 % of the total biomass), sea-cucumber *Cucumaria frondosa* (5.7 %), sponges *Stryphnus ponderosus* (2.9 %), sea stars *Ctenodiscus crispatus* (2.8 %), shrimp *Sabinea septemcarinata* (2.3 %) and brittle stars genera *Gorgonocephalus* (*G. arctica* and *G. eucnemis*) (2.4 %). The contribution of each of the other species did not exceed 1% of the total biomass of megabenthos bycatches.

12 MARINE MAMMALS AND SEABIRDS

12.1 Marine mammals

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

During the BESS 2021, marine mammal observers were onboard all Norwegian and Russian RVs. In total, 2 168 individuals of 10 marine mammal species were observed during the BESS, of these 153 individuals were not identified to species level. The distributions of marine mammals are given by numbers in Table 12.1.1 and locations in Figures 12.1.1-12.1.2.

As in previous years, white-beaked dolphin (*Lagenorhynchus albirostris*) was one of the most abundant and widely distributed species. Higher numbers of dolphins were recorded north of 74°N compared to the previous year.

Table 12.1.1. *Number of marine mammal individuals observed during the BESS in 2021.*

Name of species	Total	%
Fin Whale	246	11.4
Humpback Whale	157	7.2
Minke Whale	175	8.1
Sei whale	12	0.6
Blue whale	2	0.1
Unidentified whale	79	3.6
White-beaked dolphin	1375	63.4
Harbour Porpoise	20	0.90
Killer Whale	4	0.20
Sperm Whale	22	1.00
Unidentified dolphins	70	3.2
Walrus	2	0.1
Unidentified marine mammal	4	0.20
Total sum	2168	100

Besides white-beaked dolphin other toothed whales observed included sperm whale (*Physeter macrocephalus*), harbour porpoise (*Phocoena phocoena*) and killer whale (*Orcinus orca*). Sperm whales were observed in the western areas (west of 30°E) of the Barents Sea and at deeper waters along the continental slope. The harbor porpoises were recorded mainly in the southeastern coastal areas. Killer whales were recorded in Svalbard South and Southeastern Basin regions.

The baleen whale species minke (*Balaenoptera acutorostrata*), humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*) and blue whales (*Balaenoptera musculus*) were also abundant in the Barents Sea in 2021.

Minke whales were widely distributed in the Barents Sea. The densest aggregations of minke whale were overlapping with capelin concentrations in the western areas and southwest of Svalbard (Spitsbergen).

The humpback whales were mainly recorded in the northern central areas. The highest densities of humpback whales were recorded in areas of high aggregations of mature capelin, and often together with fin and minke whales.

Fin whales were widely distributed in the research area, and was recorded to about 50°E. The densest aggregations of fin whale were recorded in the north and southwest of Svalbard (Spitsbergen).

In 2021, 12 individuals of sei whales were recorded south of Svalbard (Spitsbergen); this is a species which has not been identified in previous ecosystem surveys.

Two blue whales were recorded north of Svalbard (Spitsbergen).

In 2021, the only pinniped species observed was walrus (*Odobenus rosmarus*), of which two were recorded at Svalbard (Spitsbergen).

Harp seal (*Pagophilus groenlandicus*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*) and polar bears (*Ursus maritimus*) were not observed during the survey, likely due to lack of ice in the survey area.

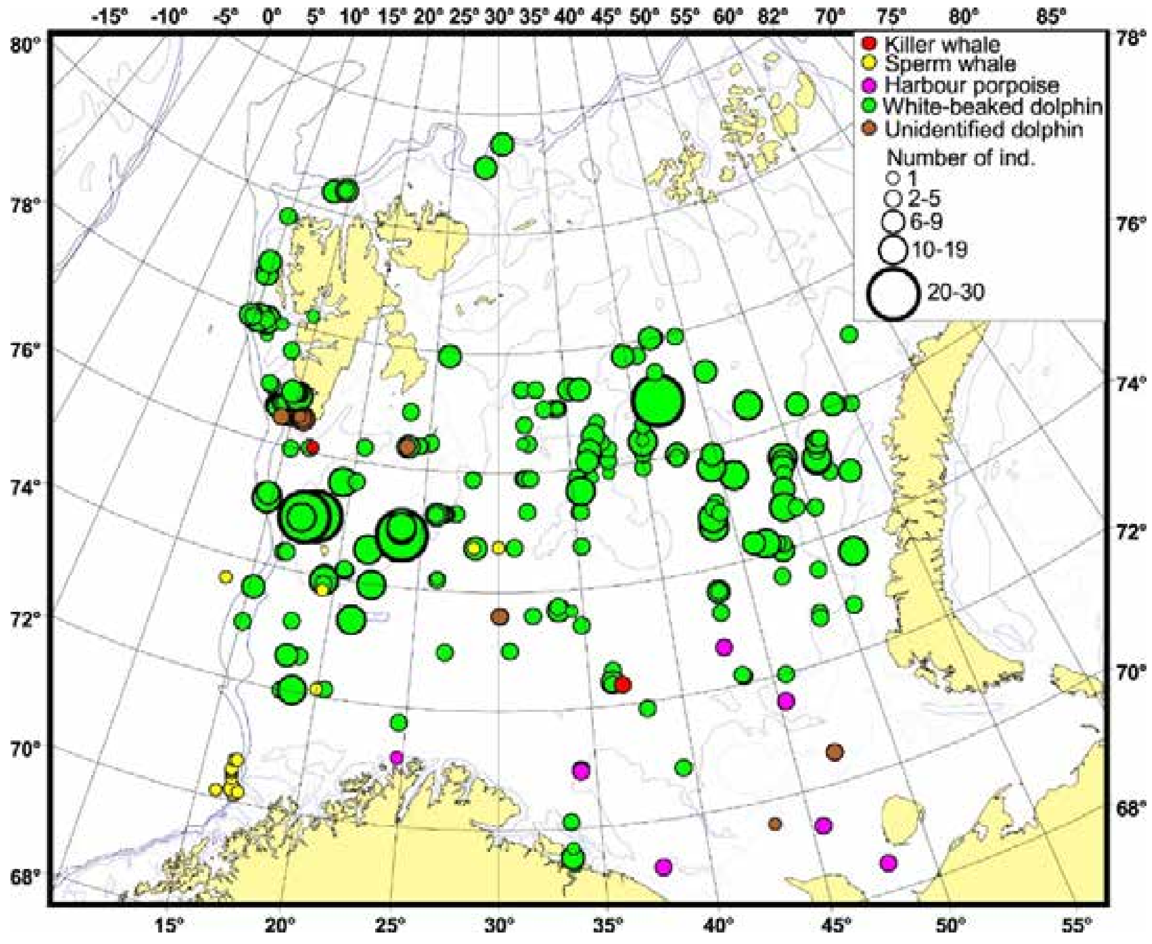


Figure 12.1.1. *Distribution of toothed whales in BESS 2021*

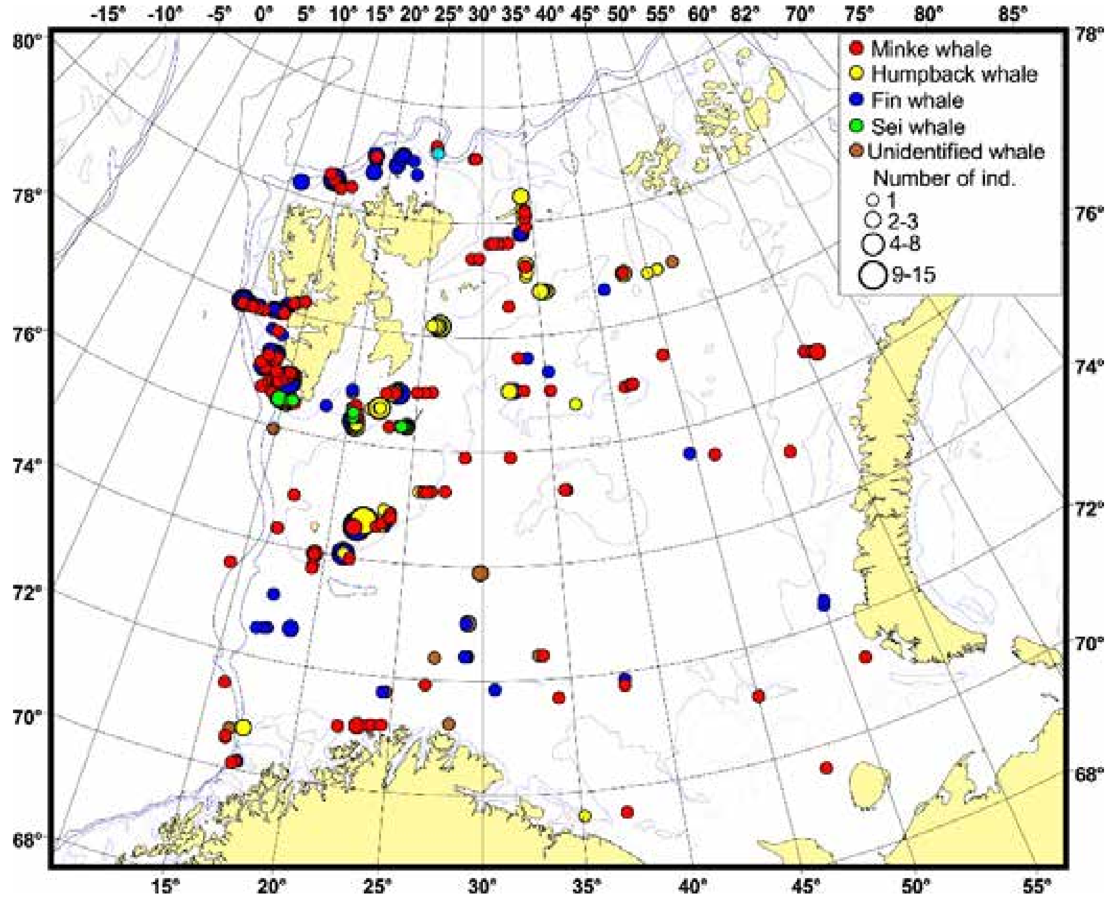


Figure 12.1.2. *Distribution of baleen whales in BESS 2021*

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 *G.O. Sars*, 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.

For the Norwegian part of the survey, participation of seabird observers was restricted to *G.O. Sars* only due to Covid-19 restrictions. The coverage of seabird observations in the northern and eastern part of the Norwegian sector was accordingly limited (Figs 12.2.1, 12.2.2). Total transect length covered by *G.O. Sars* was 2070 km. Total transect length covered by the Russian research vessel;

Vilnyus, was 4668 km. A total of 21 291 birds belonging to 32 different species were counted. High density of thick-billed murre (*Uria lomvia*), kittiwake (*Rissa tridactyla*) and Northern fulmar (*Fulmarus glacialis*) were found in the northeastern part of the area, while Atlantic puffin (Fratercula arctica), common murre (*Uria aalge*), herring gull (*Larus argentatus*) and black-backed gull (*Larus marinus*) dominated in the south (Figs. 12.2.1, 12.2.2). For the first time, little auks (*Alle alle*) were not observed. This is probably because the survey lacked observations north of Svalbard (Spitsbergen).

Broadly, the distribution of the different species was similar to the distribution in the 2020 survey. Alcids were observed throughout the study area but the abundance and species distribution varied geographically. Thick-billed murres were found in the central and northern part of the Barents Sea, Atlantic puffins were found in the southwestern part and common murres were found in the south. Among the ship-followers, black-backed gulls and herring gull were found in the south. Glaucous gull (*Larus hyperboreus*) was found 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.

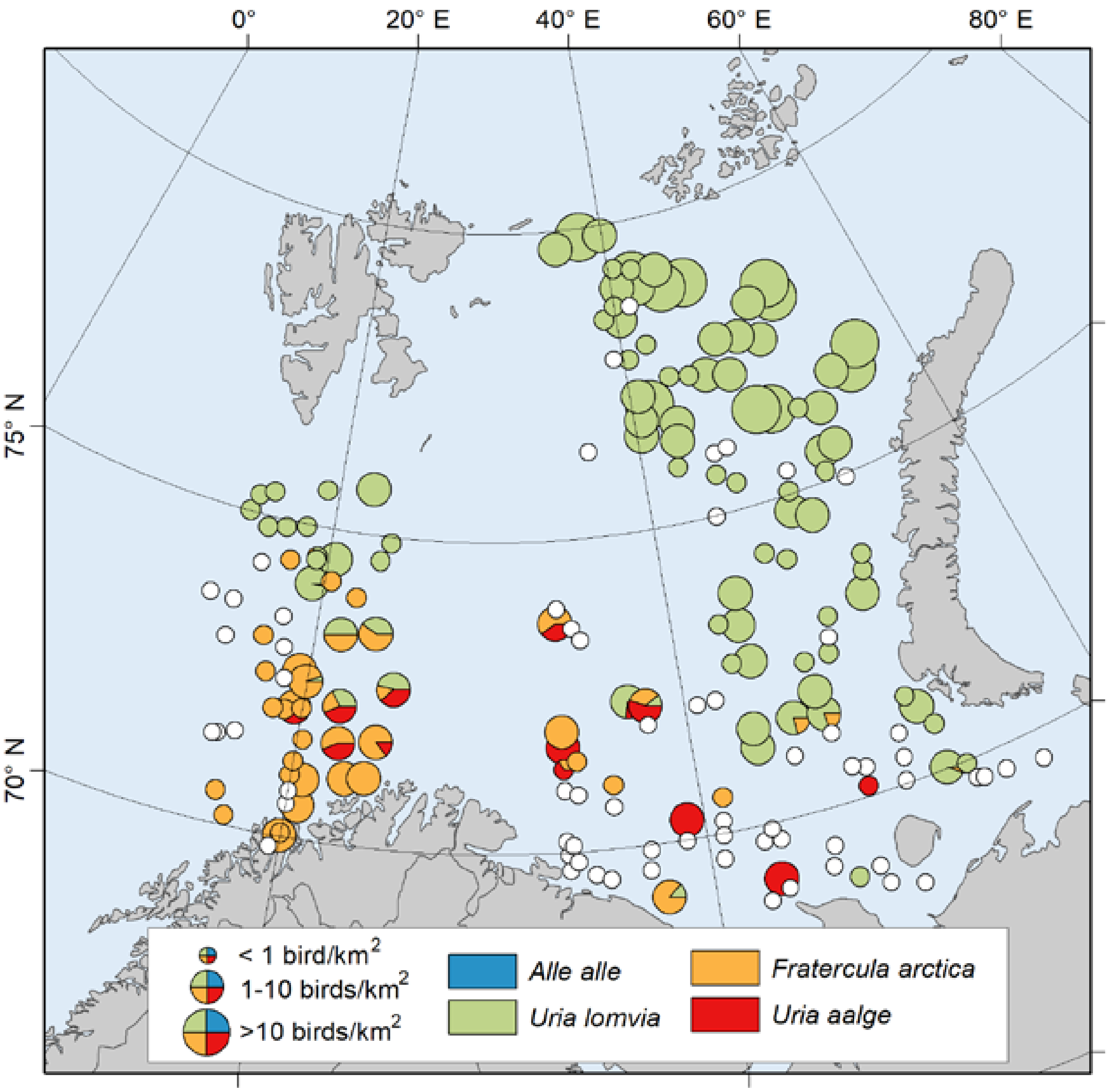


Figure 12.2.1 *Density of auk species along seabird transects in 2021. White circles are zero density. Note that little auks (Alle alle) were not observed in 2021.*

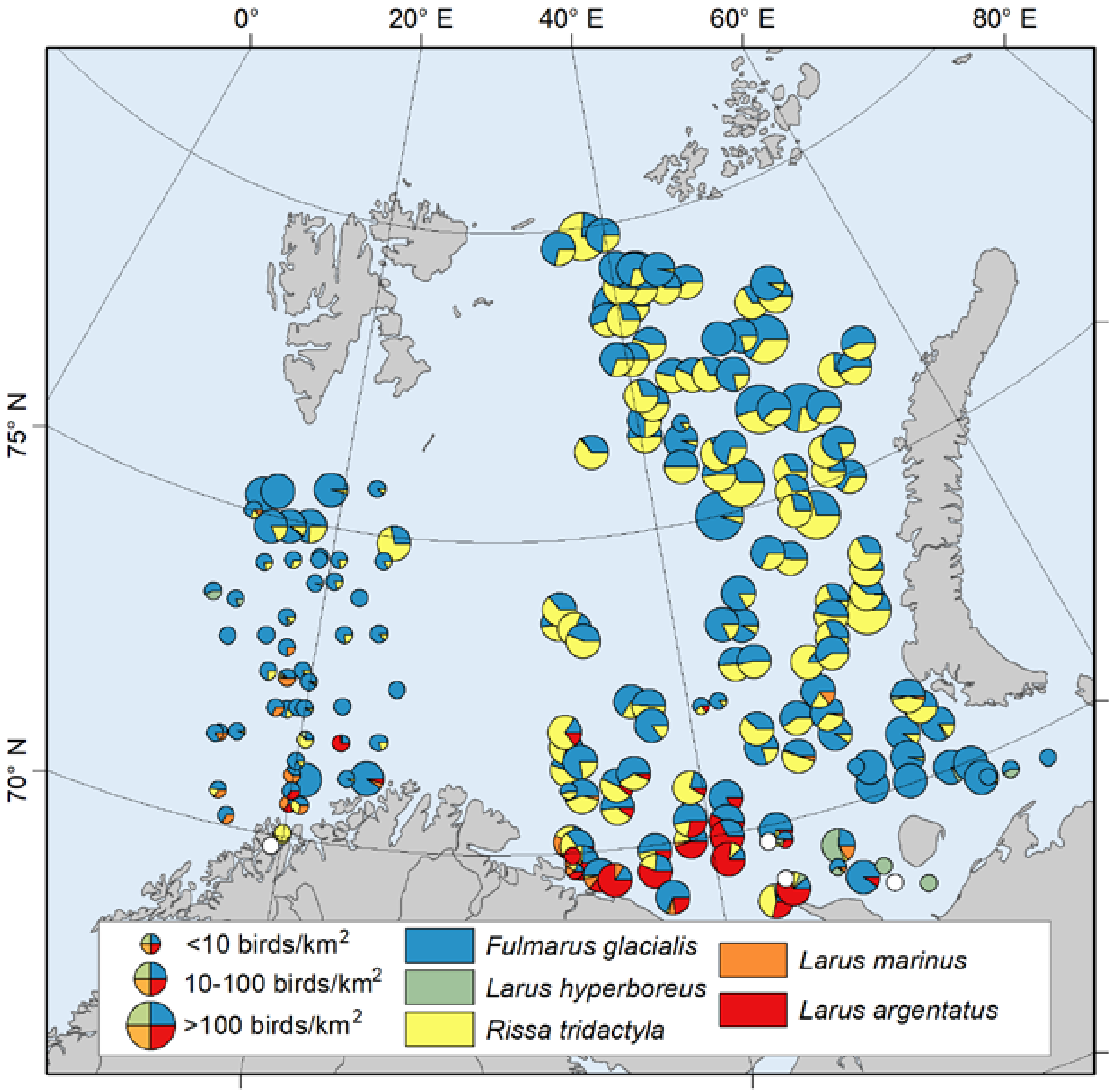
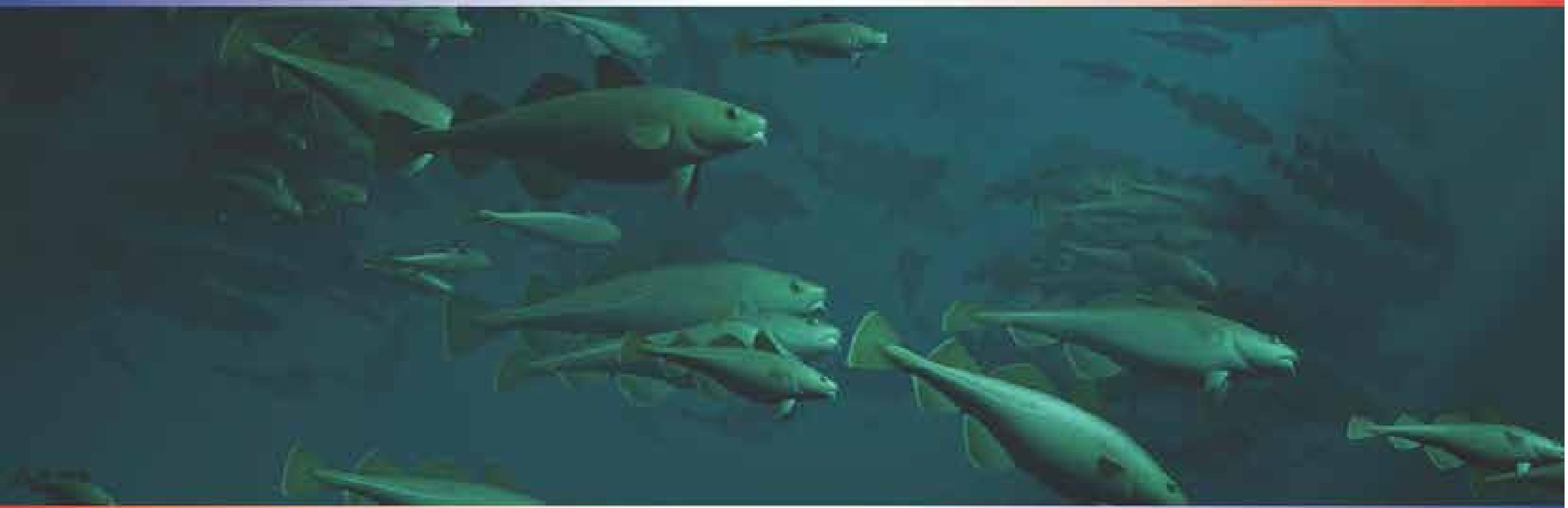


***Figure** 12.2.2   Density of the most common gull species and Northern fulmar along seabird transects in 2021. Note that because these species are attracted to and tend to follow the ship, densities are systematically over-estimated.*



Institute of Marine Research – IMR

Polar branch of the FSBSI "VNIRO" ("PINRO")