Barents Sea in 2021: based on the IMR annual ecosystem survey and Barents Sea Opening and Vardø-N section

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Vidar Lien, Elena Eriksen, Elizabeth Jones, Randi Ingvaldsen, and the IMR ecosystem survey team lead by Gro van der Meeren

Barents Sea: an inflow shelf to the Arctic in change
Multiyear ice decrease and seasonal ice zone expand

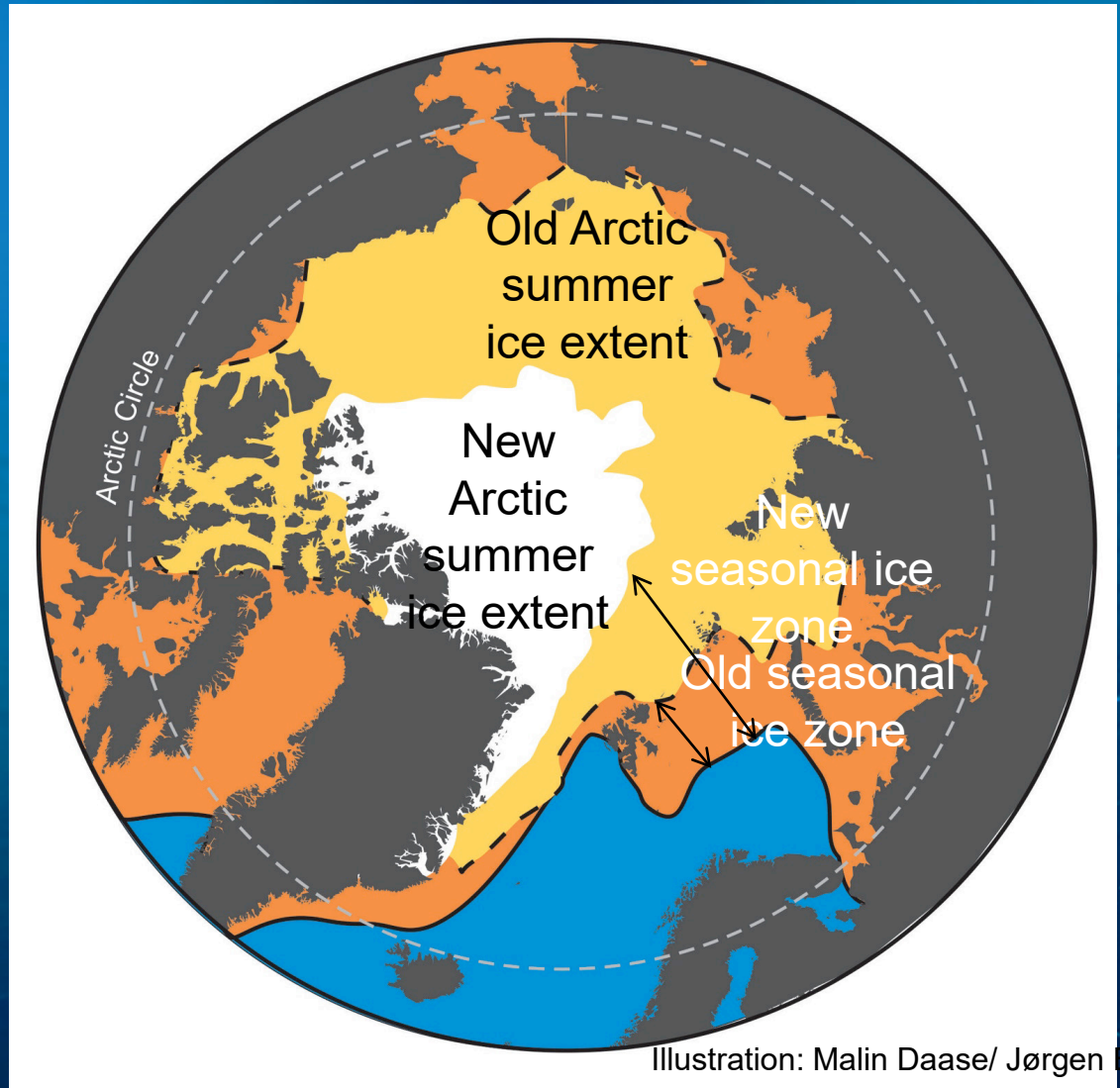


Illustration: Malin Daase/ Jørgen Berge

Changing sea ice zone has large implications for the northern Barents Sea system

- For example:
- Heat and gas fluxes
- Biogechemical processes
- Ocean acidification

INSTITUTE OF MARINE RESEARCH

the Nansen LEGACY

Atlantification: Decreased winter sea ice cover caused by inflow of warm Atlantic water reaching the surface ocean that delay sea ice formation in winter

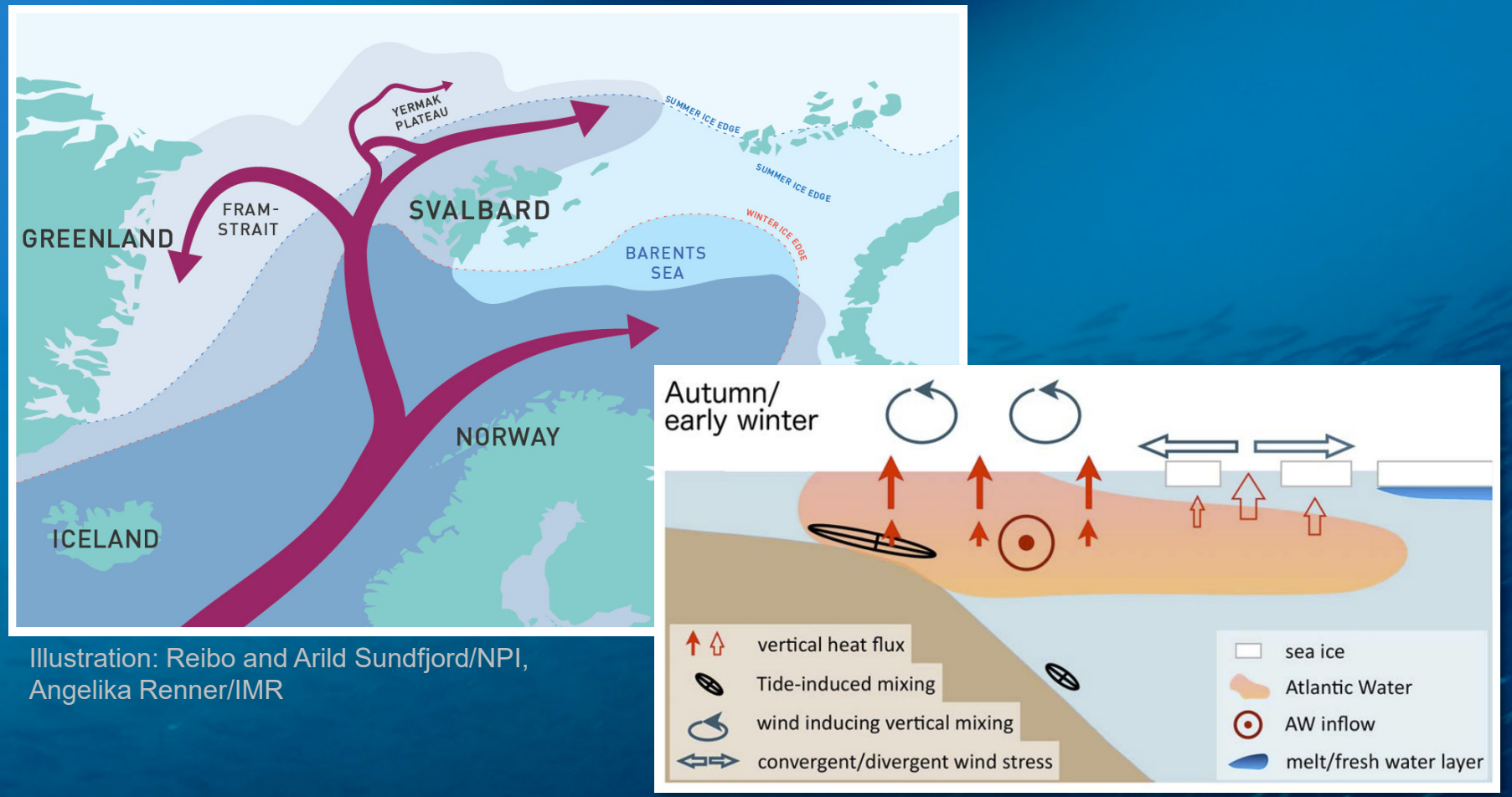


Illustration: Reibo and Arild Sundfjord/NPI, Angelika Renner/IMR

Renner et al. (2018)
J Geophys Res Oceans

Ecosystem changes

nature climate change

LETTERS

PUBLISHED ONLINE: 18 MAY 2015 | DOI: 10.1038/NCLIMATE2647

Recent warming leads to a rapid borealization of fish communities in the Arctic

Maria Fossheim[1]*, Raul Primicerio[2], Edda Johannesen[1], Randi B. Ingvaldsen[1], Michaela M. Aschan[2] and Andrey V. Dolgov[3]

Warming has lead to a change in spatial distribution of fish communities, with boreal communities expanding northwards!

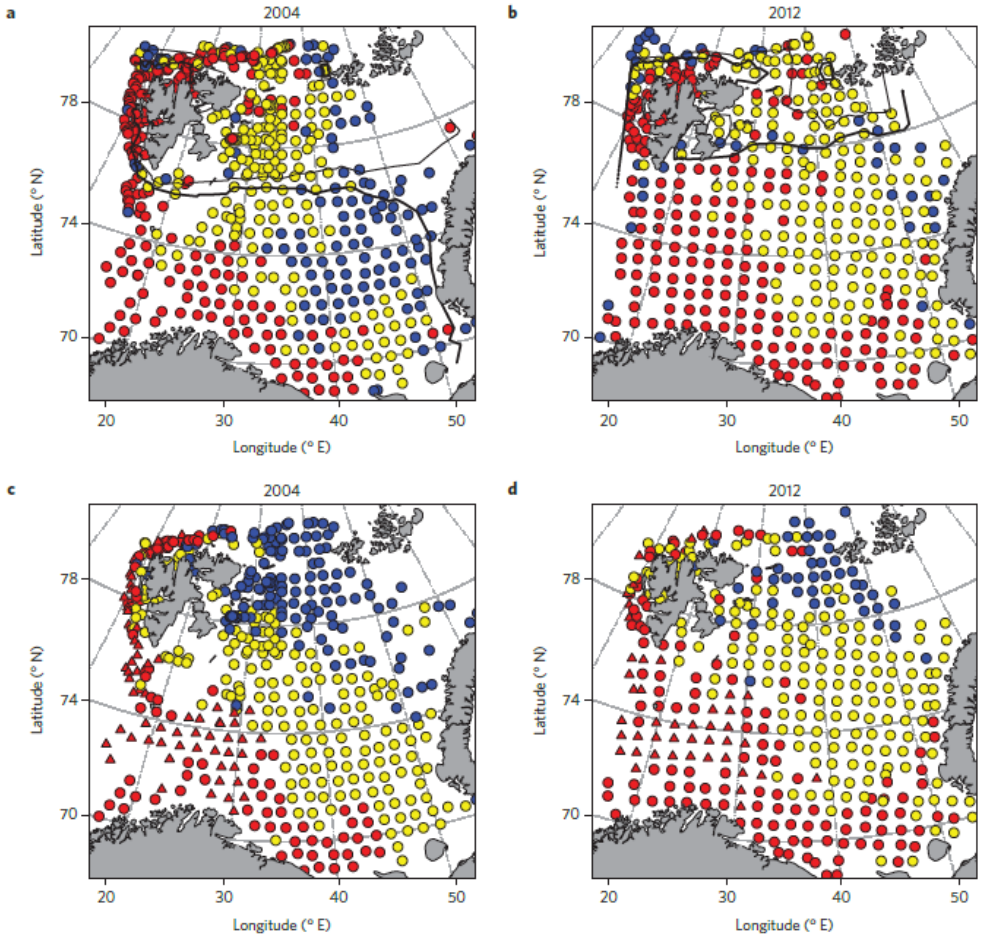


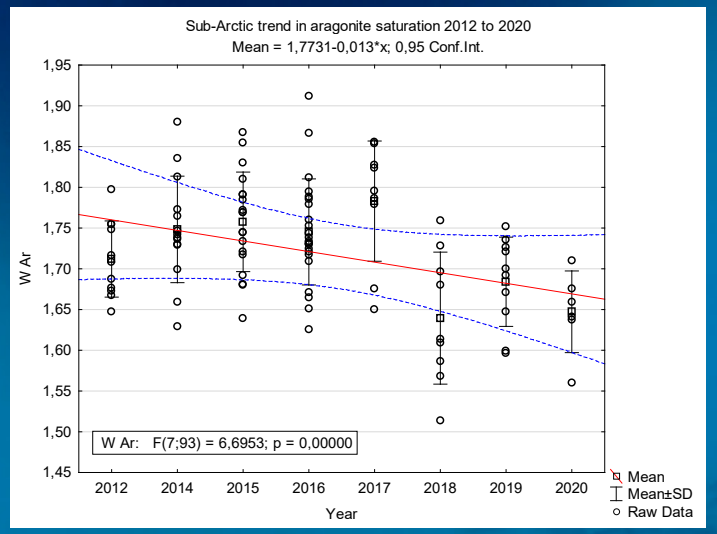
Figure 1 | Environmental conditions and fish communities in the Barents Sea. a,b, Water masses and ice presence in 2004 (**a**) and 2012 (**b**): Atlantic Water (red, $T > 2$ °C), Arctic Water (blue, $T < 0$ °C) and mixed-water masses (yellow, 0 °C $< T < 2$ °C). Ice-presence isolines are given in number of days with ice present during the year: 120 days, bold line and 180 days, fine line. **c,d**, Fish communities identified on bottom trawl stations in 2004 (**c**) and 2012 (**d**). Atlantic, Arctic and Central communities: red, blue and yellow symbols, respectively. Circles: shallow sub-communities, triangles: deep sub-communities. Maps for all years in Supplementary Figs 4 and 7 (Supplementary Methods).

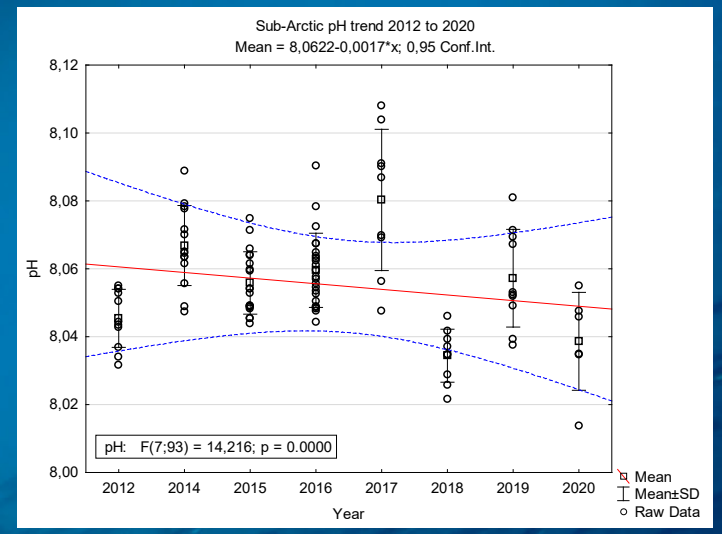
Ocean acidification follow the anthropogenic atmosperic CO_2 increase. Barents Sea time serie pH trends: work in progress.

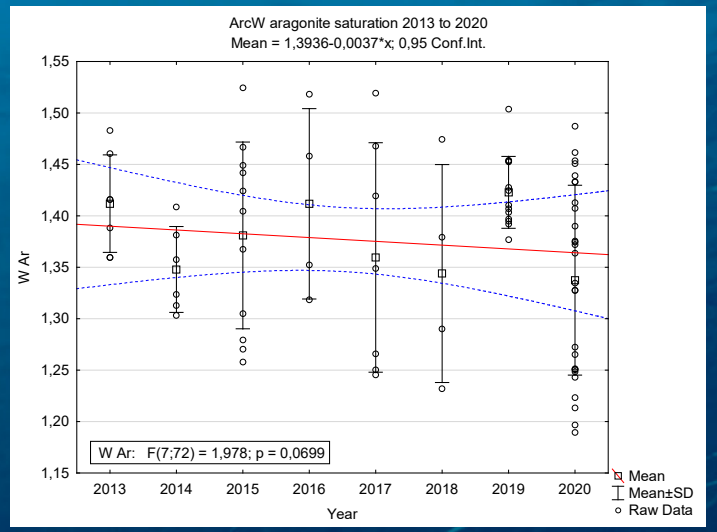
- Mean values for the Arctic core water mass (T<0 °C, >40m) were calculated in the area between 76-80 °N, 20°E to 34 °E, Sub-Arctic (T>2°C)

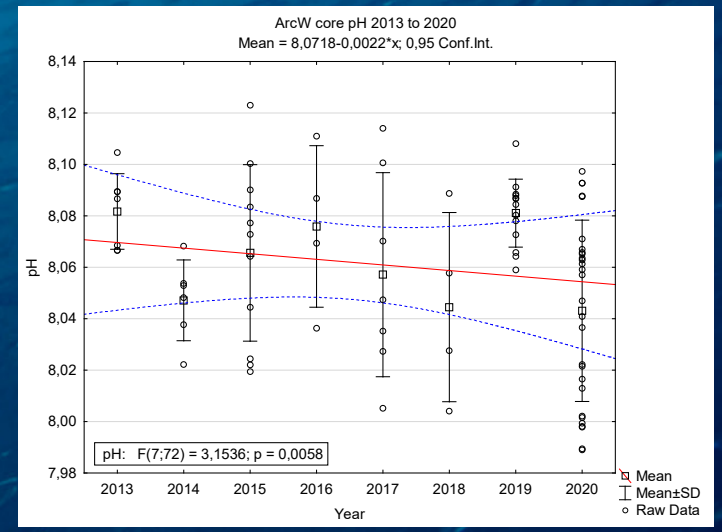
Arctic water: 2013 to 2020 shows a trend of decreasing pH of 0.0022 yr^{-1} and ΩAr of 0.0037 yr^{-1}

Sub-Arctic /Atlantic (T>2°C): 2012 to 2020 shows a trend of decreasing pH of 0.0017 yr^{-1} and ΩAr of 0.013 yr^{-1} , generally follow
expected decrease from atmospheric CO_2 increase due to human activities





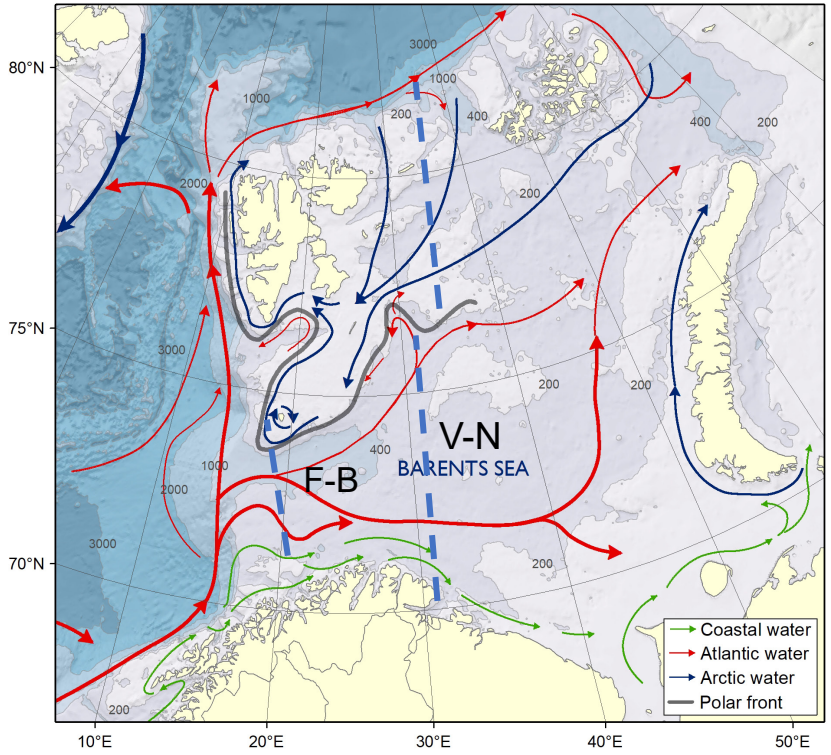




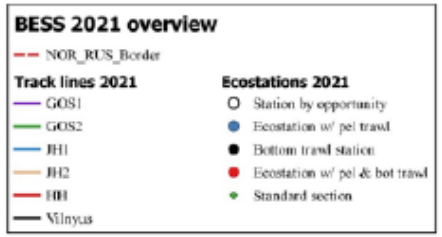
Chierici et al., In: Siwertsson and Arneberg report

IMR cruises in 2021 focus on the Barents Sea: Time serie sections and Ecosystem survey (BESS)
Fugløya-Bjørnøya and Vardø-North section covers coastal, Atlantic and Arctic water

V-N: time series since 1965, chem: 2011



Barents Sea Ecosystem surveys: started 2004, based on long-term NOR-Russian collaboration



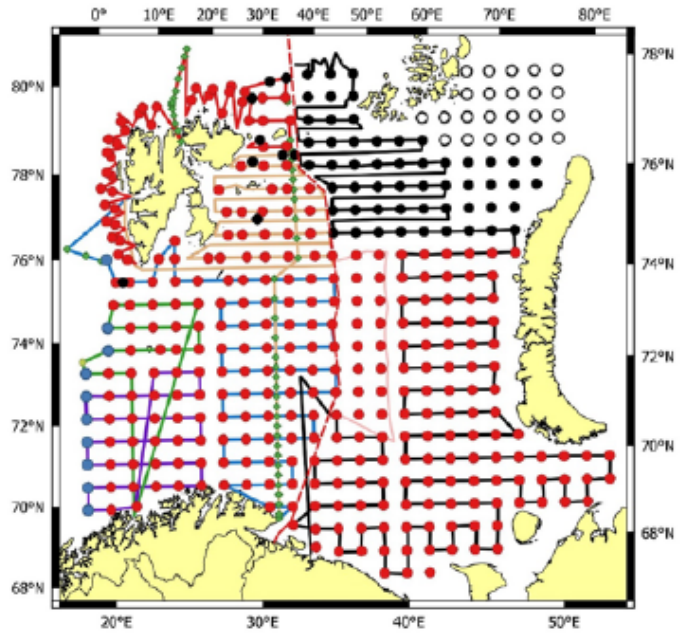


Figure 2.1 BESS 2021, planned survey map with ecosystem stations and vessel tracks.

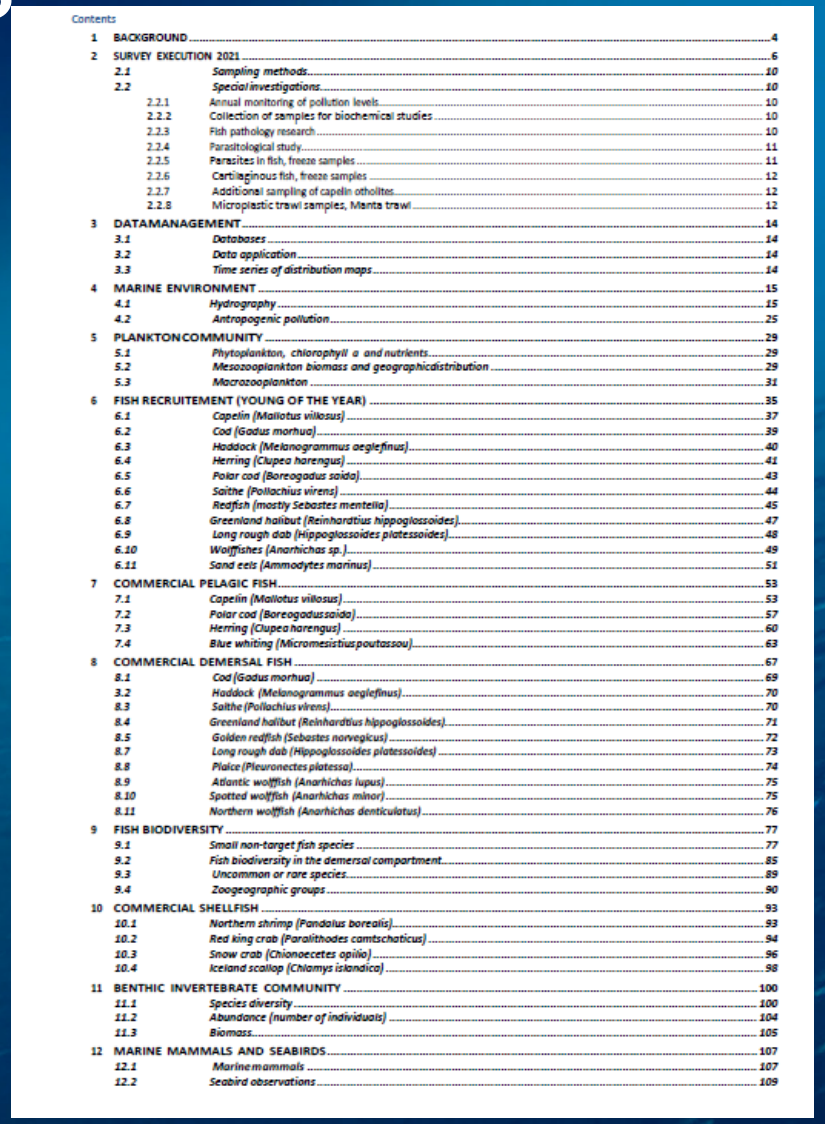
- V-N focus on physical and chemical oceanography
- BESS on biological topics (fish, zooplankton, ecosystem)

Sampled parameters

V-N and F-B + BESS

Salinity
Temperature
Nutrients (NO2, NO3, PO4, Si)
Total alkalinity (AT)
Total Dissolved inorganic carbon (DIC)
→ Derived pH and $CaCO_3$ saturation (Ω)
Dissolved oxygen (some cruises)
Chlorophyll a, phaeopigments
Zooplankton biomass
Phytoplankton biomass

Additional BESS 2021



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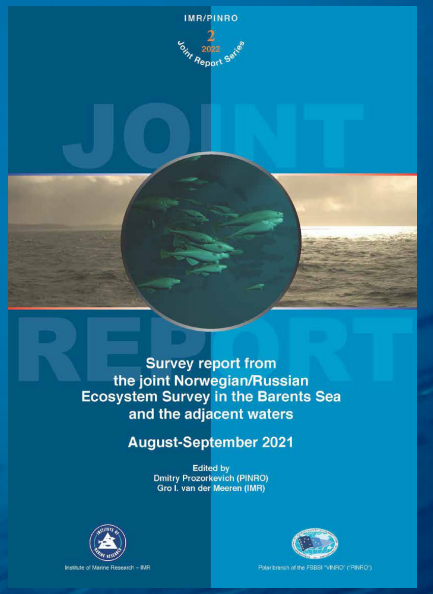
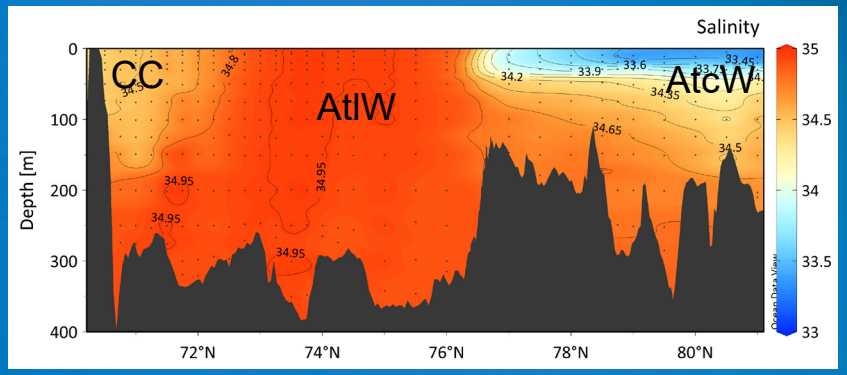
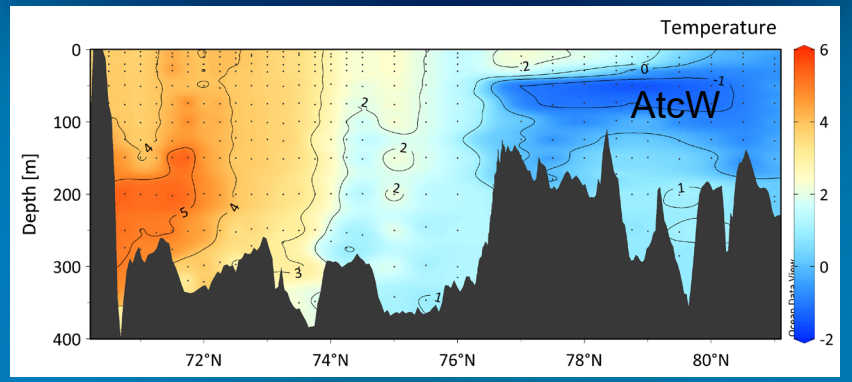
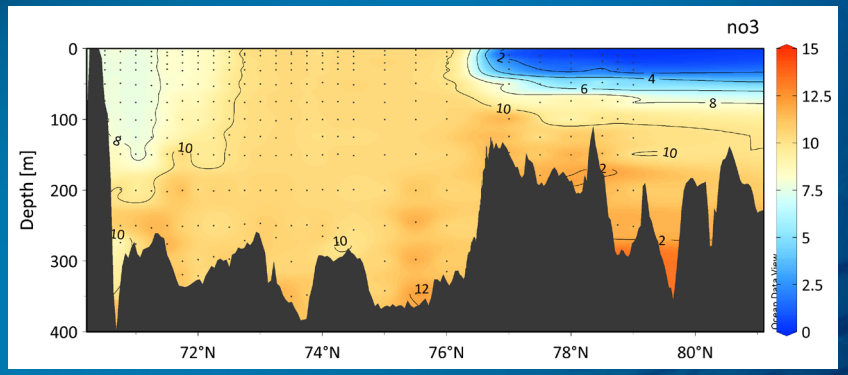


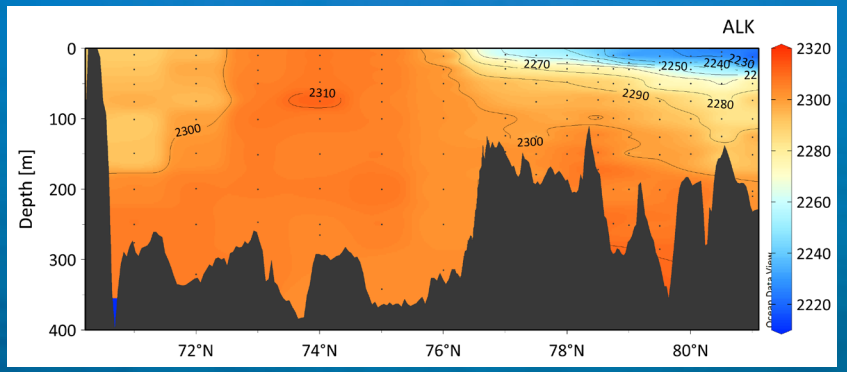
Vardø-North section contrasts between Atlantic water (T>2 °C, warmer more saline and higher AT, DIC. nitrate and Arctic water (cold and fresher, lower AT, DIC and nitrate).

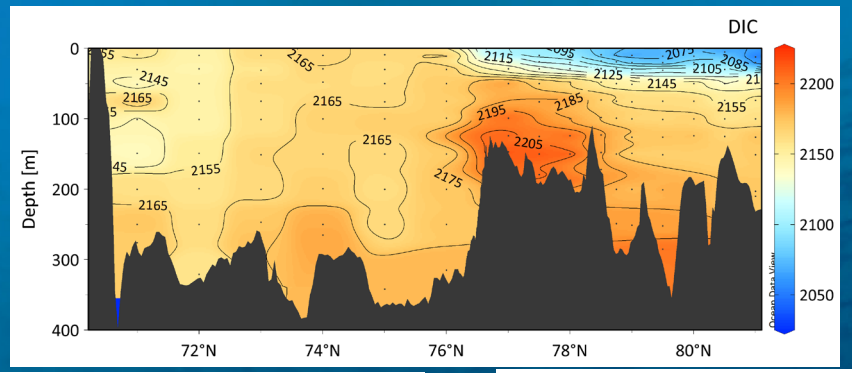
Deep water canyons show accumulation of carbon and nutrients→ lowest ΩAr and pH, high pCO2 and DIC

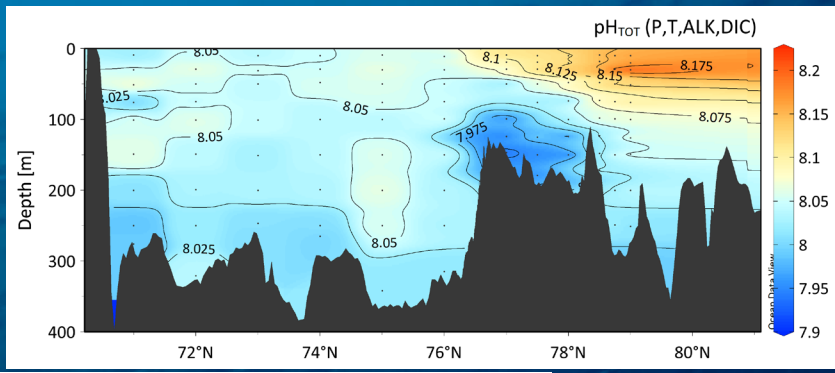


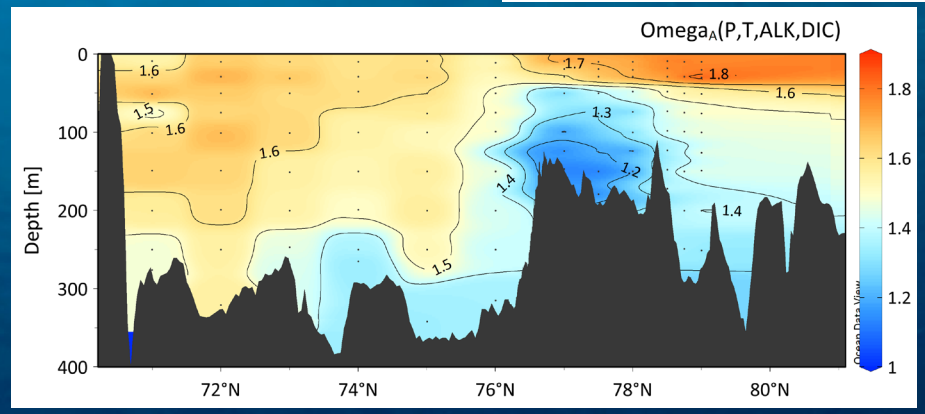


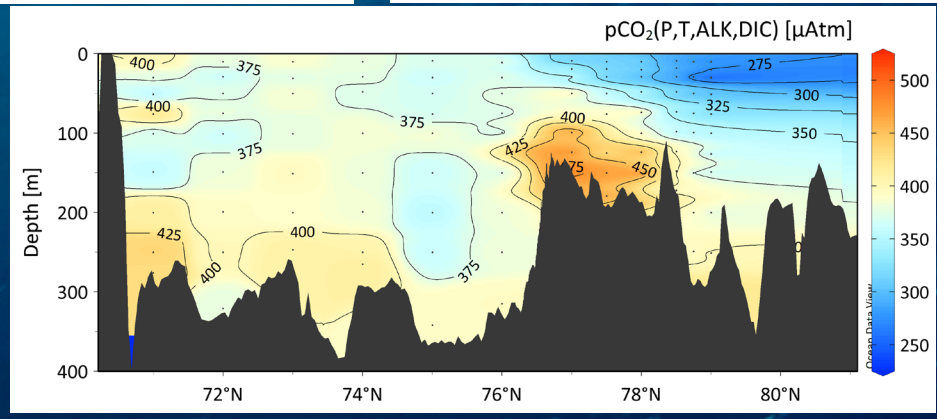






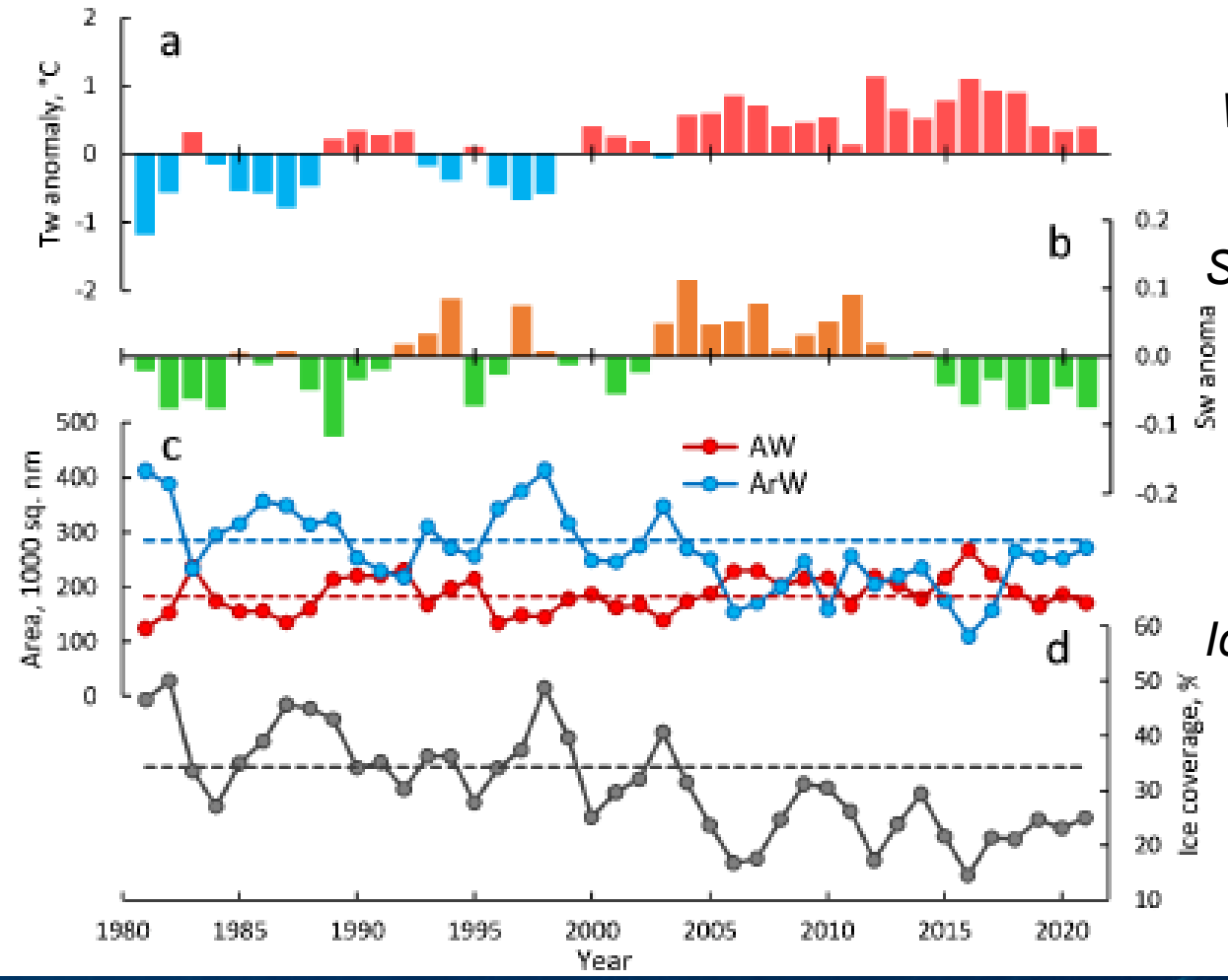






Year 2021 in a long-term context (1980-2021)

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.



Warming since2000, little less warm in 2021

Salinity changes different periods: fresher in 20

Ice coverage still low but increased since 2016

ICES. 2022. Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). ICES Scientific Reports. 4:50. 235 pp. http://doi.org/10.17895/ices.pub.20051438

BESS 2021: IMR-VNIRO ecosystem survey: divide into biogeographical regions→ focus on the fish recruitment and ecosystem change→ Annual report content list show variables, report to several ICES WG groups

IMR-VNIRO Ecosystem survey's cover the whole Barents Sea: focusing on fish resources: since 1950's, but annually since 2004. Highly productive area: Main area for Norwegian and Russian fisheries >50 yr Norwegian-Russian collaboration

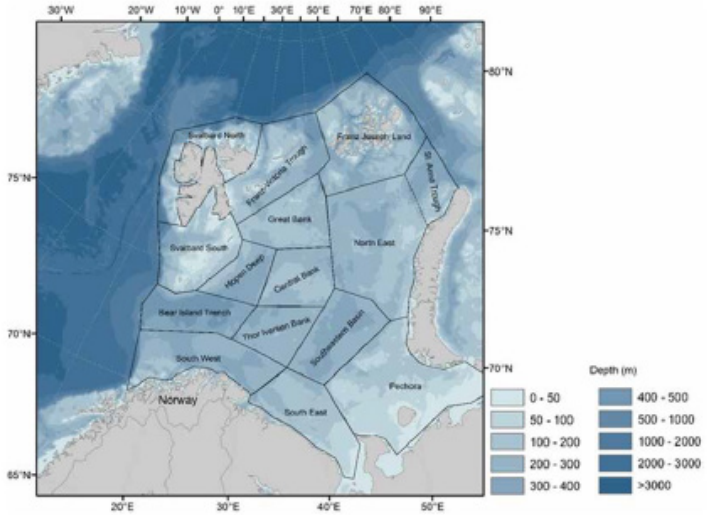


Figure 6.2. Map showing subdivision of the Barents Sea into 15 WGIBAR-subareas (regions) used to calculate estimates of 0-group abundance based on the BESS.

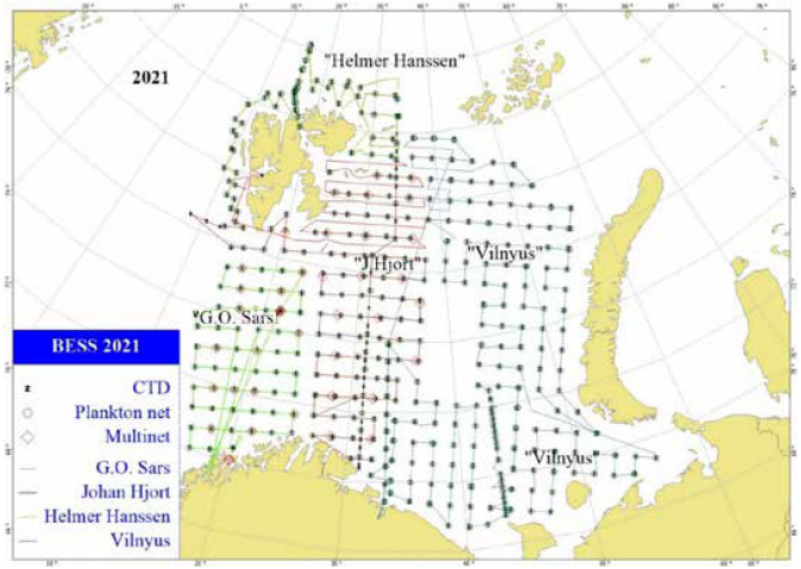
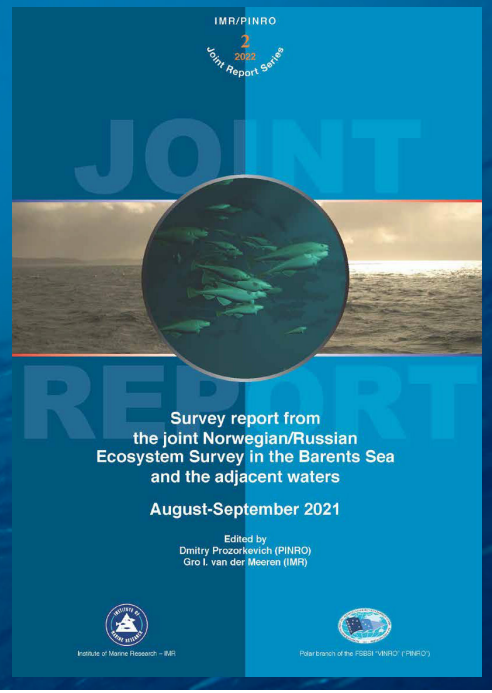


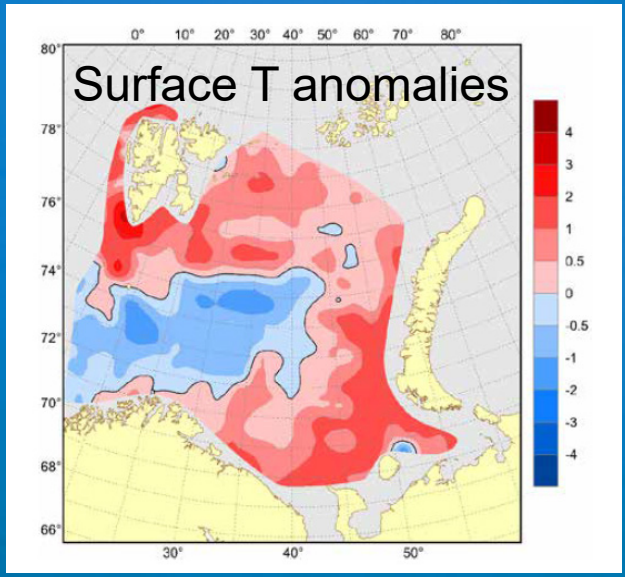
***Figure 2.3** BESS 2021, realized vessel tracks with hydrography and plankton samples at ecosystem stations.*

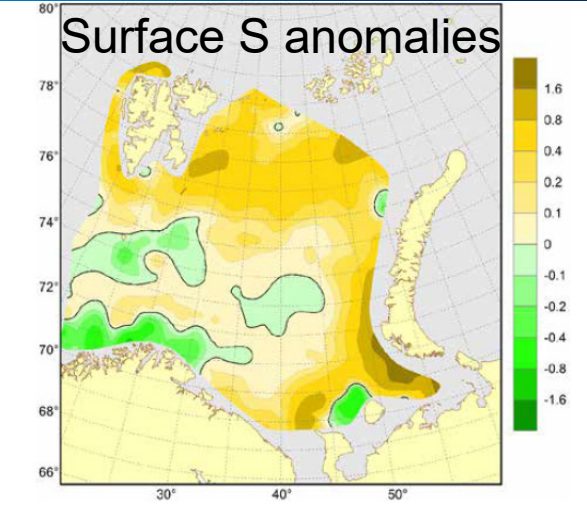


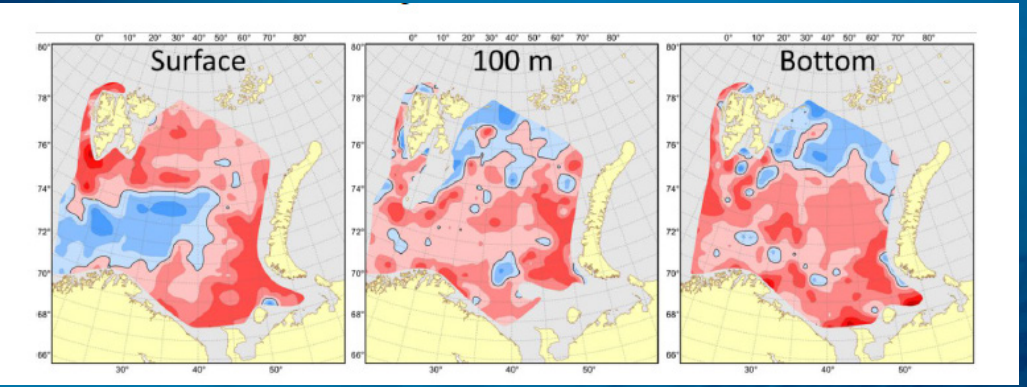
The 19-th joint Barents Sea autumn Ecosystem Survey (BESS) was carried out during the period from 15-th August to 03-th October 2021 by the Norwegian research vessels: "G.O. Sars", "Johan Hjort", and "Helmer Hanssen", and the Russian research vessel "Vilnyus". Exchange of Russian and Norwegianexperts 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.

ICES. 2022. Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). ICES Scientific Reports. 4:50. 235 pp. http://doi.org/10.17895/ices.pub.20051438

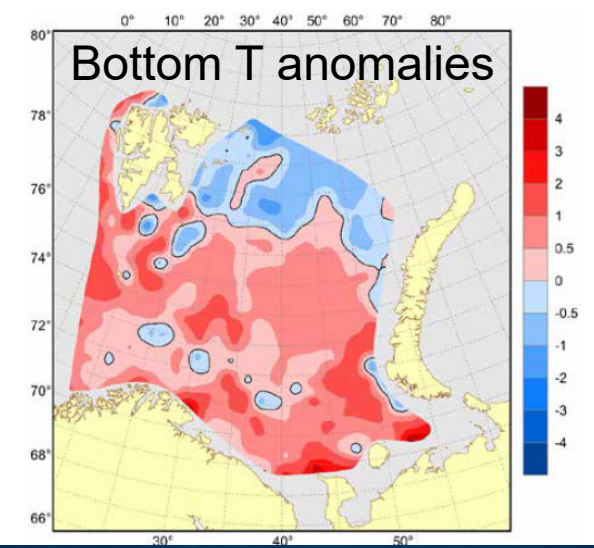
Physical condition in 2021: continued loss of sea ice cover, cooler and fresher surface water in the Atlantic domain, warmer and more saline in Arctic domain: bottom warmer and fresher in south, cooler and fresher in the north

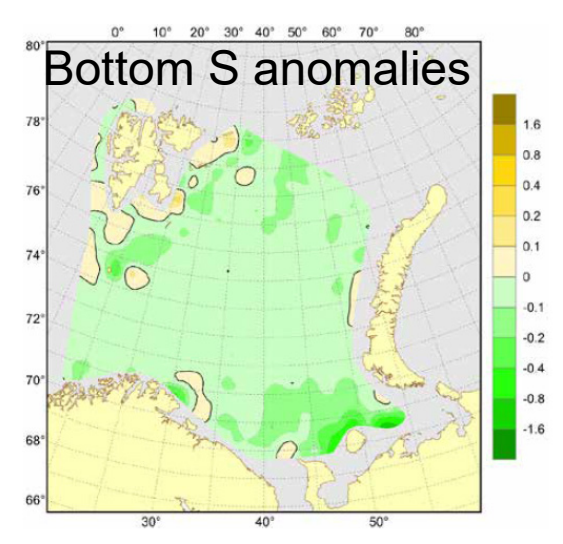


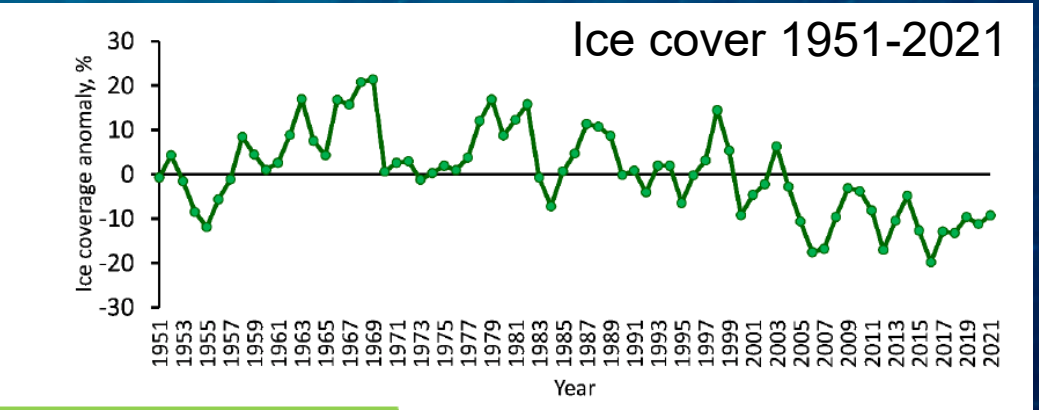




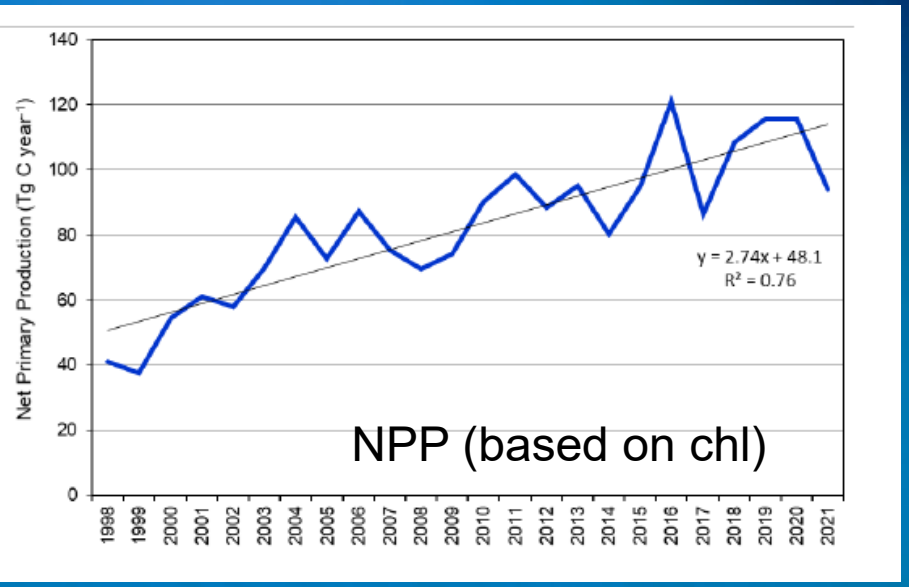
T anomal 1981-2010, Aug-Sept 2021

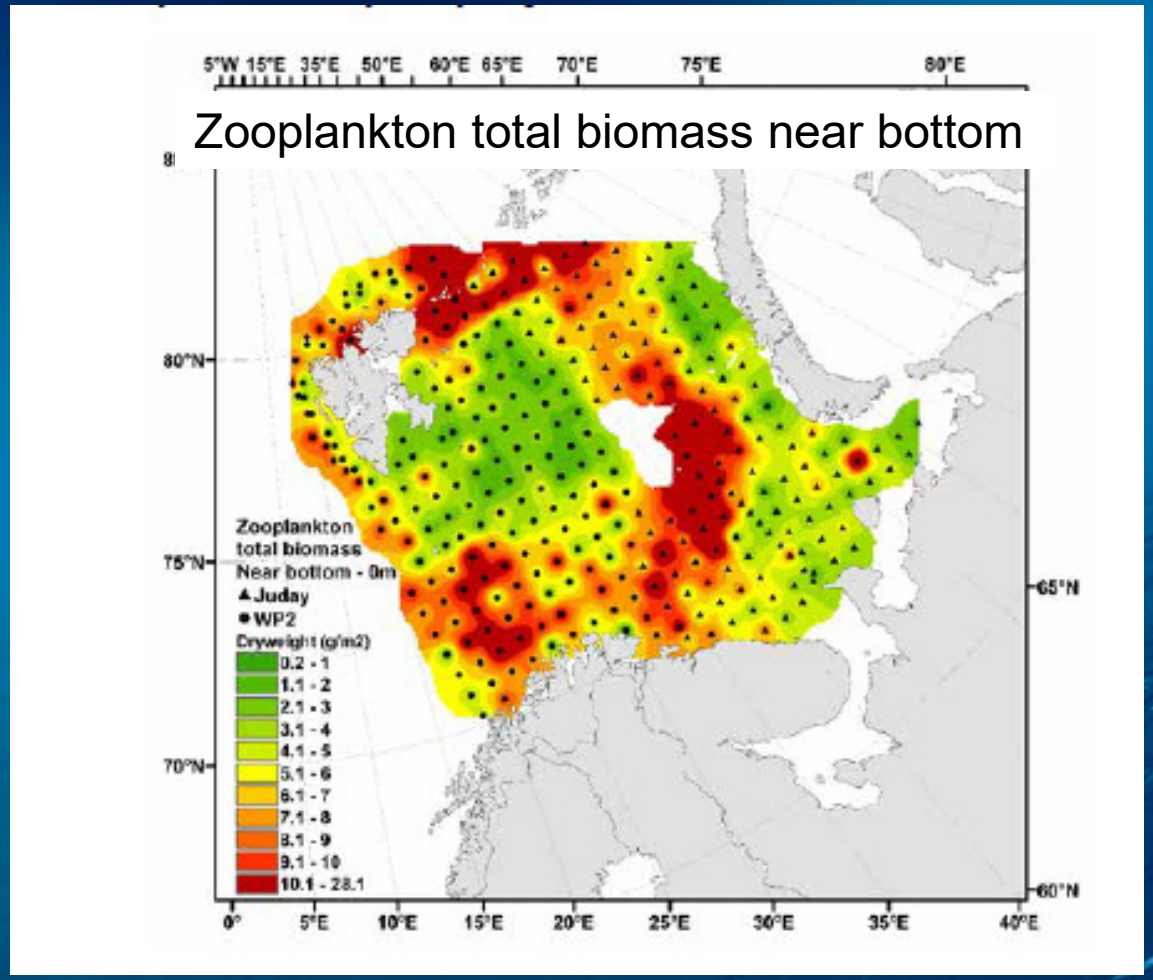






Other examples of results from BESS 2021





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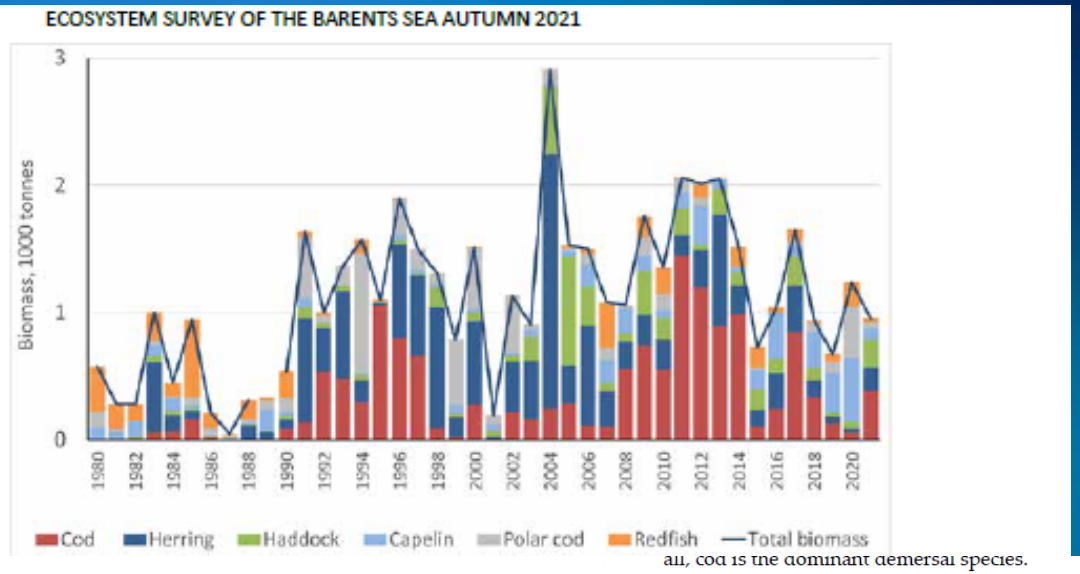
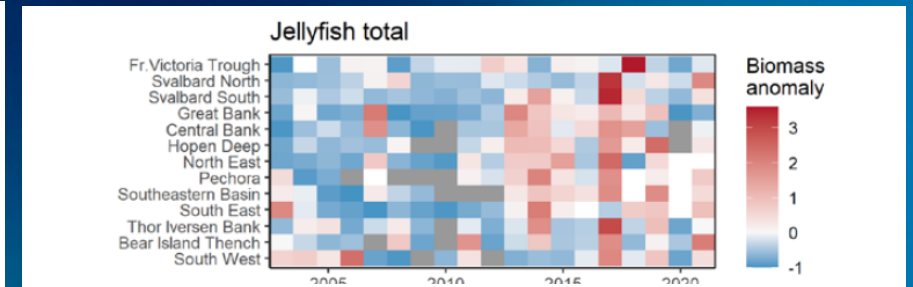
Continued: BESS 2021



Biomass of 0-group fish based on long-term trend 1980-2021



Spatial and temporal distribution of jellyfish 2003 to 2021

all, cod is the dominant demersal species.

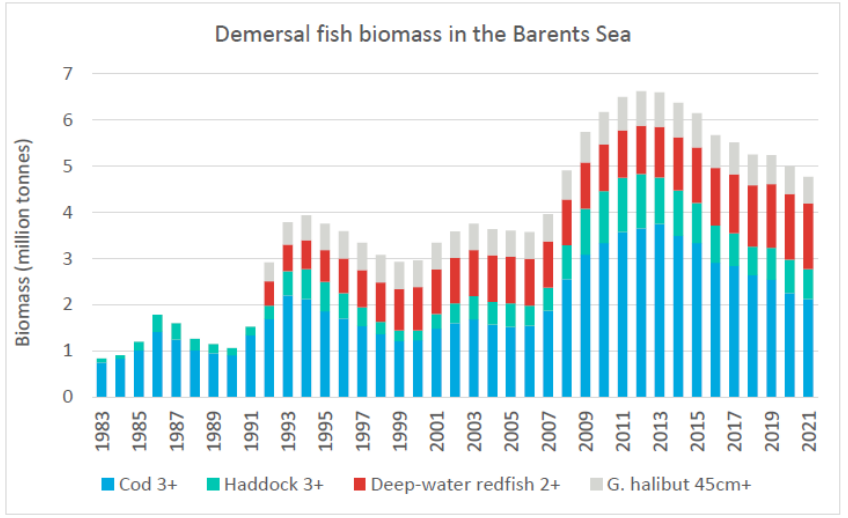
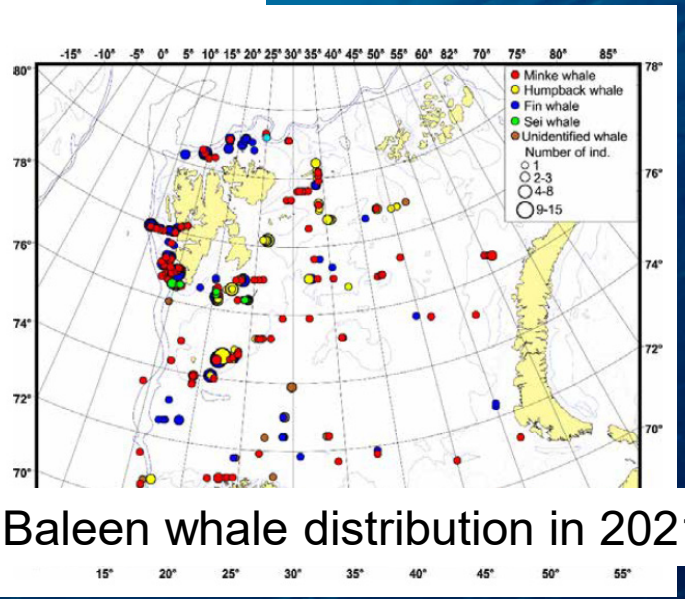


Figure A4.7: Biomass estimates for cod, haddock, saithe and beaked redfish during the 1960–2020 period from AFWG 2020 (ICES 2020). Note: saithe is only partly distributed in the Barents Sea.



Baleen whale distribution in 2021

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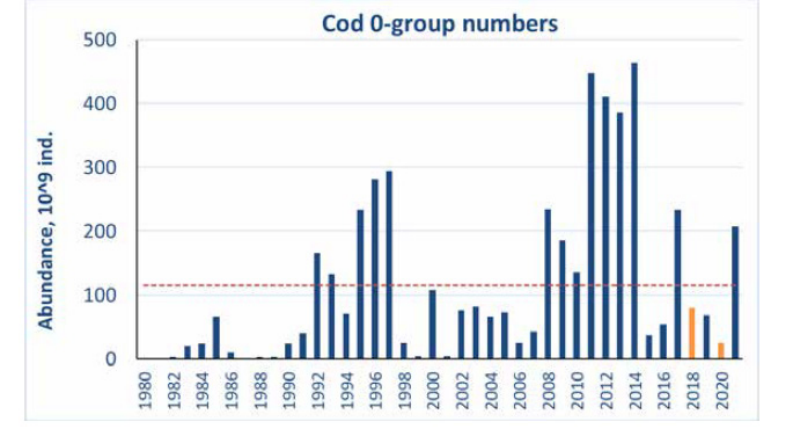
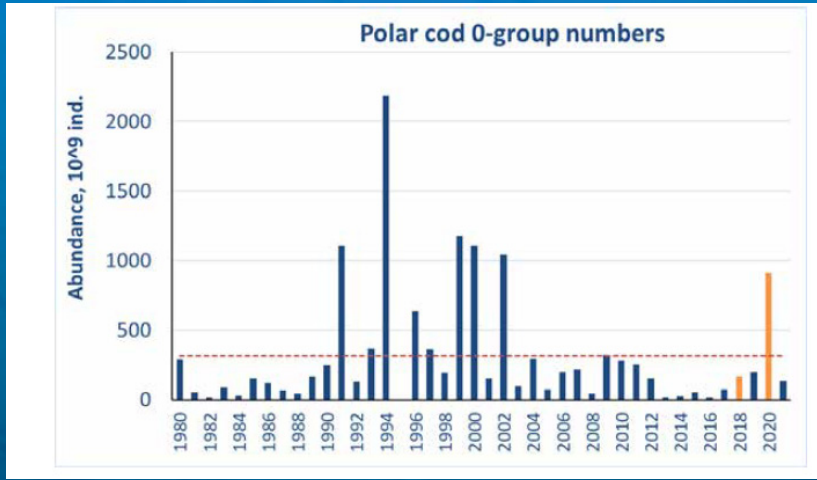
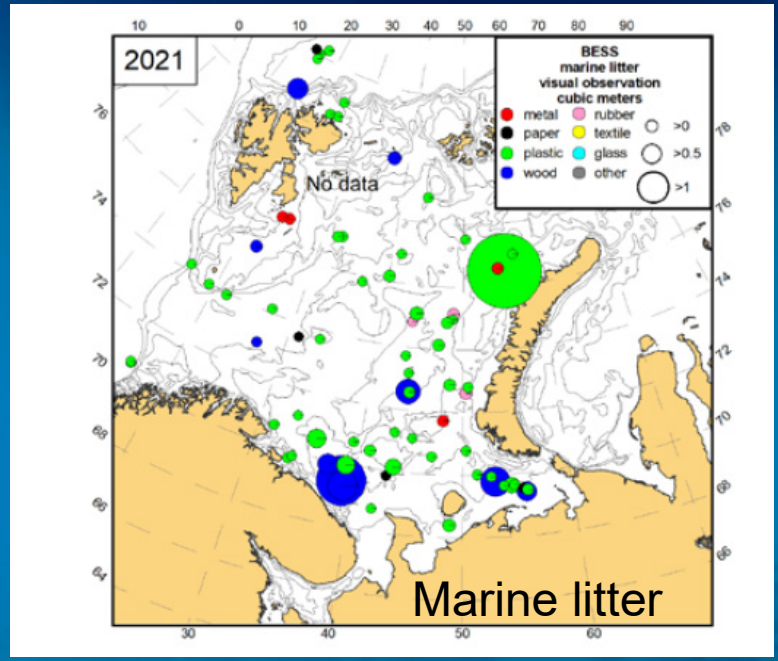
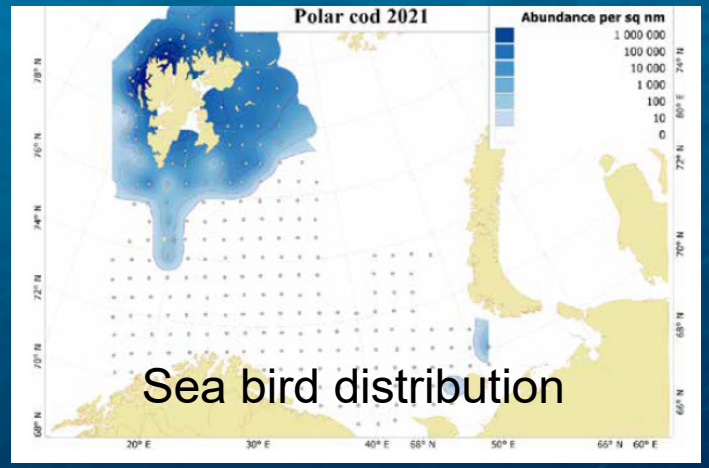
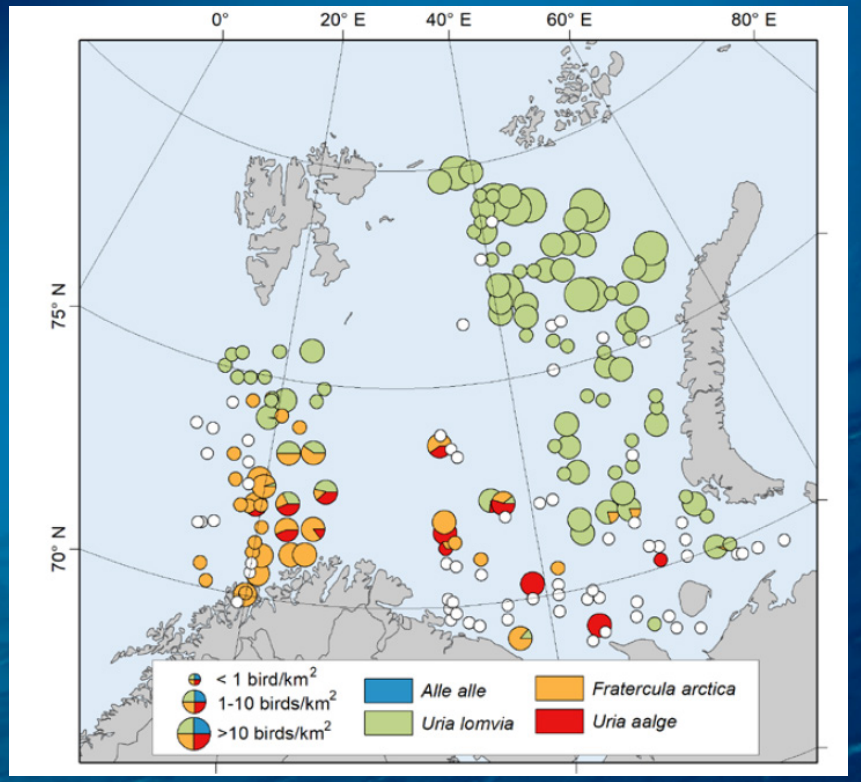
Continued: BESS 2021











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BESS 2021: Summarized to stakeholders: Graphical abstract

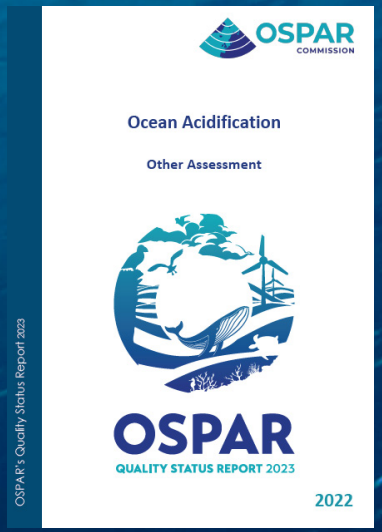
Graphical summary

	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

ICES. 2022. Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). ICES Scientific Reports. 4:50. 235 pp. http://doi.org/10.17895/ices.pub.20051438

Contributions to reports for advice to management and databases

- Status reports for the monitoring group (Norwegian Env. Agency) Norwegian Seas
- Vulnerable habitat reports (No: SVO)
- Barents Sea ecosystem survey reports (WGIBAR,
- ICES working groups (WGIBAR, WGCRAB, and more…)
- Ocean Acidification monitoring reports (annually)→ digitalized
- IGC-OA ICES/OSPAR reports QSR 2023
- GOA-ON
- UN SDG



Data

- Physical and Chemical data (CTD, nutrients, AT, DIC) from the F-B and V-N, BESS 2021 are submitted to Norwegian Marine Data Centre (NMDC)
  Norwegian Env. Agency and Svalbard Integrated Observatory Systems (SIOS).

- Ocean acidification data (AT, DIC) also submitted to synthesis data products such as Glodapv2023
- Submitted to UN SDG 14.3.1 (marine surface acidity)

- BESS 2021 data are shared between IMR and VNIRO (not shared in 2021)
- BESS IMR biological data contact Chapter PI's in the cruise report and BESS ICES report for collaboration

Progress and tentative titles

Potential Synthesis

- Variability of ocean acidification state and main drivers: comparison with other inflow Arctic shelves such as Chuckhi Sea, ESS. E.g Pacific winter water effect on OA

Individual cruise

- Decadal trends in OA and anthropogenic CO_2 in Barents Sea (using data from 1999-2022, eMLR? or other method) Lead: Chierici
- Connection between central Arctic and northern Barents Sea
- Atlantification and chemical change

- Ecosystem survey's IMR-VNIRO collaborative papers and reports (Contact: Vidar Lien)