

the Nansen LEGACY



The future Barents Sea,
risks, mitigation and
adaptation options

Workshop Report



The future Barents Sea, risks, mitigation and adaptation options

Gardermoen, August 29, 2019

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To be cited as: Benjamin Planque, Per Arneberg, Mette Skern Mauritzen, Tor Eldevik and Nina Mikkelsen (2020). The future Barents Sea, risks, mitigation and adaptation options: Workshop Report. *The Nansen Legacy Report Series 5/2020*.

DOI: <https://doi.org/10.7557/nlrs.5664>

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ISSN 2703-7525

Publisher: Septentrio Academic Publishing, Tromsø, Norway

Executive summary

The workshop on “*the future Barents Sea, risks, mitigation and adaptation options*” jointly supported by the Nansen Legacy project (RCN #276730) and the Barents Risk project (RCN #288192) was held at the Hotel Park Inn by Radisson at Oslo-Gardermoen Airport on the 29th August 2019. The workshop was attended by 7 researchers and 10 stakeholders, representing the following research institutions: University of Bergen, University of Tromsø, Institute of Marine Research, and the following sectors and management areas: environment, energy, fishery and technology.

The objective of the workshop was to undertake a joint exploration of the possible states of the Barents Sea by the horizon 2050, the associated risks and the possible ways to mitigate or adapt to them. The workshop was divided in four sessions. Session #1 focussed on risks and ecosystem services, session #2 focussed on futures for the Barents Sea, session #3 consisted in group work to explore how risk may change under future scenarios and session #4 discussed science-stakeholder interactions.

During these sessions, a broad range of issues were discussed. Some salient points that emerge from the presentations, group work and discussions are: different stakeholders have different ways of defining risk and managing it; the notion of *ecosystem services* is not part of the culture of all stakeholders and it should be better communicated; among all future scenarios considered, the global governance perspective was considered most often and associated to increased risks; science-based (fact-based) policy is valued by stakeholders; communication between stakeholders and scientists is valued by stakeholders; dialogue between parties is an important tool to reduce risk, and the dialogue method used in the meeting is perceived as a good way to identify the most pressing issues.

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Workshop introduction

The meeting agenda as well as a booklet on scenarios (Appendix 3) were distributed in electronic format to participants ahead of the workshop. The scenario booklet was provided in printed form at the workshop.

Per Arneberg opened the workshop with a welcome of all participants. This was followed by a rapid round table when participants briefly introduced themselves.

Session #1: risks

The first session was dedicated to risks.

A round table was conducted to explore how risks in the Barents Sea are perceived, prioritised and handled by different organisations.

The following points were raised:

There are important risks associated with possible future climate change, i.e. temperature, ice edge, and the associated responses of the Barents Sea ecosystem. Possible risks associated with human activities should therefore be minimised. Resource management should be optimised (best ratio benefit/risk). There are environmental (e.g. pollution) risks to species and ecosystem. Increased in ship traffic (e.g. north-east passage) increases environmental risks. Geopolitical risks (e.g. relationships with Russia) are important to consider for the management of oil & gas and other activities in the Barents Sea. Increasing nuclear activities by Russia constitutes a risk. Ecosystems face risks regarding biodiversity and vulnerability. The state and vulnerability of ecosystems needs to be understood and assessed to evaluate the risks posed by human activities (e.g. oil extraction) to the ecosystem state. The geographical border between Norway and Russia is a particularly sensitive area. For fishing, there are risks associated with the movement of fish and shellfish species, risks of areal conflicts and uncertainties regarding geopolitical changes. Multiple risks and combined impacts are most difficult to address. These will require joint efforts across sectors, across management bodies and across research institutions. The increasing dissemination of fake news is worrying. Degraded scientific information and poor use of science is a risk to management and policy. Scientific knowledge and future outlook based on scientific evidence is important (e.g. for bioprospecting). Monitoring ecosystem state and human activities is important to handle risk.

The round table was followed by a first presentation by Mette Mauritzen on the Barents Risk project. Examples of ongoing research on ecosystem vulnerability include studies of ecological traits (eg. Growth, reproduction, mobility, body size, etc.) and of food-web structure (who eats whom).

The presentation provided specific information about *ecosystem services* and how these are defined in Barents Risk (following the IPBES¹ nomenclature) i.e. *supporting, provisioning, regulating* and *cultural services*. It also highlighted the range of impact studies, from *single sector – single response* to *multi sectoral – multiple responses* and the range of scientific models to address the associated risks, from *qualitative* to *semi-quantitative* and *quantitative* studies.

¹ Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, www.ipbes.net

Qualitative and semi-quantitative analyses can help in prioritising management needs in relation to risks to ecosystem services before conducting more elaborate quantitative analyses. The latter often involve complex numerical models of the social-ecological system which rely on data availability, data quality, system knowledge, and sufficient scientific working capacity.

Session #2: future

The second session was dedicated to the future.

A round table was conducted to explore which future changes are anticipated in the Barents Sea, and how different organisations may prepare for them.

The following points were raised:

Climate is changing and climate change should be incorporated in management plans. Ship traffic patterns are changing and are expected to change further with increased tourism, oil transportation, and shipping. An ice-free Arctic would mean increased traffic from Asia. This poses risks to the Barents Sea ecosystem who can be vulnerable to increase traffic. The geopolitical situation is changing and a possibly more unstable situation in the future would have negative effects. There will be changes in international collaborations (e.g. through the Arctic Council) and possible changes in regulations (e.g. in the Svalbard Protection Zone). The anticipated increase in Russian nuclear-powered vessels can increase radiation risks although the current technology is less risky than before. There will be changes in biological production, changes in the Barents Sea ecosystem. However, many of these changes are hard to anticipate and in the absence of knowledge it is important to follow a precautionary approach. There will possibly be increased areal conflicts within sectors, between sectors or between nations. At the same time one can expect increased interactions and cooperation between industries, across sectors. Monitoring of ongoing changes in the Barents Sea will continue to be important for management in the future. Several stakeholders insisted on the importance of scientific knowledge, the need to communicate scientific results and science-based projections of future changes, and to use more scientific evidence to assess risks. Also important is that scientific information be better/more used in policy in the future.

The round table was followed by a second presentation by Tor Eldevik on the Nansen Legacy project. The presentation focussed on research about the future, from days to weeks, months and decades. The need for anticipating future changes, and for understanding the coupling between physical and biological processes (e.g. temperature and fish production or geographical distributions) was emphasised. The importance of coupling regional models of the Barents Sea ocean dynamics to scenarios (e.g. on greenhouse gas emissions) was also highlighted. In other words, it is not enough to just look into the past to anticipate the future.

Following the presentation, several issues were raised:

- Sometimes it's difficult to relate to scenarios because they lack realism, they can be too extreme or too simple,
- it is not always clear who, among different public institutions, has the responsibility for defining risks nor who has the responsibility for informing about risks and vulnerability. This depends on the type of risk and the sector concerned with the risk.
- Practical definitions of risk exist in a number of organisations, sometimes in the conventional form: *risk = probability x consequence*.

A third presentation was given by Benjamin Planque on multi-perspective scenarios for the Barents Sea by 2050. The methodology for elaborating the scenarios and the application to the Barents Sea are based on a previous workshop². Four perspectives are considered, namely *fisheries management*, *ecosystem*, *ocean climate* and *global context and governance*. For each of these perspectives, a summary of current trends is presented, followed by the elaboration of three contrasted narratives about the future. Multi-perspective scenarios are then constructed by combining the narratives of the four different perspectives³. A scenario booklet was printed to help participants to quickly combine narratives and select the multi-perspective scenario(s) of their choice (Appendix 3).

Session #3: group work

During the third session, the ten stakeholders divided into 5 groups. Each group was asked to consider the following questions:

1. What are the most important ecosystem services, from your organisation's perspective? (Hva er de viktigste økosystemtjenestene fra perspektivet til din organisasjon?)
2. Which risks do you consider in relation with these ecosystem services, from your organisation's perspective? (Hvilke risikoer er knyttet til disse økosystemtjenestene fra perspektivet til din organisasjon?)
3. How are these risks dealt with, today? (Hvordan håndteres disse risikoene i dag?)
4. How could these risks be dealt with under future scenarios? (Hvordan vil risikoene kunne håndteres under ulike fremtidsscenarier?)

The objective of the group work was to connect ecosystem services, risks, adaptation, and scenarios. It was not the intention to extensively cover all types of services, risks, adaptations and scenarios, but rather to get an impression, from few examples, of how these connections were made by different stakeholders.

Group 1

Group 1 considered energy (oil and gas, wind) provisioning as the ecosystem service of interest. Oil discharge (operational), oil spills (accidental) or seismic activities can affect this service by reducing social acceptance of oil extraction and leading to a reduction in licenses to operate. Political instability is a risk for the sector. Risk to the oil industry constitutes a political and economic risk, nationally. The group considered a scenario with continuation of trends in climate, ecosystem and fisheries associated with degraded global context and governance. Under this scenario, degraded fisheries elsewhere lead to increase in the demand for fishing access from national and foreign fleets in the Barents Sea and this increases the risk of areal/cross sectoral conflicts. If the ecosystem becomes more fragile, this also would increase the risk that the consequences of possible oil spills would be more serious. There was no proposed change in strategy for handling risks/management under this scenario. Management and handling of risk are fact-based and knowledge-based and it is important that they remains so in the future, i.e. that risk assessments be conducted in a systematic manner.

² The workshop took place in 2016 in Sommarøy, Troms. The detailed work is presented in Planque, B., Mullon, C., Arneberg, P., Eide, A., Fromentin, J.-M., Heymans, J. J., Hoel, A. H., et al. 2019. A participatory scenario method to explore the future of marine social-ecological systems. *Fish and Fisheries*, 20: 434-451. Available at: <https://doi.org/10.1111/faf.12356>

³ Combining 3 contrasted narratives along 4 perspectives leads to $3^4 = 81$ possible scenarios

Group 2

Group 2 considered food production as the ecosystem service of interest. Risk to this service includes decline or collapse of fish and shellfish populations, possibly due to overfishing by foreign fleets; reduction of access to fishing grounds for conservation purposes; lack of stable bilateral agreements between Russia and Norway; increase in fuel price and lack of economic profitability. Dialogue between parties (fisheries, environmental NGOs, regulatory bodies) is today an important tool for risk management. Flexibility (e.g. the possibility to quickly switch between fishing technologies) is also considered as a tool to minimise risk. Current management practices (e.g. TACs and quotas, national regulations, certifications) contribute to risk minimisation and dialogue between parties is particularly important to avoid overfishing. The group considered a scenario with a negative outcome in all perspectives (i.e. fisheries management, climate, ecosystem and global context/governance). There is little capacity to adjust to risk when all the perspectives are pointing in the wrong direction which is expected to lead to a situation of higher vulnerability. A second scenario with a more positive future for the ecosystem coupled with continued trends in other perspectives was also considered. This was presumed to provide a situation of reduced risk to food production. Degradation of the international political climate is an issue of concern. Bilateral fisheries agreements in the Barents Sea remain largely unaffected by other political tensions today, but the risk for fisheries would increase if this changes in the future.

Group 3

Group 3 considered primary production and nutrient cycling as the ecosystem services of interest. Risk to these ecosystem services include increased ocean temperature (although it is unclear whether this will increase or decrease production), ocean acidification, changes in ocean currents at basin scale (e.g. reduction of the AMOC⁴, which is anticipated to reduce production) and impact of pollution (oil spills). The management of the risks associated with the services is an international issue, very much connected to climate change and emission reduction policies (Paris agreement⁵). The production of scientific knowledge combined with management plans are important to managed risk. The group considered a scenario with continued trends in ecosystem and global context/governance coupled with increased risk of oil spills. In this scenario, risk could be reduced by increasing restrictions on oil exploitation/transport. It was considered that good marine climate would be associated with good global governance.

Group 4

Group 4 considered biological productivity, biodiversity, regulation of climate and acidification as the ecosystem services of interest. Risks to these services include (fish) stock collapses, species extinctions, reduced productivity or reconfigured ecosystems. Such changes pose a threat to business (e.g. reduced access to living resources). The group considered a scenario with continued trends in climate and ecosystem and degraded fisheries management and global governance. Future changes in the Barents Sea ecosystem are expected to be different south and north, in ice-covered vs. non ice-covered areas and in deep or shallow regions. Future technology developments can have positive effects on the environment. The negative trend in governance would increase risks in the

⁴ Atlantic Meridional Overturning Circulation

⁵ <http://www.cop21paris.org/about/cop21/>

future. Actions for reducing risks include increased efforts in ocean assessments, and increased dialogue and greater involvement of Norway in international forums (e.g. Arctic Council) with increased scientific profiling.

Group 5

Group 5 considered provisioning services (food and other resources) and tourism as the ecosystem services of interest. Risks associated with these services include acute and long-term pollution and impaired bilateral/international cooperation. The current strategies for handling environmental risks include monitoring and reporting and well-dimensioned preparation (training and exercises, impact assessments). Maintaining contacts, at personal level, can be important to support bilateral cooperation between Norway and Russia. The group considered a scenario with continued trends in fisheries management and climate, healthy ecosystem and degraded governance. Many issues could be handled as today but the degradation of international/bilateral cooperation would lead to increased risks and lack of transparency in reporting incidents between nations. A degraded economic situation with decreased support to research and assessment would also impact the capacity to reduce/prepare to risks.

Session #4: future risks and science

The fourth session was conducted in plenary. It was an open dialogue session, with some focus on science stakeholder interactions, in the context of the research projects Barents Risk and Nansen Legacy. Some points of discussion are summarised below:

There is a high interest for the Arctic elsewhere in the world and this gives the region a high cultural value. Cultural services are important ecosystem services and need to be considered (e.g. education)

Changes occurring elsewhere, in particular resource availability will have an impact on the future pressures to extract resources from the Barents Sea.

Future changes in the geographical distribution of species, the occurrence of species invasions, and projected changes in biodiversity, combined with conflicts over access and extraction of resources were flagged as important issues to consider.

The strong seasonality in the Barents Sea is also an important aspect for dealing with risks.

It was not always clear for stakeholders how the scientific field work conducted in a research project like the Nansen Legacy could feed into management and serve their needs. It was pointed that research projects which include a translation into management/policy are the most important ones for stakeholders.

The concept of *ecosystem services* is not part of the culture of all stakeholders and it would be beneficial to share this better.

Risk is considered by different stakeholders in different ways, and this reflects the different nature of the issues they have to deal with. Risks to public health, risks to persons (accidents) or risk to ecosystems cannot be managed in the same way. Some approaches are based on estimating $risk = probability \times consequence$ (e.g. chronic pollution), while in other instances it is more important to focus on the pressure (e.g. noise pollution), because the consequences are not well defined, or to develop a *cultural approach* to risk management by developing good practices to reduce risks.

Today's dialogue method used in the meeting is perceived as a good way to identify the most pressing issues.

The results from this workshop will be presented in a follow up workshop at the Nansen Legacy Annual meeting in October 2019. One aim of this workshop will be to discuss how the scenarios, threats and adaptation options may be studied by scientific research in the various disciplines represented in the Nansen Legacy. The participants at the annual meeting will be primarily scientists from diverse cultural and scientific backgrounds, and age, so we expect that the discussion will be rich also during that workshop.

The results from this workshop will also be used to define which ecosystem services and which associated risks will be prioritised in the Barents Risk project. They will serve as an input to the stakeholder 'conceptual' workshop that will be held in October 2019.

Appendix 2. Meeting agenda

10:00-12:00

Round table of introduction by participants (10')

Theme #1: risks

Presentation of the Barents risk project (Mette Mauritzen, IMR)

Theme #2: future

Presentation of the Nansen Legacy 'Future Barents Sea' (Tor Eldevik, UiB)

11:30-12:30 Lunch break

12:30-14:30

Presentation of the scenario 2050 booklet (Benjamin Planque, IMR)

Ecosystem services in the future: risks, mitigation and adaptation options

Introduction to group work (Per Arneberg, IMR)

Work by group (pairs)

14:30-15:30

Restitution of group work

15:30-16:00

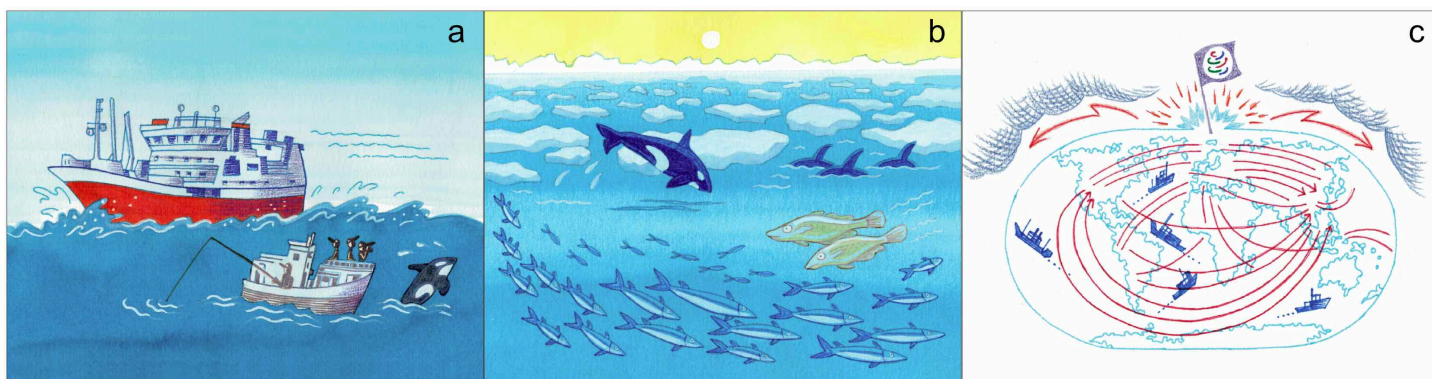
Theme #3: science applications

Barents Sea 2050 Scenario booklet

Scenario workshop – 29 August 2019

Risks, mitigation and adaptation options

Nansen Legacy - Barents Risk



How to use the scenario booklet?

The booklet is a tool to construct multiple perspective scenarios.

There are 4 suggested perspectives:

- 1) Fisheries management,
- 2) Ecosystem,
- 3) Ocean climate,
- 4) Global context & governance.

The first page of the booklet provides a brief description of the current states and trends according to each perspective. The following three pages provide contrasted scenarios for the Barents Sea by 2050.

A complete multi-perspective scenario is constructed by combining 4 single perspective scenarios (for example: Business as usual fisheries management & increase of biological production, ecosystem health and harvesting potential & continued warming & strengthening of multilateral governance).

It is possible to add new single perspective scenarios on the last page. It is possible to add a new perspective on the bottom of each page.

The definitions of acronyms used in the text (in italics) are given at the end of the document.

Fisheries management States and trends	<p>The total annual catch in the Barents Sea is about 1.4 million tonnes. The main exploited species are cod, capelin, saithe, haddock, redfish, Greenland halibut, shrimps, red king and snow crabs, captured by coastal and long-distance fleets which operate a variety of fishing gears (nets, lines, traps and trawls). Management is supported by the cooperation between Norway and Russia through the <i>JNRFC</i>, <i>IMR-PINRO</i> and <i>ICES</i>. There are bi-lateral agreements with long-term management plans and <i>HCRs</i> for shared stocks. The current Norwegian fisheries management objectives are to ensure sustainable and economically profitable exploitation of wild living marine resources and genetic material and to ensure employment and settlement in coastal communities.</p>
Ecosystem States and trends	<p>The mean annual <i>NPP</i> is about 59 million tonnes carbon. Primary production is dominated by phytoplankton in ice-free areas and by ice algae in ice-covered regions. Nutrient influx from Atlantic waters partly controls <i>NPP</i>. <i>NPP</i> varies greatly between years and there is a recent upward trend in productivity. There are important year-to-year fluctuations in zooplankton production. Populations of pelagic invertebrates (e.g. krill, amphipods), pelagic fishes (e.g. capelin, herring, polar cod), demersal fishes (e.g. cod, haddock, saithe), benthic invertebrates (e.g. bivalves, echinoderms, crabs), mammals (e.g. whales and seals) and birds (e.g. puffins, fulmars and kittiwakes) interact and display strong seasonal, geographic and interannual variations. The stocks of the major demersal fish species have reached record high levels (combined biomass of cod, saithe and haddock in excess of 5 million tonnes). Some recent expansions to the northeast are attributed to ocean warming and are described as a 'borealisation' of the Barents Sea. The biomass of gelatinous plankton has increased, and populations of snow and king crabs have established in the Barents Sea.</p>
Ocean climate States and trends	<p>The Barents Sea is a transition zone between the warm and saline Atlantic water and the colder less saline Arctic water. There are no major rivers flowing into the Barents Sea. Parts of the Barents Sea are seasonally ice-covered. The region is characterized by strong geographical gradients between Atlantic waters in the southwest and Arctic waters in the northeast, large seasonal changes in ocean climate and light regime and important inter-annual variations in the strength of Atlantic water inflow and exchange of cold Arctic water. Over the last decades, the most prominent trends are increasing sea temperatures and decreasing ice coverage. In early 2016, sea temperatures measured in the Fugløya-Bear Island and Vardø-North sections, which are representative of the dynamics in the Atlantic water masses were around 1°C above the 1977-2006 average. Since satellite earth observations started in 1979 the decrease in Barents Sea ice coverage has been 9,7 % in April and 14,7 % in September. The present Barents Sea ocean climate has never been observed before.</p>
	<p>Most of the Norwegian fish production is exported, primarily to the <i>EU</i> followed by the <i>USA</i> and Asian countries. Global capture fisheries operate at their upper limit. The market price of fish has not increased as much as the average income in Norway, but profitability has increased following a decreasing number of fishermen and the development of more efficient capture techniques. The global institutional context of the Barents Sea <i>SES</i> is defined by <i>UNCLOS</i>, the 1995 <i>UN</i> Fish Stocks Agreement and agreements and guidelines developed by the <i>FAO</i> over the last decades. Third party countries are granted access and quotas in the Barents Sea through a comprehensive system of fisheries agreements with Norway and Russia respectively. Relevant global trends include: (a) increasing ecosystems considerations in fisheries management, (b) growing concerns for global food security and biodiversity, (c) consideration of mining, oil extraction and shipping, (d) raising public awareness on Arctic issues and threats, and (e) geopolitical developments in the high North. Polar treaties and the Arctic Council are getting increased political significance. In 2017, an agreement was reached to prevent unregulated fishing in the high seas area in the central Arctic Ocean.</p>

<p>Perspective 5 States and trends</p>	
<p>Fisheries management Scenario #1</p>	<p>Baseline: Business as usual. Fisheries management, regulations and economic situation in the Barents Sea are similar to the 2010's. Fishing capacity and wealth concentration continue to increase although at a slower pace than in the 2010's. Norwegian fisheries management goals are maintained within a framework of cooperation between countries. High catch of cod is prioritized. The <i>HCR</i>-based management plans for the main commercial species (cod, haddock, saithe, and herring) are further developed. The capelin stock is managed by a target escapement strategy. Concerns about the size of the cod stock being too large, in relation to its pressure on capelin and polar cod, are addressed through multi-species <i>HCRs</i>. There is no active price support policy, nor decline in market price. Prices are primarily determined on international markets for fish products and observed price trends for the main commercial species caught in the Barents Sea are assumed to continue: the industry is a 'price taker', i.e. there is no company big enough, or in position to affect the level of prices. Current stock productivity remains similar, in relative terms, to those of the 2010's.</p>
<p>Ecosystem Scenario #1</p>	<p>Baseline: increase then stabilization of biological production. There is a continuous increase then stabilization in the biological production of the Barents Sea. This leads to a similar pattern in the production of commercial demersal fish species as in the 2010's. Pelagic species fluctuate between high and low abundance levels on decadal time scales. This is accompanied by a geographical expansion of Atlantic/boreal species towards the northeast of the Barents Sea. The occurrence of species invasions has ecosystem impacts and creates opportunities for new fisheries. Although the ecosystem state varies on intra-annual and inter-annual time scales, the overall ecosystem 'health' is at a similar level as in the 2010's.</p>
<p>Ocean climate Scenario #1</p>	<p>Baseline: Continued warming. Ocean warming continues, accompanied by a reduction in the geographical extent and thickness of sea ice and by ocean acidification. Natural climate oscillations (e.g. <i>AMO</i>) still modulate this climate trend. The polar front is pushed further northeast and the biological production season starts earlier and becomes longer. The annual mean ocean temperature has increased by 0.7°C in the upper hundreds of meters. This leads to ice free conditions in September in the central Arctic Ocean and a reduction of ice extent by around 4 million km² in March. In the Barents Sea, this is manifested by a continuous retreat of the ice towards the northeast. The Atlantic Meridional Overturning Circulation (<i>AMOC</i>) is weakened due to increase in high latitude temperature and precipitation which make high latitude surface water lighter. The stability of these waters therefore increases, which in turn decrease the strength of the <i>AMOC</i>. The effects of a weakened <i>AMOC</i> are anticipated to dominate over ocean climate natural variability after 2050.</p>

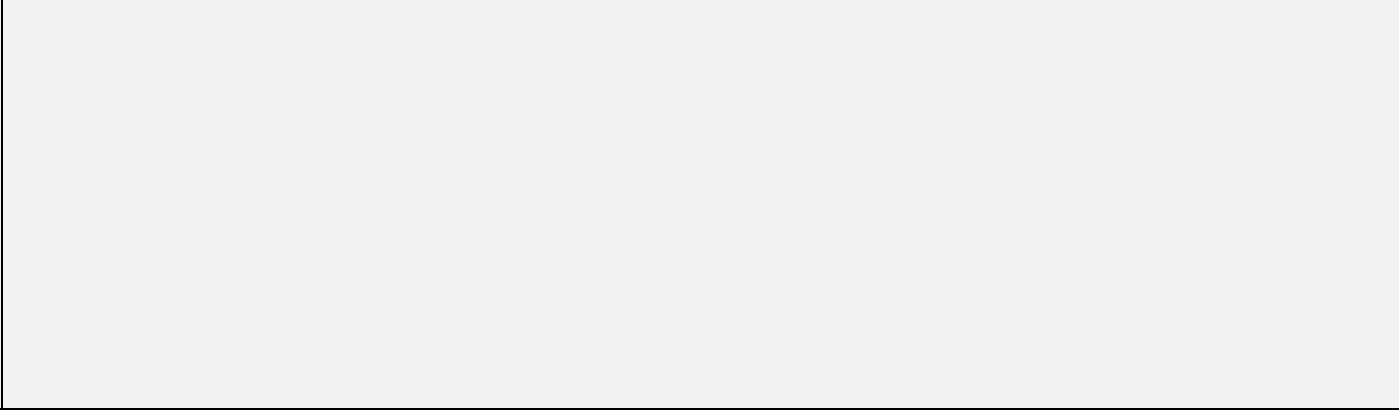
Global context - governance Scenario #1	<p>Baseline: ongoing trends of multilateral governance and globalization continue. The role of UN organizations declines in some domains (<i>UNESCO's crisis</i>) but is re-affirmed in those related to the marine environment. The work to address the 2030 Sustainable Development Goals (<i>SDGs</i>) is ongoing, but the targets of <i>SDG-14 (Oceans)</i> are met to different degrees and overfishing remains a problem globally. International conservation NGOs affirm themselves as important actors. <i>UNCLOS</i> and the 1995 UN Fish Stocks Agreement are being actively implemented by a growing number of states. Free trade policies derived from the principles of the World Trade Organization (<i>WTO</i>) are prevalent in the international trade of seafood. The international Court of Justice and the International Tribunal for the Law of the Sea remains the main instruments for the resolution of disputes. While international offshore ocean governance puts greater emphasis on conservation and management of biodiversity, this take place in a context of increasing global needs for fish resources, and regional increase in tourism, shipping and minerals, oil and gas extraction with associated impacts on fish and fisheries.</p>
Perspective 5 Scenario #1	
Fisheries management Scenario #2	<p>Degraded: poor management practices and short-sighted views. Despite a growing understanding of the interactions between ecosystem components and species, fisheries management focus on selected single species approaches. TACs are often set above recommended safe levels. The market price of commercial species, due to race-to-fish conditions, leading to poor fishing practices and a concentration of landings over short periods of time, declines except when it is artificially maintained through active public price policies, despite the fact that such policies contribute to reinforce overall capacity. Technological advances that significantly affect fishing practices and performances but are poorly considered in the design of fisheries regulations. Trust between scientists, managers, fishermen and civil society is eroded. Compliance with regulations declines. There is a gradual decline in the stability and development of international agreements for fisheries management.</p>
Ecosystem Scenario #2	<p>Pessimistic: collapse of fish stocks, degradation of ecosystem health. Most stocks of demersal fish species (cod in particular) fall below safe levels. Pelagic stocks fluctuate at faster rates than before. Invertebrate species pullulate (e.g. jellyfishes) and species invasions increase. Populations of top predators steadily decline. The general ecological situation in the Barents Sea is qualified as degraded or unhealthy. A combination of factors, including climate, fishing, pollution (noise, persistent organic pollutants, heavy metals, plastics, oil) and invasive species lead to severe modifications in the productivity and functioning of the Barents Sea ecosystem.</p>

<p>Ocean climate Scenario #2</p>	<p>Hot future: faster warming and ice melting. The rate of warming, ice melt and acidification exceed those observed in the 2010's. The new regimes of temperature, salinity, stratification and pH are outside the range of situations observed in the past with significant consequences on the biological system (e.g. production, species composition, biogeography). The change in the annual mean ocean temperature in the upper hundred meters north of 60°N is 2.2°C, and the Arctic becomes seasonally ice free (in September) by the middle of this century. The climate trend is so strong that the effects of natural climate oscillation become weak in comparison, while extreme weather events become more frequent. Sea ice extent after 2050 is neither expected to increase considerably nor return to the 2010's state.</p>
<p>Global context - governance Scenario #2</p>	<p>Pessimistic: decline of multilateral governance and raise of protectionism. Poverty alleviation and human development are not prioritized, nor are multilateral agreements. The development of the global framework based on <i>UNCLOS</i> is halted and protectionism takes precedence in trade relations. Bilateral treaties based on political and economic considerations become the reference for all exchanges between countries (preferential trade agreements). There is a growing tendency for entities such as states, companies and fleets to operate individually in order to protect their own positions. Arbitration is generalized as a tool for solving international conflicts, even between states and private investors. This interferes, in environmental problem's solving. At a regional level, the framework for fisheries agreements and dialogue degrades. Interactions and conflicts between fisheries and other sectors (tourism, shipping, oil and gas) are poorly handled. Trust between actors declines, as well as compliance with regulations. Social equity and ecological health have low priority.</p>
<p>Perspective 5 Scenario #2</p>	
<p>Fisheries management Scenario #3</p>	<p>Improved: participatory and ecologically responsible management. Objectives for the management of the fisheries are defined at the ecosystem level. Current regulations on individual species are supplemented with ecosystem-level regulations (e.g. multi-species <i>TACs</i>). There is an increased participation of actors with interest other than fisheries, such as conservation groups, other industries, communes or unions, into the management process. Technological advances are fully incorporated in the design of regulations, with an emphasis on conservation and improved fishing efficiency (e.g. less by-catch). Price trends for seafood are increasing relative to the general level of income and costs, due to improved quality of fish landed and efforts to meet the demand for high quality products. Trust between scientists, managers, fishermen and the civil society is high and so is compliance with regulations.</p>

<p>Ecosystem Scenario #3</p>	<p>Optimistic: increase of biological production, ecosystem health and harvesting potential. There is a continuous increase in the biological production of the Barents Sea, paralleled by an increase in production of demersal and pelagic fish species and in their geographical expansion. Species that have recently been discovered to have a high commercial potential are also highly abundant and productive. Top predator populations are healthy and abundant. The general ecological situation in the Barents Sea is qualified as healthy with a high biological production channelled through to commercial species. A combination of factors, including climate change, fishing, petroleum activities and invasive species has led to modifications in the productivity and functioning of the Barents Sea ecosystem that have benefitted the harvesting potential of the system without degrading its health.</p>
<p>Ocean climate Scenario #3</p>	<p>Cold future: import of fresh water and shutdown of the AMOC. Surface melt draining into crevasses and hydro fracturing in the Greenland and Antarctic ice sheets lead to accelerated melting and dramatic increase in sea level by 7m. The increase in freshwater produced an amplifying feedback that further accelerates ice melt at depth by placing a lid of fresh and cold water on the polar ocean. This has limited heat loss to the atmosphere and space, and thereby warmed the ocean at the depth of ice shelves. The increased stratification resulted in a shutdown of the <i>AMOC</i>, and thereby reduced poleward heat transport. In turn, the reduction in the <i>AMOC</i> led to lower surface atmospheric temperature in the Arctic in some areas. The result is a colder and icier Barents Sea where the extent of winter ice expands back towards the southwest Barents Sea.</p>
<p>Global context - governance Scenario #3</p>	<p>Optimistic: strengthening of multilateral governance. The 2030's and 2040's saw a return to the original principles of multilateralism which associates developed and developing countries, the strengthening of the <i>UNCLOS</i>-based legal framework and the implementation of the <i>SDGs</i>. Global governance of marine resources and biodiversity is developed with explicit consideration of food security, ecosystem conservation, equity and economics through a new implementing agreement to <i>UNCLOS</i>. Regionally, this has led to an improved and expanded dialogue between Norway and Russia, a broadening of fisheries cooperation with regards to economic benefits, equity, ecological conservation and improved compliance with regulations. Consequences of technological advances, as well as interactions between sectors operating in the Barents Sea (tourism, shipping, oil and gas) are considered and incorporated into governance plans.</p>
<p>Perspective 5 Scenario #3</p>	

Ocean climate Scenario #4	
Ecosystem Scenario #4	
Fisheries management Scenario #4	

Perspective 5
Scenario #4



Acronyms

AMO: Atlantic Multidecadal Oscillation

AMOC: Atlantic Meridional Overturning Circulation

EU: European Union

FAO: Food and Agriculture Organisation of the United Nations

HCR: Harvest Control Rule

ICES: International Council for the Exploration of the Sea

IMR: Institute of Marine Research

JNRF: Joint Norwegian Russian Fisheries Commission

NPP: Net Primary Production

PINRO: Polar Research Institute of Marine Fisheries and Oceanography

SES: Social Ecological System

SDG: Sustainable Development Goals of the United Nations

TAC: Total Allowable Catch

UN: United Nations

UNCLOS: United Nations Convention on the Law Of the Sea

UNESCO: United Nations Educational, Scientific and Cultural Organization

USA: United States of America

WTO: World Trade Organisation

The Nansen Legacy in numbers

6 years

The Nansen Legacy is a six-year project, running from 2018 to 2023.

200 people

Currently, there are 204 persons involved in the project. By the end of the project period, the Nansen Legacy will have educated a total of 50 PhD students and postdoctoral fellows.

1 400 000 km² of sea

The Nansen Legacy investigates the physical and biological environment of the northern Barents Sea and adjacent Arctic Ocean.



10 institutions

The Nansen Legacy unites the complimentary scientific expertise of ten Norwegian institutions dedicated to Arctic research.



>10 fields

The Nansen Legacy includes scientists from the fields of biology, chemistry, climate research, ecosystem modelling, ecotoxicology, geology, ice physics, meteorology, observational technology, and physical oceanography.


50/50 financing

The Nansen Legacy has a total budget of 740 million NOK. Half the budget comes from the consortiums' own funding, while the other half is provided by the Research Council of Norway and the Ministry of Education and Research.


>350 days at sea

The Nansen Legacy will conduct 15 scientific cruises and spend more than 350 days in the northern Barents Sea and adjacent Arctic Ocean between 2018 and 2022. Most of these cruises are conducted on the new Norwegian research icebreaker RV *Kronprins Haakon*.



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