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# Annex 4: Short report of the Barents Sea ecosystem status 2021

This document gives a short summary of the current state and recent change of different components of the Barents Sea ecosystem while also briefly discussing possible causes of state and change. It is issued for the first time in 2021 and is planned to be updated yearly. The ecosystem status summary is intended for a wide audience, including scientists, teachers, students, decision-makers, and the public interested in the Barents Sea ecosystem and marine environmental issues more in general. It is prepared by the ICES Working Group on Integrated Ecosystem Assessment for the Barents Sea (WGIBAR). It represents a summary of scientific information prepared by the group and does not constitute ICES advice.

## Highlights

The Barents Sea has experienced a warming trend since 1970s, while becoming colder after 2015–2016. Temperatures in 2021 were still typical of warm years. The areas covered by Atlantic and Arctic Waters in autumn were similar to 2020, while the area covered by cold bottom waters increased slightly and turned out to be the largest since 2011. Ice coverage of the Barents Sea has increased since 2016 due to lower temperatures and lower area covered by Atlantic Water, but the ice coverage in 2021 was still below average (1981–2010).

Some decrease in mesozooplankton biomass, mainly in some western and central areas, measured in autumn 2021 could be influenced by high predation pressure due to a large capelin stock, possibly a lower advection of mesozooplankton with inflowing waters into the Barents Sea (BS) and variation in local production. Krill indices of biomass have shown increasing trends over recent decades to the increased contribution from *M. norvegica* in the BS. The total biomass of amphipods was slightly higher than long term mean (2003–2021) but the lowest since 2014.

The 2021-year classes of cod and haddock were strong, while those of polar cod, redfish seem to be weak. Capelin and herring year classes was moderate. In 2021, the total biomass of 0-group in the Barents Sea was slightly below long term mean and was close to 1 million tonnes.

The total stock of capelin was estimated to about 4 million tonnes, which is the highest estimated biomass since 2008 and above the long-term level. The biomass of polar cod in the Barents Sea recovered after a long time decline and in 2021 was estimated 1.3 million tonnes.

Most of the main demersal fish stocks (cod, haddock, Greenland halibut, beaked redfish, long rough dab, saithe) in the BS are in a healthy state and at a level at or above the long term mean. Cod food consumption in 2021 was close to the level of 2020. Capelin is still the most important food item for cod. Importance of euphausiids, hyperiids, polar cod and snow crab has increased in cod diet, while importance of haddock, shrimp and herring has decreased.

The northern shrimp stock is relatively stable. The snow crab population distribution and abundance is stable. Aggregations of the red king crab have been shifted eastward and north-eastward last decade, however in 2021 compared 2020 location of main aggregations of red king crab were stable.

The distribution of megabenthos may show relative stable large-scale patterns but with slightly increasing biomass. This may indicate a long-term change toward warmer seabed conditions. Two new boreal species was recorded in the SW where also the general biomass of benthos increases the most.

The centre of gravity of the most common species shifted northward for several species the last 11 years. In the same period, the abundance of pelagic surface feeding birds has decreased.

The abundances of minke, fin and humpback whales in the BS increased after 2000 and have stayed at high levels. Their distributions, especially of minke and humpback whales, generally overlap with capelin distributions in late summer–autumn.

# Graphical summary

| | Topic | Overall trend | Situation in 2021 | Certainty | Possible implications |
|---|---|---|---|---|---|
| | Ocean climate | A warming trend since 1970s, while becoming colder after 2015–2016. Since then the areas covered by Atlantic and Arctic Waters has decreased/increased with slightly increase of ice coverage. | Cooling but still warm | Highly certain: dedicated monitoring with good spatial coverage exists. | Affect production and distribution of plankton, fish, benthos and marine mammals |
| | Primary production | Net Primary Production (NPP) showed a marked significant increase. The NPP increased significantly both in the western and eastern regions. | Net Primary Production (NPP) showed a slightly decrease in 2021, but still high | Highly certain: the phytoplankton estimates are based on satellite data covering the whole productive season with high geographic solution. | Increased food resources for herbivores since 2009 |
| KG | Zooplankton biomass | Mesozooplankton biomass has been relatively stable during last decades. Krill indices of biomass and abundance have shown increasing trends, while the amphipod biomass index in the Arctic showed a decreasing trend over recent decades | Some decrease in mesozooplankton biomass – particularly in western and central regions. Krill and amphipod biomass indices for 2019 and 2020 are not calculated yet | Moderately certain: plankton biomass is measured during autumn (at the end of the feeding period for fish) and is thus not directly linked to annual zooplankton biomass/production in the area | Reduced food sources for planktivorous feeders, including pelagic fish and juvenile fish. |
| | Zooplankton spatial distribution | The spatial distribution of mesozooplankton biomass showed a typical pattern with high values in southwestern, deep central-eastern, and northern areas, and relatively low levels in central areas. | Compared to the preceding 5-year averages, mesozooplankton biomass in 2020 was generally lower in the western and central Barents Sea, while more variable in the eastern Barents Sea. | Moderately certain: the surveys do not cover the entire BS. | May affect distribution of planktivorous fish |
| KG | 0-group biomass | The biomass of 0-group fish (cod, haddock, NSS herring, capelin, polar cod, and redfish) were low in 1980s, increased in 1990s and was high in 2004–2016. | The 0-group fish biomass varied from low to moderate since 2016 and was in 2021 slightly below the long term mean due to strong recruitment of cod and haddock. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for fish stock development |
| | Mega benthos | The biomass slightly increased during 2005–2021, most in boreal, less in Arctic areas following same spatial pattern as | In 2021, the number of taxa and biomass of mega-benthos was above the long term mean, while abundance (number of | Moderately certain: the surveys did not cover the entire BS; reduced taxonomic identification | Reduced or increasing benthos biomass and VME may affect food availability and |

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| | | previously years. Two new boreal species recorded in the SW. Species diversity increase considerably due to greater expert skills. Several VME species recorded but annual trends still unsure. | individuals) was below. Critical amounts (NAFO) of sponges taken in the SW. | (2020) and lack of coverage in central Barents Sea (202) made comparison between 2020 and 2021 difficult/impossible. VMEs in the high north was not covered. | shelter/structural habitats for benthivores vertebrates and invertebrates. New boreal species indicate long-term shift in benthic ecosystem. |
| | Shellfish | The spatial distribution of commercial shellfish species: shrimp - in central and northern part, red king crab - in southeast, snow crab - in central and northeast. | In 2021, the biomass/abundance of commercial species (shrimps, snow crab, king crab) is relatively stable. No change in distribution of snow crab, red king crab, shrimps. | Moderately certain: lack of spatial coverage some years for snow crab and shrimp. I<br>Highly certain: good coverage for red king crab. | Nothing generally implications due to stable stocks status. |
| | Pelagic fish biomass and spatial distribution | The biomass of pelagic fish stocks (capelin, herring, polar cod, and blue whiting) decreased since 2008, but in 2019 a positive trend began. | In 2021, the total biomass of pelagic fish increased and was highest since 2014 due to strong recruitment of capelin and polar cod. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for plankton biomasses, predators, and fisheries opportunities |
| | Capelin | Growth of capelin stock due to strong 2019-year class and moderate 2020-year class. | The total capelin stock is 4 million tonnes, which is the highest since 2008. The mature stock 1.4 million tonnes and close to long-term level. | Highly certain: dedicated monitoring with good spatial coverage exists. | A good food base for predators and fisheries opportunity. Decrease in plankton biomass, decrease in fish growth. |
| | NSS herring | The negative trend in herring recruitment continues. Were not abundant year classes after 2016. | The number of juvenile herring is extremely low. Numerous year classes left out the Barents Sea. | Highly certain: dedicated monitoring with good spatial coverage exists. | Poor recruitment and declining fishing stock. |
| | Polar cod | From 2010–2019 there seemed to be a general decrease in biomass of polar cod in the Barents Sea, but the strong year class of 2015 and 2020 gave an increase in polar cod stock biomass in 2016 and 2021. | The total stock is close to 1.5 million tonnes and is at a high level. | Moderately certain: lack of spatial coverage some years | A good food base for predators. |

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| Blue whiting | After 2016, the number began to decrease significantly. | Biomass at a low level, about 500 thousand tonnes. | Moderately certain: depends on fish distribution inside standardized area | Nothing generally implications due to distribute the main stock outside Barents Sea and low biomass inside now. |
| Demersal fish biomass | At recent years the biomass of main demersal fish stocks (cod, haddock and Greenland halibut) while saithe, beaked redfish biomass are increased. | In 2021, recent trends in all stocks kept. | Highly or moderately certain: dedicated monitoring with good spatial coverage exists but lack of spatial coverage some years | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Cod | The biomass of cod decreased from 3.7 million tonnes in 2011–2012 to close to 0.7 million tonnes in 2020. | In 2021, the total biomass of haddock decreased to 2.2 million tonnes due to weak and average recruitment in recent years. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Haddock | The biomass of haddock decreased from 1.2 million tonnes in 2013 to close to 2.2 million tonnes in 2020. | In 2021, the total biomass of cod decreased to 0.7 million tonnes due to weak and average recruitment in recent years. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Saithe | The biomass of saithe increased from 0.6 million tonnes in 2013 to close to 1.0 million tonnes in 2020. | In 2021, the total biomass of saithe continued slight increasing. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for pelagic fish biomasses and fisheries opportunities |

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|---|---|---|---|---|
| Greenland halibut | The biomass of Greenland halibut decreased from ca 0.8 million tonnes in 2013 to close to 0.6 million tonnes in 2020. | In 2021, the total biomass of Greenland halibut decreased slightly due to weak and average recruitment in recent years. | Highly certain: dedicated monitoring with good spatial coverage exists | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Beaked redfish | The biomass of beaked redfish was stable at 2001–2010 around 1 million tonnes and increased slowly due to good recruitment to close 1.5 million tonnes in 2020. | In 2021, the total biomass of redfish continued slight increasing. | Moderately certain: lack of spatial coverage some years | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Long rough dab | The biomass of long rough dab at 2004–2020 varying from 0.3 to 0.5 million tonnes with mean value around 0.4 million tonnes | In 2021, the total biomass of decreased slightly | Moderately certain: lack of spatial coverage some years | Direct implications for pelagic fish biomasses and fisheries opportunities |
| Seabirds | The centre of gravity of the most common species shifted northward for several species the last 11 years. In the same period, the abundance of pelagic surface feeding birds has decreased | The spatial distribution of seabirds in autumn 2021 reflects the climatic gradient from a boreal Atlantic species in the south and west, to an Arctic species in the north and east | Moderately certain: lack of spatial coverage some years | Seabirds are displaced toward the north following a period of warming. |
| Marine mammals | The abundances of minke, fin and humpback whales in the BS increased after 2000 and have stayed at high levels. Their distributions, especially of minke and humpback whales, generally overlap with capelin distributions in late summer-autumn | The white-beaked dolphin was the most frequently observed species of marine mammals in 2021. This species has extended its distribution further northwards. Minke and fin whales are widely distributed throughout the BS. Fin whales had large aggregations west and north of Svalbard and minke whales are very abundant in BS in summer. | Highly certain: Good spatial coverage in summer and autumn | High intra- and interspecific competition is expected among baleen whales and a large feeding pressure on pelagic prey and krill is expected. |

# Climate

## Current status and recent changes

The Barents Sea is a shelf sea of the Arctic Ocean. Being a transition area between the North Atlantic and the Arctic Ocean, it plays a key role in water exchange between them. Atlantic waters enter the Arctic Ocean through the Barents Sea and the Fram Strait. Variations in volume flux, temperature and salinity of Atlantic waters affect hydrographic conditions in both the Barents Sea and the Arctic Ocean and are related to atmospheric pressure systems.

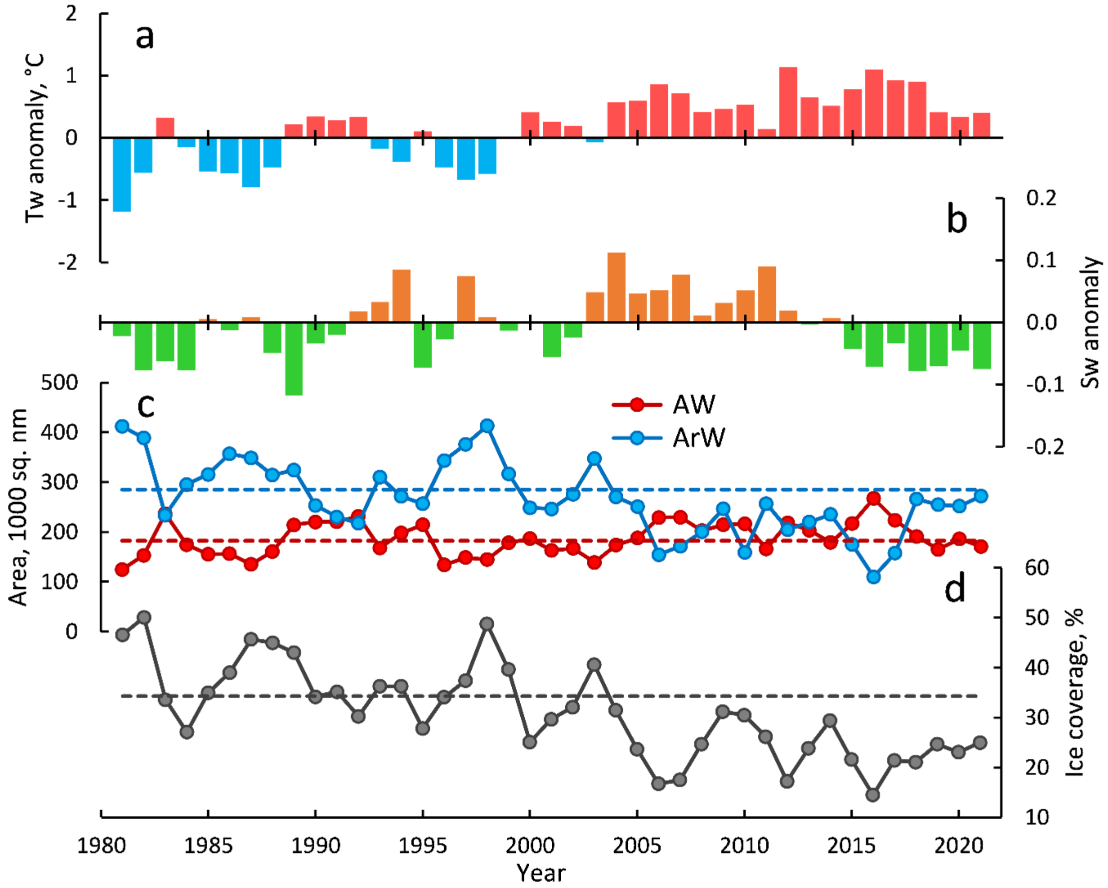


**Figure A4.1: A subset of climate indicators for the Barents Sea: annual mean a) temperature and b) salinity anomalies in Atlantic waters (0–200 m) in the Kola section (Murman Current); c) areas of Atlantic (>3°C, AW) and Arctic (<0°C, ArW) waters in the Barents Sea in August–September, based on 50–100 m averaged temperature; d) annual mean ice coverage of the Barents Sea expressed as a percentage of the total sea area. Dashed lines show the 1981–2010 long term means.**

The Barents Sea has experienced a warming trend since the late 1970s/early 1980s (e.g. Boitsov et al. 2012, Matishov *et al.* 2012, Smedsrud *et al.* 2013, González-Pola *et al.* 2019, Skagseth *et al.* 2020), while becoming colder after 2015-2016 (Figure A4.1). Nevertheless, air and water temperatures in 2021 were still higher than the long term average, being typical of warm years. In the past decades, the area of Atlantic Water (>3°C) has increased in the Barents Sea, whereas the area of Arctic Water (<0°C) has decreased. The strongest rate of change occurred in the early 2000s, with a rapid increase in the Atlantic Water area and a corresponding reduction in the Arctic Water area. The period from 2006-2016 was characterized by a small area of Arctic Water and high variability. After 2016, the Arctic Water area has increased to comparable amounts as in

2004–2005. The situation in 2021 was much similar as to in 2020. The area covered by cold bottom waters (<0°C) turned out to be the largest since 2011.

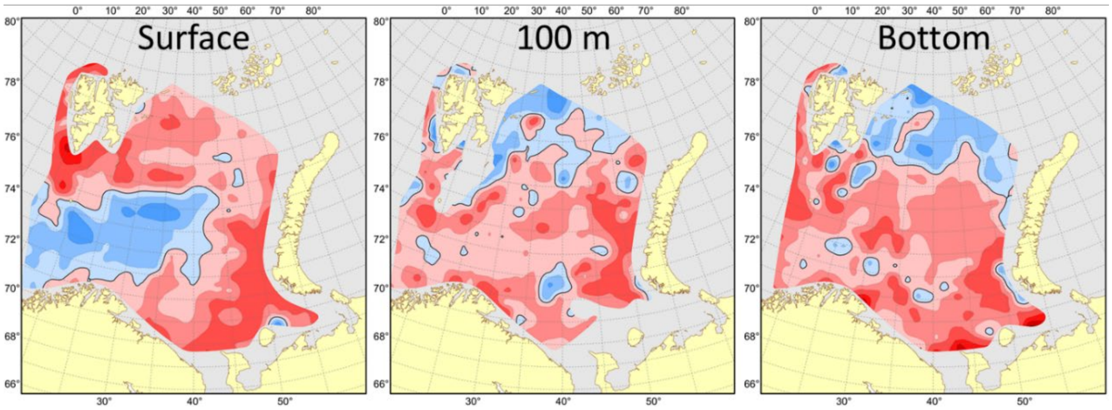


**Figure A4.2: Temperature anomalies (°C, 1981–2010 reference period) in August–September 2021.**

In August–September 2021, surface, deeper, and bottom waters were still warmer than the 1981–2010 mean (by 0.7, 0.5 and 0.7°C on average, respectively) in most of the Barents Sea (from 70% of the surveyed area at the surface to 79 and 77% at a depth of 100 m and near the bottom, respectively). Negative anomalies (about −0.4°C to −0.5°C on average) were mainly found in the southwestern and central Barents Sea at the surface and in the north in deeper and bottom waters. (Figure A4.2). The ice coverage of the Barents Sea has increased since 2016 but was in 2021 still below average (Figure A4.1). Its seasonal maximum occurred in February–March, earlier than usual. There was no ice in the sea from August to October.

## Possible reasons for recent changes

Increasing temperatures upstream in the Norwegian Sea (Ingvaldsen *et al.*, 2021), altered large-scale atmospheric patterns (Smedsrud *et al.* 2013), reductions in sea ice import to the northern Barents Sea (Lind *et al.* 2018), and less cooling within the Barents Sea (Skagseth *et al.*, 2020) are all factors contributing to the general warming and associated reductions in sea ice observed in the Barents Sea since the 1970s. However, the temperatures in the Norwegian Sea have been decreasing over the last decade, resulting in lower temperatures in the warm water flowing into the western Barents Sea since 2015–2016 (Ingvaldsen *et al.*, 2021, ICES 2021). Statistical analysis of the internal structure of the long-term variations in hydrometeorological parameters imply that the temperatures will continue to decline slightly over the next two years (2022–2023), although still remaining relatively high.

# Phytoplankton

## Current status and recent changes

The phytoplankton development in the Barents Sea is typical for a high latitude region with a pronounced maximum in biomass and productivity during spring. During winter and early spring (January–March), both phytoplankton biomass and productivity are quite low. The spring bloom is initiated during mid-April to mid-May and may vary strongly from one year to another.

The bloom duration is typically about 3–4 weeks and it is followed by a reduction of phytoplankton biomass mainly due to the exhaustion of nutrients and grazing by zooplankton. The spring bloom in the Atlantic water domain without sea ice is thermocline-driven, whereas in the Arctic domain with seasonal sea ice, stability from ice-melt determines the timing of the bloom.

Although the NPP of the whole Barents Sea showed substantial interannual variability, there was a marked significant increase during the study period, 1998–2021 (Figure A4.3, $p = 0.001$). Average NPP for the whole Barents Sea was much lower in years 1998–2008 than in the more recent decade 2009–2021 (64.8 and 97.1 Tg C, respectively). The NPP in the western and eastern regions of the Barents Sea increased significantly during the study period ($p < 0.01$), the increase in the northeastern region was up to 5 times larger compared to the southwestern region.

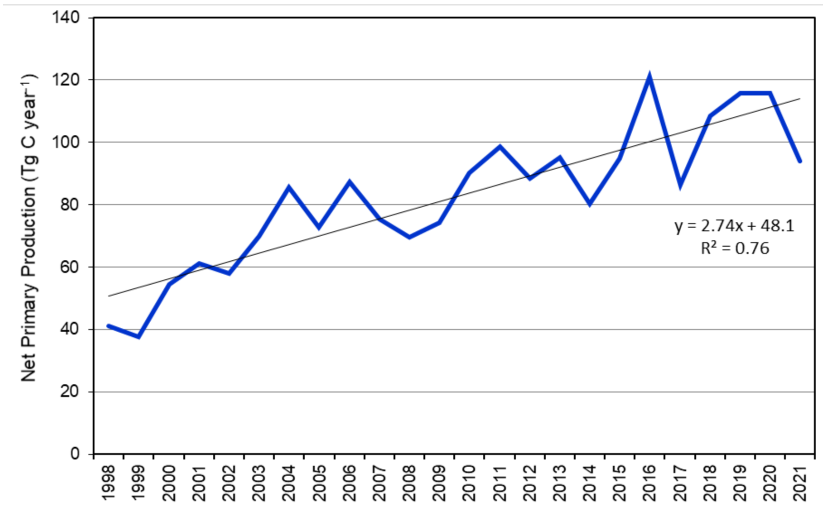


**Figure A4.3: Annual net primary production (satellite based NPP) for the whole Barents Sea.**

## Possible reasons for recent changes

The strong decline in sea ice cover due to warming (leading to more areas with open water and longer period without ice cover) seems to be the key driver of increasing NPP in recent years in the Barents Sea (Dalpadado *et al.* 2020).

# Ice biota

## Current status and recent changes

The proportion of first-year ice and young ice increase at the expense of multiyear ice and result in less complex ice-associated communities (Melnikov *et al.* 2002, Olsen *et al.* 2017, Hop *et al.* 2020). Some species groups have been absent (acoels, flatworms and nematodes) and others greatly reduced (rotifers and ice amphipods) in the ice north of Svalbard in the last decades (Hop *et al.* 2013, Barber *et al.* 2015, Ehrlich *et al.* 2020). Species that are associated with sea ice for most of their life cycle are at risk of extinction or being greatly reduced although there are mechanisms that maintain ice fauna in the water column (Berge *et al.* 2012, Kunisch *et al.* 2020) or at the seabed in shallow areas (Poltermann 1998, Weslawski *et al.* 2010). Changes in the sea ice cover and ice algae production can also have consequences for pelagic foodwebs relying on ice-associated carbon sources (Kohlbach *et al.* 2016, Flores *et al.* 2019, Kohlbach *et al.* 2021).

### Possible reasons for recent changes

Due to high temperatures and low sea ice extent in recent years, the ice coverage of the Barents Sea is expected to remain below normal. Ice-covered areas impacted by warm Atlantic water masses have experienced increased melting of the underside of the sea ice which is for example reflected in a reduced ice algal biomass in the lower part of the ice in the Barents Sea (Barber *et al.* 2015). Reduced ice algal biomass can also explain the reduction of ice amphipods in the Nansen Basin north of Svalbard (Hop *et al.* 2013, Barber *et al.* 2015) or changes in the connection between ice produced in shallow shelf areas and the deep Arctic Basin (Ehrlich *et al.* 2020). With thinner and consequently more mobile ice the loosely attached ice algal communities on the underside of the ice will detach more easily due to the movement of the ice and/or due to the ice drifting into warmer Atlantic water (Assmy *et al.* 2013). The proportion of first-year ice and young ice will continue to increase and species that are associated with sea ice for most of their life cycle are at risk of extinction or being greatly reduced. Earlier ice melting, later freeze-up and a more transparent ice cover will further reduce the relative contribution of ice algae to total primary production and have the potential to increase the frequency and intensity of under-ice phytoplankton blooms (Ardyna *et al.* 2020).

## Zooplankton

### Current status and recent changes

Mesozooplankton play a key role in the Barents Sea ecosystem by transferring energy from primary producers to animals higher in the foodweb. Some decrease in mesozooplankton biomass, mainly in some western and central areas, measured in autumn 2021 could be influenced by high predation pressure due to a large capelin stock, possibly a lower advection of mesozooplankton with inflowing waters into the BS and variation in local production.

Krill indices of biomass have shown increasing trends over recent decades to the increased contribution from M. norvegica in the BS.

### Possible reasons for recent changes

Though the biomass of capelin, the most abundant planktivorous fish has varied considerably, the mesozooplankton biomass has remained rather stable (6–8 g dry wt. $m^{-2}$) in the Barents Sea since the mid-2000s. The ice-free conditions, and subsequent increase in net primary production provide improved feeding conditions for zooplankton, hence, likely leading to more stable biomass levels of mesozooplankton in recent years, even at periods with high predation pressure (Dalpadado *et al.* 2020). This has likely resulted in a weakening of the previously observed negative relationship between capelin and mesozooplankton biomass. If the warming will be persistent and ice-free areas will increase, this may promote further Atlantification (or borealization) of mesozooplankton in the Barents Sea.

# Shellfish

## Current status and recent changes

The snow crab (*Chionoecetes opilio*) is a newly established species in the Barents Sea and was first recorded in May 1996 in the Goose Bank area (Strelkova, 2016). Since then it has increased in both distribution and abundance. The snow crab population hasn't spreading, and its abundance is stable in the Barents Sea.

Northern shrimp (*Pandalus borealis*) is common and widely distributed in the Barents Sea on the depth (25–350 m) muddy flats of the Barents Sea and in temperatures between -0.5–1.5°C. The stock of the northern shrimp is relatively stable. Aggregations of the red king crab (*Paralithodes camtschaticus*) have been shifted eastward and north-eastward last decade, but in 2021 compared 2020 does not have main changes.

# Megabenthos

## Current status and recent changes

The distribution of megabenthos biomass shows relative stable large-scale patterns. Biomass and number of taxa was above long term mean, while abundances were below. High biomass particularly in the southwest; and another, but much more variable, high biomass in the northeast and northwest. In the southeast king crabs increased the biomass north of Kapp Kanin (Figure A4.4). Fluctuation of total biomass of megabenthos is positive correlated with the water temperature on the Kola Sections, but with a time-lag of about 7 years (ICES, 2020). The boreal areas have more increase in biomass compared to the Arctic and Subarctic areas. Combined with the first records of new boreal species in the southwest, this may indicate a long-term change in the seabed ecosystem toward a warming Arctic. This means that the southwest are both warming, experience increasing in biomass and are receiving new boreal species but at the same time, this area also hold sponge-fields that resulted in trawl-catches that exceeded the critical value defined by NAFO. Other VMEs, mostly in the north, should be followed carefully during climate change and species invasion/spreading.

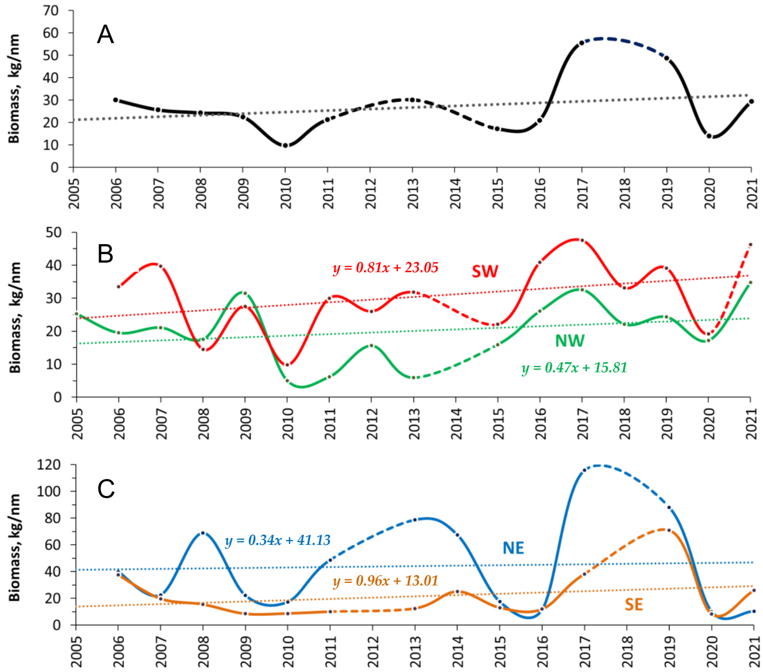


**Figure A4.4: The development of the megabenthos biomass in the Barents Sea (kg/nm) and its inclinations. This is provided as the mean across the entire Barents Sea (upper figure), in the western Barents Sea (the southwest SW, and the northwest NW), in the eastern Barents Sea (northeast NE, and the southeast SE) according to BESS 2005–2021.**

## Possible reasons for recent changes

Fluctuation of total biomass of megabenthos is positive correlated with the water temperature on the Kola Sections, but with a time-lag of about 7 years (ICES, 2020). The boreal areas have more increase in biomass compared to the Arctic and Subarctic areas. Combined with the first records of new boreal species in the southwest, this may indicate a long-term change in the seabed ecosystem toward a warming Arctic.

## Biomass of 0-group fish

### Current status and recent changes

0-group fish are important consumers of plankton and are prey for predators (larger fish, seabirds and marine mammals) and are therefore 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 (1980–2021, Figure A4.5). During 2004–2014, the 0-group biomass was very high, and the fluctuations were largely controlled by cod, herring, and haddock. From 2015 and onwards, the biomass has varied from low and dominated by mainly capelin, to moderate and dominated mainly by cod, although also herring and haddock contributed. In 2020, polar cod constituted almost 1/3 to total 0-group biomasses. In 2021, cod, haddock and herring biomasses were higher than previous three years, although the total 0- group biomass were at an average level and close to 1 million tonnes (Figure A4.5).

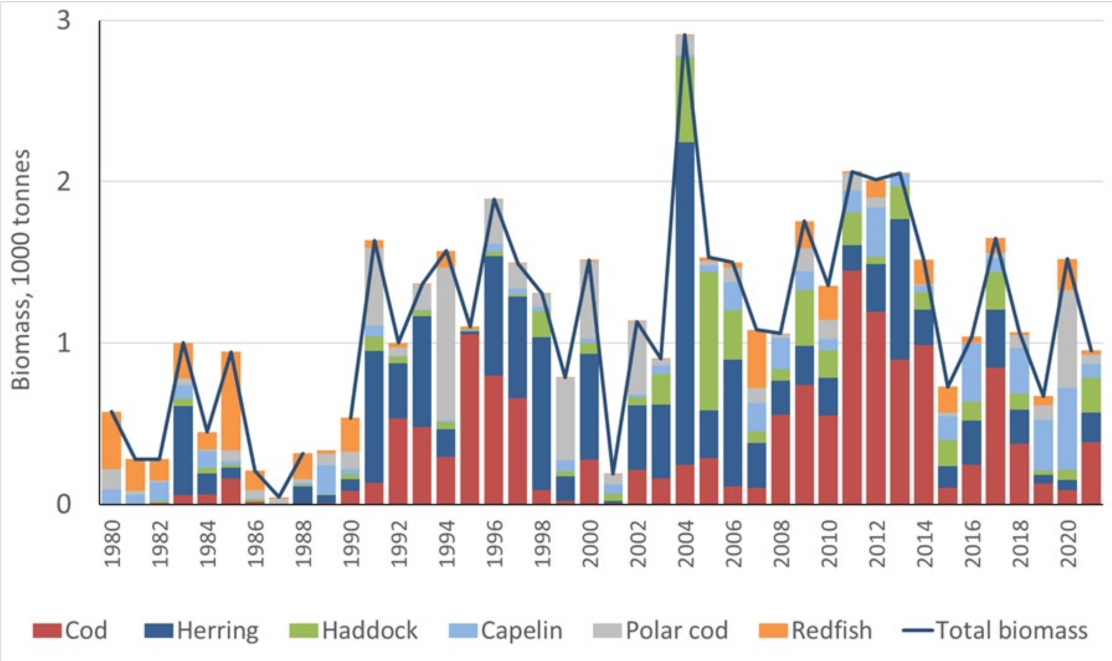


**Figure A4.5: Biomass of 0-group fish species in the Barents Sea, in August–October 1980–2021. The biomass of 0-group fishes for the period 1980–1992 were estimated based on abundance indices and mean fish weight, while it was based on fish biomass from 1993 and onwards. Indices were calculated in SAS software for the period 1980–2017 and in R from 2018.**

# Pelagic Fish

## Current status and recent changes

Capelin (*Mallotus villosus*), young herring (*Clupea harengus*, age 1–4), and polar cod (*Boreogadus saida*) constitute the bulk of pelagic fish biomass in the Barents Sea. During some years (e.g. 2004–2007 and 2015–2016), blue whiting (*Micromesistius poutassou*) also had relatively high biomass in the deeper, western parts of the Barents Sea. Total biomass of the main pelagic species during 1986–2021 fluctuated between 0.5 and 9 million tonnes; largely driven by fluctuations in the capelin stock (Figure A4.6). During 2014–2020, the cumulative biomass of capelin, herring, polar cod, and blue whiting was below the long term average, while in 2021 the cumulative biomass was above the average, and at the same level as in the period 2004–2013. In 2019, the total biomass of pelagic fish in the Barents Sea was at its lowest level over the past 23 years, but the biomass increased considerably from 2019 to 2020 due to strong 2019 year classes of capelin and polar cod. The significant increase in NSS herring biomass was driven by the growth of the 2016-year class.

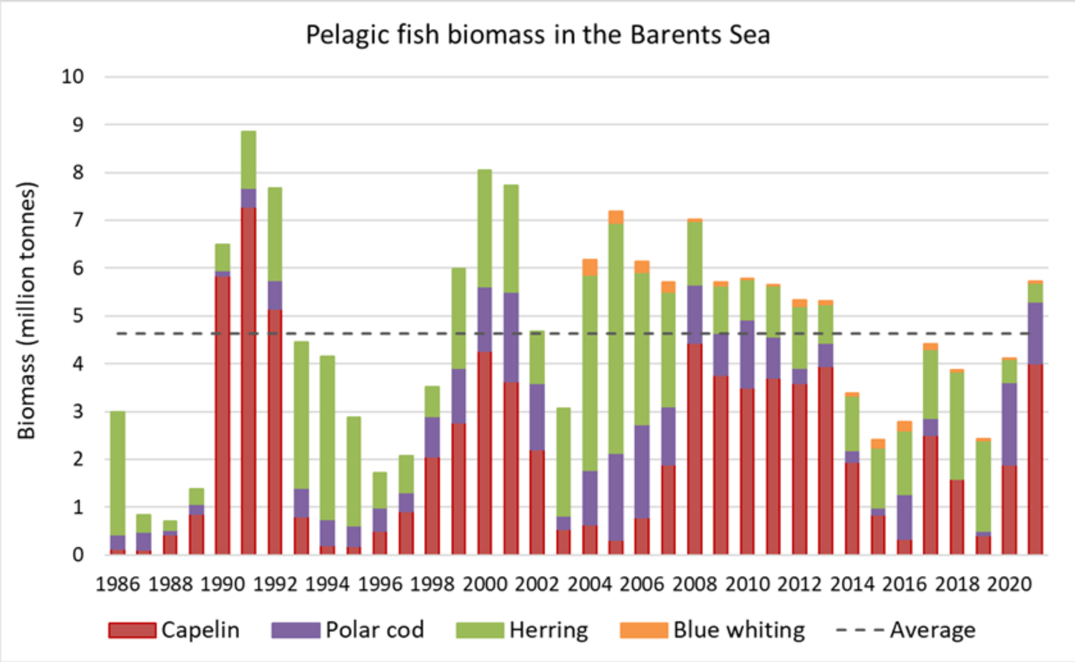


**Figure A4.6: Total biomass of pelagic fish component (excluding 0-group) in the Barents Sea in 1986-2020.**

## Possible reasons for recent changes

While the major stock collapses of capelin in the 1980s, 1990s and 2000s were all mainly caused by recruitment failures (Gjøsæter *et al.* 2016), which propagated through the population, it is more unclear what has caused the recent fluctuations in stock size (Figure A4.5). Inconsistencies in cohort abundance from year to year complicates the analysis of possible reasons for variation in stock size, but the estimates over time suggest increased mortalities at all life stages, indicating that other mechanisms than those involved in the major stock collapses may have been instrumental.

The recent strong recruitment to the polar cod stock in 2016 and 2020 leading to sudden increase in stock size (Figure A4.5) were surprizing, given that the temperatures in the Barents Sea is currently above the long term average and this is thought to hamper polar cod recruitment. However, a slight cooling during recent years may have contributed to the observed increase in recruitment. It is uncertain to what degree a connection between the polar cod in the Barents Sea and polar cod in the Kara Sea may have complicated our picture of the stock development in recent years.

The fluctuating amount of young herring and blue whiting in the Barents Sea (Figure A4.5) is directly connected to the recruitment fluctuation in these stocks, since the Barents Sea serves as nursery area for the juvenile herring and juvenile blue whiting, especially when these stocks recruit rich year classes.

# Demersal Fish

## Current status and recent changes

Most Barents Sea fish species are demersal (Dolgov *et al.*, 2011). Total biomass of cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and saithe (*Pollachius virens*) peaked in 2010–2013 and has declined since; but remains above the long term average for the time-series dating back to 1960 (Figure A4.7). The northeast Arctic cod stock is currently in good condition, with average total stock size, and high spawning-stock biomass. The Northeast Arctic haddock stock reached record high levels in 2009–2013, due to very strong 2004–2006-year classes. Subsequent recruitment has normalized and ten became very poor in the recent three years. The stock remains at a relatively high level and the decline in total stock in recent years was halted to the abundant 2016-year class, but the forecast for 2022 predict a further decline in total stock biomass while spawning-stock biomass is predicted to be stable. Greenland halibut (*Reinhardtius hippoglossoides*) and beaked redfish (*Sebastes mentella*) are important commercial species with large parts of their distribution within the Barents Sea. The fishable component of the Greenland halibut stock (length ≥45 cm) increased from 1992 to 2012 and then stabilized before decreasing slightly in the most recent years. Biomass of deepwater redfish was higher during 2013–2021 than in preceding years. Most of the adult fish are observed in the Norwegian Sea. During the last decade, the deepwater redfish spawning-stock biomass has remained relatively stable around 800 000 tonnes. Among other demersal species, the long rough dab has the highest stock biomass. Overall, cod is the dominant demersal species.

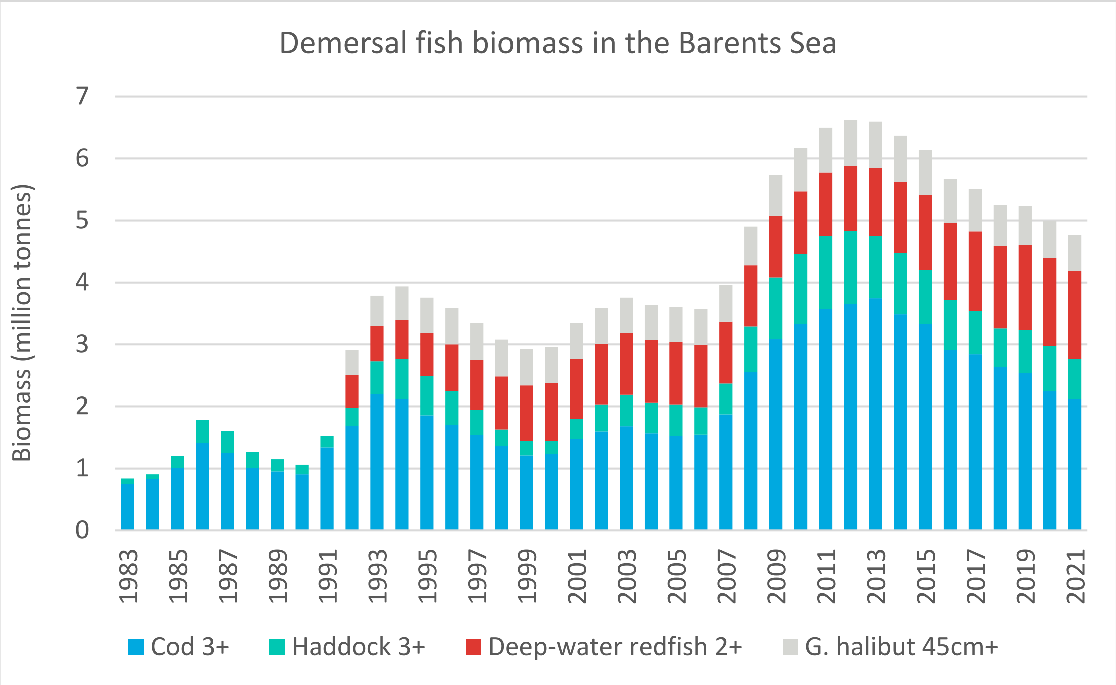


**Figure A4.7: Biomass estimates for cod, haddock, saithe and beaked redfish during the 1960–2020 period from AFWG 2020 (ICES 2020). Note: saithe is only partly distributed in the Barents Sea.**

Cod is the major predator on capelin; although other fish species, seabird and marine mammals are also important predators (Dolgov *et al.* 2011). Capelin is still the most important food item for cod. Importance of euphausiids, hyperiids, polar cod and snow crab has increased in cod diet, while importance of haddock, shrimp and herring has decreased.

Most of the main demersal fish stocks (cod, haddock, Greenland halibut, beaked redfish, long rough dab, saithe) in the Barents Sea are in a healthy state and at a level at or above the long term mean. The exception is the golden redfish stock, which is still depleted.

### Possible reasons for recent changes

Occupation of larger areas and redistribution of higher catches northwards (2004–2009) and north-eastwards (2010–2014 period) was most likely influenced by record high stock sizes, dominated by larger and older fish. During the 2015–2019 period, smaller catches of cod were taken in the northern and eastern areas compared to the 2010–2014 period. Since 2004, ice free areas have generally increased in the northern Barents Sea, increasing areas of suitable habitat for cod and allowing record high production (ICES, 2020). The northern limit of the distribution was shifted southwards from 2017 to 2019 most likely due to reduction of cod stock size. Similar situation was observed for haddock, large stock occupied a larger area in 2004–2009 and since then both stock size and occupation area decreased. Biomass of beaked redfish was higher during 2013–2020 than in preceding years, which most likely influenced an increase in occupation area into the northern Barents Sea that had suitable habitat.

## Seabirds

### Current status and recent changes

About six million pairs from 36 seabird species breed regularly in the Barents Sea (Barrett *et al.* 2002, Fauchald *et al.* 2009). Allowing for immature birds and non-breeders, the total number of seabirds in the area during spring and summer is about 20 million individuals. 90% of the birds belong to only 5 species: thick-billed murre, little auk, Atlantic puffin, northern fulmar and black-legged kittiwake. These birds utilize the intense secondary production that follows the retreating sea ice. Little auks feed mainly on lipid rich Calanus species, amphipods and krill while thick-billed murre and black-legged kittiwakes feed on polar cod, capelin, amphipods and krill. In the Atlantic part of the Barents Sea, the seabirds depend more heavily on fish, including 0-group fish, capelin, I-group herring and sandeels. The shift in diet is accompanied by a shift in species composition. In the south, thick-billed murres are replaced by its sibling species, the common guillemot. Large colonies of Atlantic puffins are found in the southwestern areas are largely sustained by the drift of fish larvae along the Norwegian coast.

Population monitoring in Norway and Svalbard has revealed a downward trend for several populations the last 30 years, including black-legged kittiwakes (Figure A4.8A) and Atlantic puffin (Figure A4.8E) on the Norwegian mainland and thick-billed murre (Figure A4.8F) in Svalbard. The population of common murre was decimated in the 1980s mainly due to a collapse in the capelin stock combined with low abundance of alternative prey. The populations on Bjørnøya and some colonies on the Norwegian mainland have increased since then (Figure A4.8C and A4.8D). The status and trends of the populations of seabirds in the Eastern Barents Sea is less known. In Svalbard, analyses suggest a borealization of the seabird community with an increase in boreal species and a decline in Arctic species (Descamps and Strøm 2021). This observation is corroborated with at-sea observations showing a northward spatial displacement of several species.

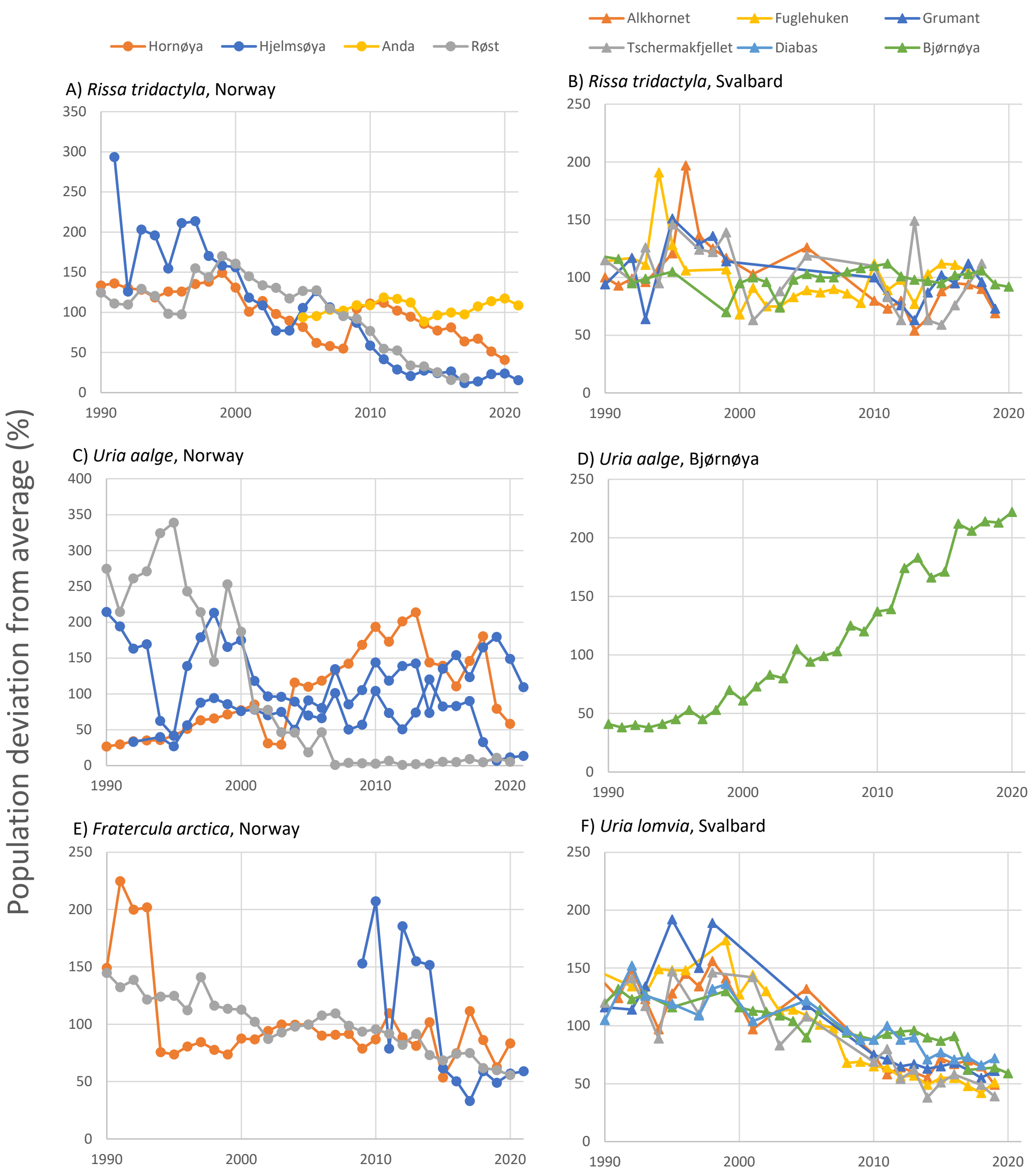


**Figure A4.8: Seabird population fluctuations in SEAPOP monitoring sites on the Norwegian mainland (left panel) and Svalbard (right panel). Data sources: Miljøovervåking Svalbard og Jan Mayen -MOSJ (www.mosj.no, updated 2022), SEAPOP (www.seapop.no, updated 2022).**

## Possible reasons for recent changes

The changes in the populations of seabirds in the Barents Sea is most likely due to changes in the availability and abundance of prey. The populations of Brünnich's guillemot and black-legged kittiwake migrate out of the Barents Sea during winter, and the decline in these populations could also be related to the situation in their wintering area in the Northwest Atlantic.

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# Marine mammals

## Current status and recent changes

In the Barents Sea about 15 cetacean species, 7 seal species and the polar bear can potentially be observed. The white-beaked dolphin is the most common cetacean species to be seen within the Barents Sea as it is distributed all over the area. Especially minke whales, but also fin whales, are distributed over large parts of the Barents Sea. Humpback whales have much more aggregated distributions north and west of Hopen and around Bear Island, and these locations are also shared by the other baleen whale species.

Summarized over the years 2004–2019, the odontocete species white-beaked dolphin and the baleen whale species minke, fin and humpback whales have completely dominated the cetacean fauna in the Barents Sea. However, different regions of the area can be characterized in different ways: In *northwest* (Svalbard area) we find the highest densities of cetaceans and especially the baleen whales besides the white-beaked dolphin; this is also an important capelin and euphausiid area. In *southwest* (Bear Island, coastline Norway-Russia) we find a productive area with high concentrations of euphausiids and juvenile fish of haddock, cod, herring, redfish and capelin. The white-beaked dolphin is dominant here but also minke and fin whales are abundant here. Along the slopes we also find sperm whales. In *northeast* (Novaya Zemlya, Franz Yosef Land) the area is dominated by polar cod, cod and capelin. This area has a lower abundance of cetaceans, mostly represented by white-beaked dolphins, minke and humpback whales; however, harp seals are important part of the fauna here. In *southeast* (Pechora Sea) there has been a lower number of observations than in the other subareas and the characteristic species are white-beaked dolphins, minke whale and harbour porpoises. This area is dominated by polar cod, cod and herring.

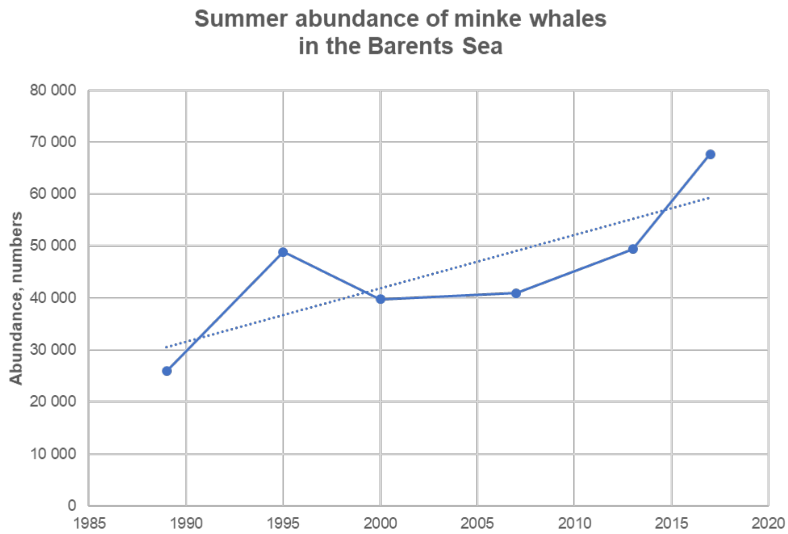


**Figure A4.9: Summer abundance of minke whales in the Barents Sea. Data sources: Solvang *et al.* 2021.**

Monitoring of walrus and polar bears shows post-conservation growth (mosj.no), but sea ice habitat loss due to a warming climate is a serious threat to all ice-associated marine mammals. Declines in Arctic sea ice and associated environmental changes have been linked to shifts in species distribution. In 2015, an aerial survey was carried out to estimate the abundance of Arctic endemic whale species in the marginal ice zone north of Svalbard. Bowhead whales were generally found close to the ice edge, while the narwhals were found deep into the ice (Vacquié-Garcia *et al.*, 2017).

Passive acoustic monitoring (PAM) data from the Fram strait suggests that bowheads and narwhal are present inside the ice all year-round (Stafford *et al.* 2012, Ahonen *et al.* 2017,2019). In 2018 the first aerial survey of white whales covering the entire Svalbard area was conducted (Vacquié-Garcia *et al.* 2020) and the stock size was estimated to 549 individuals (95% CI: 436-723). In recent years, there have also been several reports of ringed seals resting on land, which has previously been uncommon for this very ice-dependent species. There have even been registrations of ringed seals grouped together with harbour seals (*Phoca vitulina*) on land, which is a development no one had anticipated in connection with climate change and the lack of sea ice for this species (Lydersen *et al.*, 2017). Identifying marine mammal hotspots and areas of high species richness is essential to help guide management and conservation efforts. A recent major study (Hamilton *et al.* 2021) summarizes the deployment of 585 satellite transmitters on 13 species of marine mammals in the Greenland- and northern Barents Seas from the period 2005–2018 and shows that parts of the study area, especially the northernmost parts, are to be regarded as "hot spot" areas for these marine mammal species

## Possible reasons for recent changes

The northern boundary of cetacean observations within the Barents Sea varies from year to year; this is probably due to the capelin abundance and capelin distribution. From dedicated cetacean sighting surveys, the summer abundance of minke and humpback whales within the Barents Sea have increased since about 2000s and remained at a high level of abundance (Figure A4.9). The observed changes are primarily linked to an increased abundance of baleen whales within the Barents Sea ecosystem. So far, the reasons behind are unrevealed but analyses are continuing.

Walruses (*Odobenus marinus*) were once highly abundant in the Svalbard archipelago, but 350 years of unregulated harvest brought them to the brink of extinction before they were protected in 1952. The population remains Red Listed as "vulnerable" today and following several decades of protection one can now see a clear growth in the population (mosj.no). The intensive hunting of polar bears (*Ursus maritimus*) in Svalbard began around 1870, and the population was at low levels when the species was protected from 1973. The following years the population probably increased considerably, and newer data indicates that the population has not likely been reduced the last 10–15 years, despite a large reduction in available sea ice in the same period (mosj.no). Climate change is affecting different species at different rates. The sudden sea ice decline in 2006 had an impact on the spatial overlap and the predator–prey relationship between polar bear and ringed seal (*Pusa hispida*) (Hamilton *et al.* 2017).

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