Centre for the Ocean and the Arctic

DNV·GL

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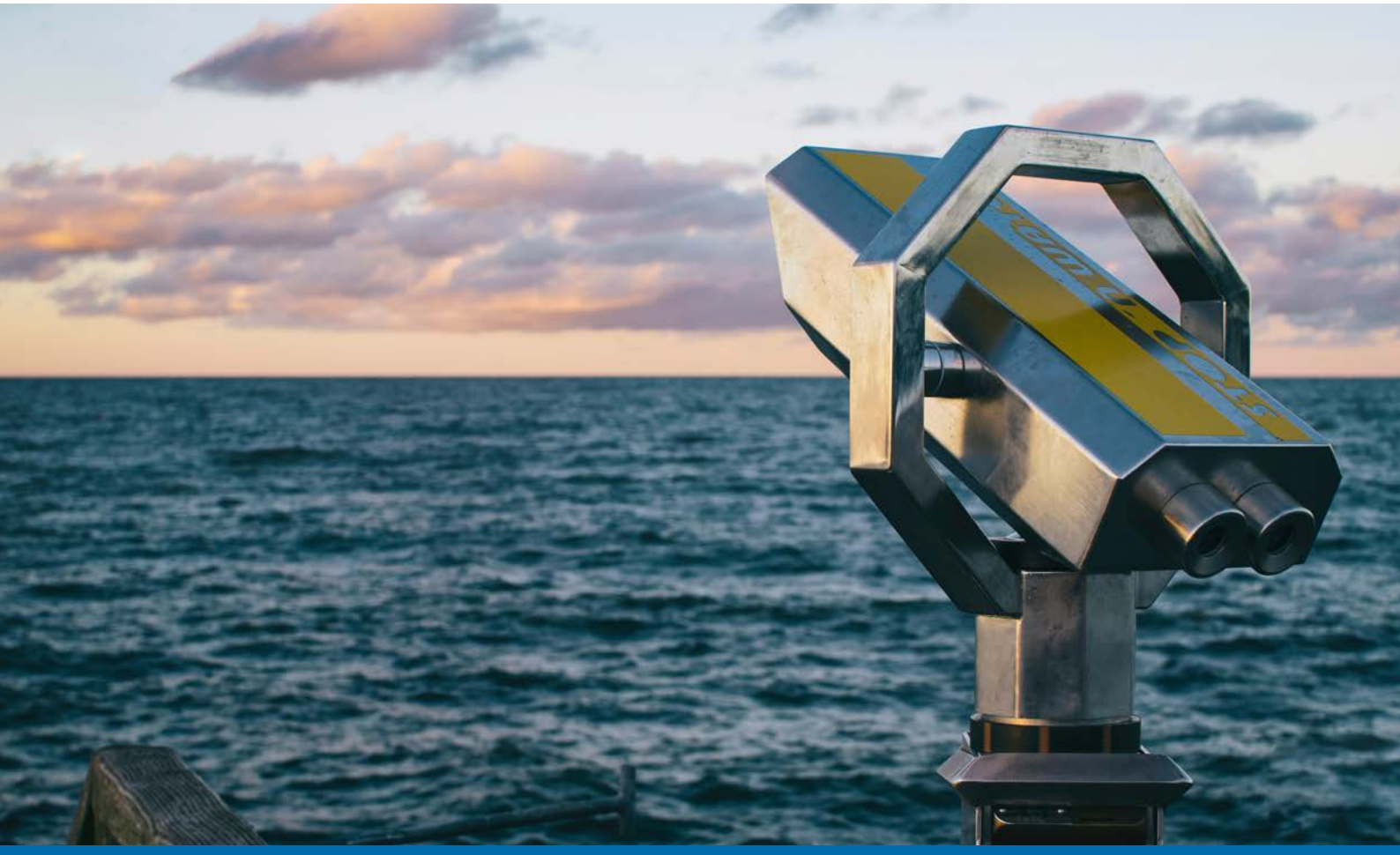
Written by DNV GL for the
Centre for the Ocean and the Arctic

Sustainable Blue Economy in the Norwegian Arctic

Part 2: Foresight for 2030 and 2050



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The future is blue

We humans live our lives on a thin membrane between two vast universes. One of these meets our gaze every time we go outdoors. Outer space is large beyond measure, still surrounded by unknown phenomena and veiled in mystery. For half a century, the innate human compulsion to explore and examine has focused on space. Now our eyes are turning to the other universe: the one that lies under the surface of the ocean, the one we do not see. The ocean space.

These two universes differ in many ways, but one difference is obvious: The ocean's incredible resources are essential in meeting our basic needs and ensuring our welfare, economic success and livelihoods. It will be impossible to feed the world's population without making better use of the ocean's living resources than we do today. It is inconceivable that our energy and transport needs can be attained without the ocean. At the same time, we need immediate help from the ocean to ensure the health of our planet. Climate change, loss of biodiversity, and plastic litter are existential challenges. The global community's sustainability goals cannot be achieved unless we both utilise the oceans and take better care of them. We stand at a crossroads. This may become the century of the oceans.

Norway is a small country, but a major seafaring nation. We have long experience and a history as pioneers in shipping, oil and gas, and aquaculture. However, the jewel in Norway's crown is that we have established a holistic marine management strategy that is both knowledge-based and ecosystem-based, with broad involvement from authorities, institutions and civil society. We have been good at finding a balance between conservation and exploitation. We have made the most of the benefits offered by a small, trust-based society. The world looks to the Norwegian model, and it is central to our ocean diplomacy.

No one knows what the future may bring. It is impossible to predict 'x-factors' – factors that throughout history have turned out to be game changers. With this report, we hope to stimulate lively debate concerning which directions maritime Norway should move in and which goals we should strive for. To help chart the course, we present probable drivers and scenarios. Finally, we highlight how interactions can give added value in a future where fine-tuning the balance between utilisation and conservation will be an ever-greater challenge.

Possibilities open new frontiers, and the ocean is the answer.

Happy reading!

Jan-Gunnar Winther
Director
Centre for the Ocean and the Arctic

Photo: Marius Fiskum

1 Executive summary

The Centre for the Ocean and the Arctic has in collaboration with DNV GL conducted an analysis of the sustainable blue economy in the Norwegian Arctic. The analysis consists of two reports:

1. *Sustainable Blue Economy in the Norwegian Arctic – Part 1: Status* was published in April 2019 and describes the recent developments and current situation in the Norwegian Arctic.

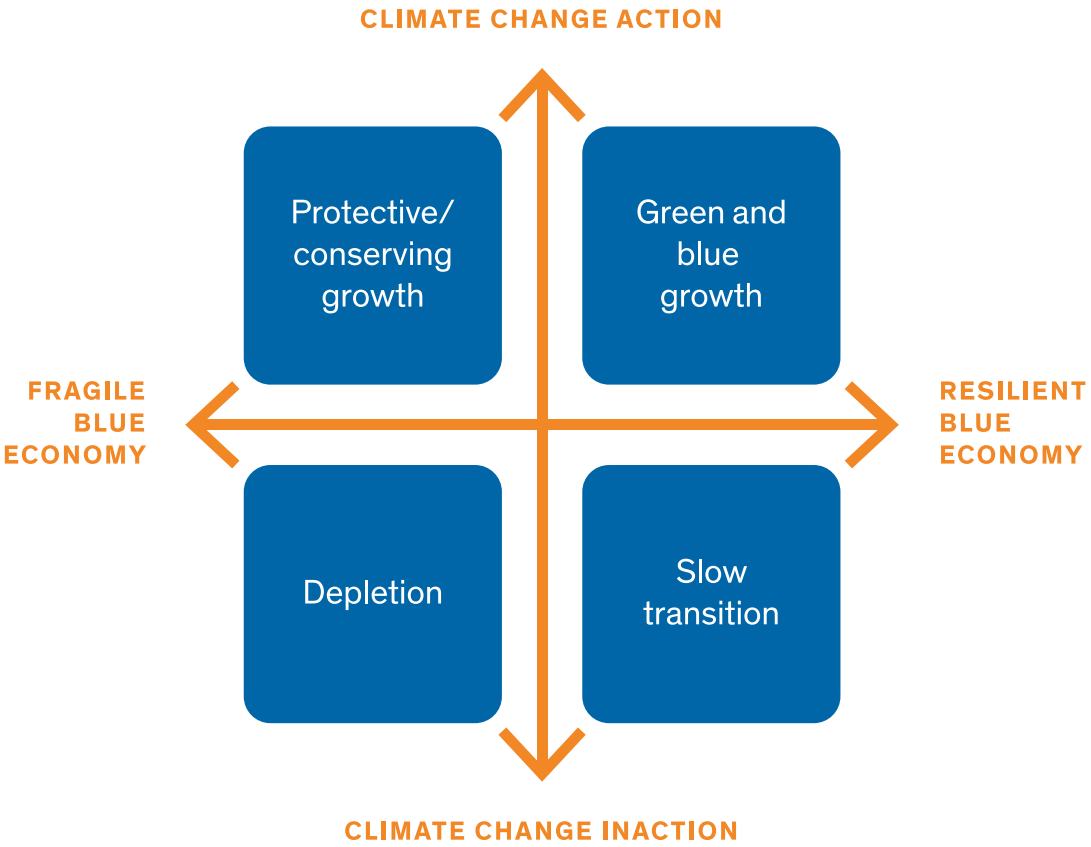
2. This report, *Sustainable Blue Economy in the Norwegian Arctic – Part 2: Foresight for 2030 and 2050*, is a foresight study based on the report presented as part 1 and other trend studies. It analyses the challenges and opportunities associated with the further development of a sustainable blue economy in the Norwegian Arctic.

This report presents four different scenarios for the Norwegian Arctic and addresses opportunities for delivering on the ambition of securing a sustainable blue economy in 2030 and 2050. It is divided into four parts:

- Introduction
- Input – existing foresight studies
- Foresight - future of the blue economy in the Norwegian Arctic
- Opportunities - achieving a sustainable blue economy

Several eminent and recognised organisations such as the IPCC, IPBES, IEA, SINTEF and DNV GL have delivered trend studies forecasting future development within climate change, biodiversity, and consequences and opportunities for the blue economy. A general conclusion is that the climate will change over the coming decades, and it will be challenging to reduce emissions enough to reduce the magnitude of this change. At the same time, the ocean offers vast opportunities for increased economic activity, especially in the Norwegian Arctic. Existing trend studies show that developments in global demography, climate and environment, economy and trade, rising income levels and new technology, are the primary drivers of the rapid expansion of economic activity related to the ocean.

To present a perspective on what the future of the Norwegian Arctic region may look like, a scenario approach is utilised in this report. Four scenarios based on two key drivers are described and each scenario is carried forward to both 2030 and 2050.



The drivers for the scenario approach are:

1. *Climate change action* (y-axis) – At the low end of the scale the global community is incapable of sufficiently reducing emissions, the objectives of the Paris Agreement are not reached, and the consequence is a future with threats to ocean health and ocean productivity. At the high end of the scale the global community is successful in implementing the actions required to reduce or limit climate change – a considerable change from today's direction.

2. *Resilient blue economic growth* (x-axis) – At the weak end of the scale, the blue economy can grow substantially but rely on a narrow selection of industries, leaving communities in precarious situations and impeding efficient sharing of resources, ideas, competence and workforce between sectors and companies. At the strong end of the scale, a resilient blue economy will be one where natural resources are utilised sustainably at a pace that facilitates balanced growth between sectors, where multiple industries have access to human and financial resources supported by efficient production processes, and where efficient regulatory environments facilitate experimentation and innovation.

The four scenarios in the quadrants are:

1. *Green and blue growth* – Strong, worldwide climate change actions towards a resilient blue economy.

2. *Slow transition* – Fossil fuels remain the chief source of energy on both global and regional scales. Global emission reduction targets are not reached, and the impacts of climate change are severe. The blue economy is kept in balance through certain limitations on industries and incentives for transfer of competence, technology and capital between sectors.

3. *Depletion* – The blue economy is non-resilient, emission regulations are few, and society has little or no willingness to engage in collective actions. Sustainability is under threat, there is a considerable loss of biodiversity, and a lack of inclination to protect nature and wildlife. Owing to climate change the Arctic Ocean is ice-free in summer, affecting geopolitical tension.

4. *Protection and conservation before growth* – Changes to the climate and ocean are relatively minor, but the region's economic situation is unstable: industrial

development has been restricted to protect the unique and vulnerable region. Consumption of raw materials and energy are kept at a moderate level. Due to limited climate change, some sea ice remains, and the Transpolar Sea Route and the Northern Sea Route are not navigable year-round for most ships.

The road towards a blue economy in the Norwegian Arctic opens many opportunities for stakeholders. It offers potential for increased value creation and commercial activity in the region. This report gives examples of opportunities that can inspire green and blue growth towards 2030 and 2050. Among the activities suggested are:

- *Harvesting from lower levels of the marine food web* – There is significant potential for harvesting proteins, for example from copepods.
- *Environmentally sound mineral resource extraction from the seabed* – Extraction of minerals from the seabed could support the green transition.
- *Production of hydrogen from natural gas* – Hydrogen can be extracted from natural gas.
- *Polar ocean technology research centre* – A research centre for cold climate ocean technologies with focus on harvesting energy from the ocean for the future.
- *Emission-free air transport for remote communities* – Emission-free air transport would be a way to improve the transport options for people in remote areas.
- *Port and maritime services development for the Northern Sea Route* – The Northern Sea Route offers an opportunity for the ports in the region to become important service providers.
- *International education as a means of raising the region's profile* – Executive MBA, BSc and MSc programmes focused on the ocean and targeting international students will encourage talented young people to stay and work in the region after graduation and contribute to raising the education level.
- *Local partnerships and local ownerships* – Establish multi-stakeholder partnerships and ownerships at local level to secure continuous development and economic growth.
- *Ecotourism* – Tourism in the Norwegian Arctic according to the principles of ecotourism.
- *Stronger local revenue from tourism* – Ensure that most of the income from tourism stays in the region.

The opportunities might serve as an inspiration for how a sustainable blue economy in the Norwegian Arctic can be achieved. It is recommended that initiatives to realise one or several of these opportunities begin with cost-benefit analyses.

A successful future and a sustainable blue economy for the Norwegian Arctic is totally dependent on cooperation between the different sectors of society. Without such close cooperation the possibility of reaching the goals and opportunities described for 2030 and especially 2050 will be severely hampered.

The foresight study shows that to be able to deliver on the ambition of securing a sustainable blue economy in 2030 and 2050, the green and blue growth scenario must be the goal. For this scenario to come true, substantial changes and investments need to be made in the Norwegian Arctic. The eight most important changes and investments for the Norwegian Arctic are considered to be:

1. Work towards even more sustainable fisheries with smaller footprints, well-managed stocks and improved technology and logistics to process the catch in local communities and efficiently transport it to markets.
2. Aquaculture must become more sustainable, for example through production in closed systems where what is currently considered waste is used as a resource, production further out to sea, and improved methods to treat fish for parasites.
3. Change the energy mix. Increase electrification by producing more energy from sources with zero CO_2 emissions (e.g., wind power and solar energy), and energy sources with lower CO_2 emissions than oil, such as gas, biofuel and hydrogen.
4. Transportation should generate zero or lowest possible CO_2 emission. Replace traditional fuel with electric, liquid biogas, hydrogen or hybrid solutions.
5. Infrastructure for rapid, secure digital communication is important towards 2030 and 2050. Investments to ensure this include launching more communication satellites to give full coverage and high bandwidth.
6. Increase competence-building. Improve the quality of education from primary school to university, including the completion rates, and focus education towards disciplines that can create jobs in the region.
7. Improve infrastructure for transportation and communication (roads, railway, shipping, power lines), and for better search and rescue capacities.
8. Form community partnerships to be able to address challenges and opportunities. They can explore local problems, identify potential solutions, and propose appropriate policies and measures.

2 Introduction

The Norwegian Arctic, comprised of the three northernmost mainland counties Nordland, Troms, and Finnmark, plus Svalbard and vast expanses of ocean in the Barents Sea, the northern parts of the Norwegian Sea and northward into polar waters, is an area of great national and international significance. There are several reasons for this, in particular the region's vulnerability to the impacts of climate change, the availability of rich natural resources, the emergence of potentially important sea routes, and how all this impacts societies and activities in the region.

This report is a foresight study exploring the future of a sustainable blue economy in the Norwegian Arctic. It describes four different scenarios and addresses opportunities for delivering on the ambition of securing a sustainable blue economy in the Norwegian Arctic in 2030 and 2050.

A first report, *Part 1: Status*, published in April 2019[1], summarised the status of the sustainable blue economy in the Norwegian Arctic in relation to the 17 global Sustainable Development Goals (SDGs). It divided the SDGs into four main categories (biosphere, society, economy and partnerships). The key results from the analyses were:

BIOSPHERE: Climate change is a major threat to the Norwegian Arctic. The Arctic is currently experiencing warming that is two to three times higher than the global annual average. A warming beyond 1.5 °C will have significant impact on risks to marine biodiversity, fisheries, and ecosystems, their functions, and their services to humans. Further, there will be an increased probability of an ice-free Arctic Ocean during the summer.

SOCIETY: The Norwegian Arctic has limited poverty, low income inequality and low unemployment. Health is generally good and life expectancy is high. The fractions of the population on disability benefits and with non-communicable diseases are slightly larger than those in Norway as a whole. A slightly higher percentage of youth in the Norwegian Arctic are overweight or obese compared to the rest of the country. Educational attainment in the Norwegian Arctic is lower than the national average; there is significant gender disparity in completion rates, with boys dropping out more often than girls, and qualified teachers are in short supply. The Sami people in the Norwegian Arctic have lower levels of formal education than the rest of the population in Norway. Violence against women and girls is a challenge in the Sami population of the Norwegian Arctic.

ECONOMY: The ocean and its resources are a key source of employment and income. Ocean-based business in Northern Norway is double of that in Norway as a whole. Some factors in the Norwegian Arctic complicate efforts to achieve higher productivity; for example, population growth and education levels

are much lower, and sick leave rates are higher in the region compared to the rest of Norway. The key ocean industries in the Norwegian Arctic are fisheries, aquaculture, shipping and ports (maritime industry), oil and gas, and tourism. The region's high level of material consumption, on par with that of the rest of Norway, poses challenges in the form of resource use, degradation and pollution throughout the life cycle of economic activities.

PARTNERSHIPS: To secure continuous development and economic growth, the Norwegian Arctic is dependent on peace and stability; it relies on development and conservation going hand in hand and expects that due regard is taken to the local society and indigenous rights. This requires multi-stakeholder partnerships at several levels – from international cooperation to local community partnerships.

This foresight report is divided into four parts:

INTRODUCTION (THIS PART): It contains a short summary of the previously published part 1 (status) report that describes the current situation and then introduces the part 2 (foresight) report.

INPUT – EXISTING TREND STUDIES: A description of key flagship trend reports with relevance for the Norwegian Arctic, providing background for the foresight study. This includes reports from the Organisation for Economic Cooperation and Development (OECD), the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and DNV GL, all covering the global situation, and reports from SINTEF, the Norwegian Government and the Norwegian Centre for Climate Services, covering Norway and the Norwegian Arctic. In addition, geopolitical references are utilised to enhance understanding of the underlying international relationships and tensions relevant for the region.

FORESIGHT - FUTURE OF THE BLUE ECONOMY IN THE NORWEGIAN ARCTIC: The foresight part presents four different scenarios for the Norwegian Arctic: green and blue growth (1), slow transition (2), depletion (3), protective/conserving growth (4). Each scenario corresponds to one quadrant of a matrix where global climate change and resilience in the blue economy are the main drivers.

OPPORTUNITIES - ACHIEVING A SUSTAINABLE BLUE ECONOMY: This part suggests opportunities and strategies for achieving a sustainable blue economy in the Norwegian Arctic. Potential developments towards 2030 and 2050 are discussed, and the fit within the four scenarios assessed. Recommendations are provided on how to proceed to make these developments likely to occur by 2030 and 2050, respectively.

3 Input – existing foresight studies

In this chapter the key flagship trend studies selected as a basis for this report are presented. They do not represent a full literature review of all potentially relevant foresight studies. The following reports are presented:

- Global foresight reports:
  - *The Ocean Economy in 2030* by the Organisation for Economic Cooperation and Development (OECD) (2016)
  - *Global Warming of 1.5°C* — a special report by the Intergovernmental Panel on Climate Change (IPCC) (2018)
  - The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (May 2019 - so far only a summary for policy makers has been published)
  - *Energy Transition Outlook 2018* by DNV GL (2018)
  - A selection of geopolitical reports relevant to the Arctic region
- Foresight reports for Norway and the Norwegian Arctic:
  - Ocean-based industry: *Norsk havøkonomi mot 2050* and *Havnæringene i nord – næringsutvikling og verdiskapning frem mot 2040* by SINTEF (2017 and 2018)
  - Climate change: *Climate risk and the Norwegian Economy* from the Climate Risk Commission, appointed by the Norwegian Government (2018) and *Climate in Norway 2100 – a knowledge base for climate adaptation* by the Norwegian Centre for Climate Services (2017)

3.1 Global foresight reports

3.1.1 OECD Report

The Ocean Economy in 2030 [2] explores growth prospects for the ocean economy and its capacity for employment creation and innovation. The study states that developments in global population, climate and environment, economic growth, trade, rising income levels and technology are the primary drivers of the rapidly expanding economic activity in the ocean. The contribution of the ocean economy in 2010 was conservatively valued to USD 1.5 trillion according to preliminary calculations based on the OECD's Ocean Economy Database. This is approximately 2.5 % of the world's gross value added (GVA). In 2010, direct full-time employment in the ocean economy was measured to approximately 31 million jobs, and the report forecasts that ocean-based industries will account for around 40 million jobs worldwide in 2030. Marine aquaculture, offshore wind, fish processing, and shipbuilding and repair will experience particularly strong growth.

Emerging ocean-based sectors identified in the report include offshore wind, tidal and wave energy, offshore extraction of oil and gas in deep-sea and other extreme locations, seabed mining for metals and minerals, marine aquaculture, marine biotechnology, ocean monitoring, control and surveillance. It is recognised that the ocean offers many opportunities for economic growth, including immense resource wealth, possibilities for employment and innovation, and importance in resolving such issues as world food security and climate change. Together with these opportunities, a range of challenges are identified: decreasing marine biodiversity, overexploitation, acidification and pollution of the ocean, climate change together with rising sea levels and higher frequency of severe ocean weather events.

Scientific and technological advances are expected to play a crucial role in the coming decades, both in order to address the many ocean-related challenges and to further develop ocean-based economic activities. Every sector of the ocean economy will be affected by the advances in technology, such as autonomous systems, computerisation and big data analytics, innovation in advanced materials, subsea engineering and technology, sensors and imaging, satellite technologies, and bio- and nanotechnology.

The productiveness and efficiency of the future ocean in terms of providing the world's population with seafood will be highly dependent on several factors. These factors include increased sea water temperature, acidification, stratification, changes in the hydrological cycle and ocean currents, eutrophication from coastal run-offs and other types of pollution, overfishing and habitat destruction.

The report gives the following recommendations to enhance sustainable development of the ocean economy:

- Foster greater international cooperation in maritime science and technology as a means to stimulate innovation and strengthen the sustainable development of the ocean economy.
- Strengthen integrated ocean management.
- Improve the statistical and methodological base at national and international level for measuring the scale and performance of ocean-based industries and their contribution to the overall economy.
- Build more capacity for ocean industry foresight.

3.1.2 IPCC report

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) published a special report [3] which addresses the impacts of global heating of 1.5 °C above pre-industrial level and related global GHG emission pathways. The work behind this report was carried out in the context of strengthening global response to climate change threats, sustainable development and efforts to eradicate poverty. The special report highlights that in order to stay within the 1.5 °C target, a more than 40 % reduction in CO_2 emission levels, compared to those in 2010, is required by 2030. Warming beyond this target will significantly impact marine, aquatic and terrestrial biodiversity and ecosystems, and their services to humans.

The report states that human activities have already caused approximately 1.0 °C of global heating above pre-industrial levels and that global heating is likely to reach 1.5 °C between 2030 and 2052 if it continues at the current rate. Impacts on natural and humans' systems from global heating are already being observed; many land and ocean ecosystems have already changed. If the trend continues, some impacts may be long-lasting or irreversible, such as the loss of ecosystems. Future climate-related risks would be reduced by upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by incremental and transformational adaption.

The report finds robust differences in regional climate characteristics between present-day and global heating of 1.5 °C, and between 1.5 °C and 2 °C. Differences include increases in mean temperature in most land and ocean regions, hot extremes in most inhabited regions, heavy precipitation in several regions and the probability of drought and precipitation deficits in some regions. Limiting global heating to 1.5 °C compared to 2 °C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more ecosystem services to humans. Global heating of 1.5 °C is likely to shift the ranges of many marine species to higher latitudes and is expected to drive the loss of coastal resources and reduce the productivity of fisheries and aquaculture. Limiting global heating to 1.5 °C will most likely reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels, consequently reducing risks to marine biodiversity, fisheries and ecosystems compared to the 2 °C scenario.

Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could be triggered at around 1.5 °C to 2 °C of global heating and may result in multi-metre rise in sea level over hundreds to thousands of years. There is high confidence that the probability of a sea ice-free Arctic Ocean during summer is substantially lower at global heating of 1.5 °C when compared to 2 °C.

3.1.3 IPBES report

In May 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published a summary for policymakers [4] stating that the global pursuit of economic growth significantly alters life on Earth. The full report has not yet been published. The summary report was put together by 145 scientists from 50 countries, and about 15,000 scientific and government sources were examined. The summary report adds to a growing scientific consensus on the need for fundamental action to save the planet.

The report concludes that 75 % of the planet's land surface is significantly altered, 66 % of the ocean area is experiencing increasing and cumulative impacts, over 85 % of wetlands area has been lost and approximately half the live coral cover on coral reefs has been lost since the 1870s with accelerating losses in recent decades due to climate change exacerbating other drivers. The report raises awareness that about one in eight of the planet's plants, insects and animals are at risk of extinction because of human activity, many within decades. It is highlighted that biodiversity is 'declining faster than at any time in human history'. By 2016, 559 of the 6190 domesticated breeds of mammals used for food and agriculture had become extinct and 1,000 more are threatened.

The report highlights the direct drivers of change in nature with the largest global impact, being in descending order: changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species. These five direct drivers result from many underlying causes, named indirect drivers of change, which in turn are underpinned by societal values and behaviours such as production and consumption patterns. For marine ecosystems, direct exploitation of organisms (mainly fishing) has had the largest relative impact, followed by land and sea use change.

The report concludes that the negative trends in biodiversity and ecosystem functions are projected to continue or worsen in the future in response to indirect drivers such as rapid human population growth, unsustainable production and consumption, and associated technological development. Goals for conserving and sustainably using nature and achieving sustainability may only be achieved through transformative changes across economic, social, political and technological factors.

3.1.4 DNV GL report

In the report *The Energy Transition Outlook 2018* [5] DNV GL presents a global and regional forecast of the energy transition towards 2050. In addition to the main report, sub-studies have been published which present details related to maritime industry, the oil and gas industry, and the power production and utilities sector. The analysis includes key elements such as global population development and technology development, and forecasts a global peak in energy consumption around 2035, and a peak in fossil energy use around 2027. This trend is primarily driven by slowing population and productivity growth, efficient end-use (particularly in transport electrification), and lower share of fossil fuels at low thermal efficiency in the energy mix. With regard to greenhouse gas emissions reduction, the report forecasts that the 2 °C target will not prove feasible and that the world will reach a heating of 2.5-2.6 °C. Further, the forecast predicts a rapid increase in electricity consumption, with electricity more than doubling of its share of energy demand by 2050. This is driven by extensive electrification in all sectors, particularly electric vehicles, which in turn leads to major expansion of electricity transmission and distribution systems. Renewable sources will dominate in electricity production, such as solar photovoltaic (PV), on- and offshore wind and hydropower.

Shipping currently accounts for more than 80 % of the world's trade by volume. DNV GL predicts a rise of 32 % in seaborne trade, measured in trillion tonne-nautical miles annually in the period 2016-2030. From 2030 to 2050 the growth is predicted to only 5 %. Seaborne transportation is forecasted to increase within all trade segments except crude oil and oil products, which are projected to peak in 2030.

It should also be mentioned that International Maritime Organization (IMO) in 2018 adopted a strategy with the ambitious aim to at least halve the total GHG emission from shipping before

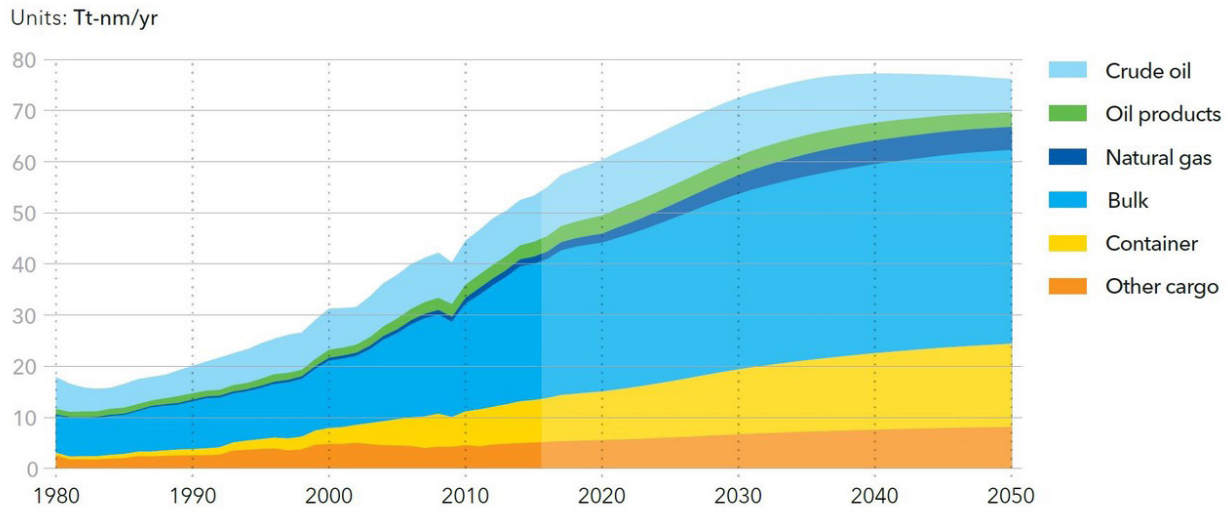


Figure 1. *World seaborne trade in tonne-miles (DNV GL 2018).*

2050 (compared to levels from 2008) and reduce the average carbon intensity (CO_2 per tonne-mile) with 40 % and 70 % by 2030 and 2050, respectively.

DNV GL's *Energy Transition Outlook* predicts that total global energy demand will peak in 2035, with 15 % higher demand than in 2017, after which it will slowly decline towards 2050 due to continuous increase in global energy efficiency, especially within the transport sector, and slower growth in productivity and global population. In 2050, 40 % of the world energy demand will be met by oil and gas, compared to 53 % today, and gas will become the dominant energy source in 2026, overtaking global oil demand, which is forecasted to peak in 2023. The global gas demand is predicted to peak in 2034 but will meet 25 % of world energy demand by mid-century.

For comparison, the International Energy Agency (IEA) *World Energy Outlook* [6], predicts that natural gas will overtake coal in 2030 to become the second-largest fuel in the global energy mix. Industrial consumers will make the largest contribution to a 45 % increase in worldwide gas use.

3.1.5 Geopolitical trend reports

Melting sea ice will increase interest in economic activity in the Arctic. The prospects of vast natural resources and important future shipping routes, combined with the region's strategic location between the East and the West, make the Arctic highly interesting. This is obvious for nations with direct borders to the region, but interest is also shown by others such as Germany, UK, China and India, all involved in research activities on land, sea or both [7].

The same development leads to an increased geopolitical interest. Civilian research activities generate information of relevance to the military, and the current information gathering and sharing will diminish the advantages of familiarity previously held by the traditional Arctic states. Presence through more civilian and military activity and planned responses may increase tension in the future. The main political challenge ahead is to successfully reconcile the different perspectives and interests in the Arctic [8, 9, 10].

3.2 Foresight reports for Norway and the Norwegian Arctic

3.2.1 SINTEF ocean economy report

The report *Norsk Havøkonomi mot 2050*, developed by SINTEF (2017) [11] is based on the work carried out by the OECD, which resulted in the report The Ocean Economy in 2030, and the methods were adapted to consider what role the ocean-based industries in Norway play today, and how the Norwegian ocean economy will develop towards 2030 and 2050.

SINTEF states that given Norway's geography, with six times as much area covered by sea as by land, the ocean is highly important for the future of the Norwegian economy. Norway contributes substantially to the global ocean economy with a total of 7 %, and more than 70 % of the Norwegian export revenues are generated from the ocean industries.

For the outlook towards 2030, the following eleven ocean-based industries were included in the study carried out by the OECD: aquaculture, capture fisheries, fish processing, marine/maritime suppliers, marine and coastal tourism, maritime shipping, offshore oil and gas, offshore wind, port activities and shipbuilding. SINTEF extended the study towards 2050 based on data from Norwegian sources, and included additional industrial sectors: biological production on lower trophic levels, cultivation and growth of seaweed, marine ingredient industry and ocean mining. These 15 sectors are grouped into five different main areas: biologically based industries ('bio-based'), marine tourism, maritime transport, offshore wind, and oil and gas-based industries ('oil-based').

Forecasted trends towards 2050 indicate substantial growth in bio-based and maritime shipping industries, while the oil-based industry will grow only until 2030, and then decrease towards 2050. Bio-based industries are forecasted to have the highest growth, with a factor of 5.1, while marine tourism and maritime transport will grow with factors 2 and 3.2, respectively. A shift in the main contribution to the Norwegian ocean economy from fossil (oil and gas) industry to renewable (bio-based) industry will take place from 2030 to 2050. Projections for the oil and gas industry were estimated with the assumption of a 40 % decrease in Norwegian oil and gas production, to meet the 2°C goal with respect to global heating [12].

3.2.2 SINTEF ocean industries report

SINTEF published *Havnæringene i nord – næringsutvikling og verdiskapning frem mot 2040* in 2018 [13].The report mainly addresses the current status and development of mature and nascent ocean-based industries in the northern parts of Norway. Employment and wealth potential for relevant industries are also projected in two scenarios towards 2040.

The feasibility study predicts a significant growth potential within ocean-based industries such as aquaculture and fisheries, maritime industry, and oil and gas. More immature industries such as offshore wind, ocean-floor minerals, and new marine species represent opportunities for increased activities in northern Norway.

Wild-capture fisheries are predicted to have growth potential mainly owing to increased demand and significantly increased value, with only a marginal increase in volume. For the fish farming sector, the challenges related to the welfare of the fish and the environment have led to limited growth in volume of salmon and trout, even though Northern Norway has great advantages within these fish farming sectors due to ample space and low sea temperature.

On the condition that new areas are opened for oil and gas exploration close to the Russian border, the northern part of the continental shelf could possibly increase its share of the total production volume in Norway from 8.5 % to 35 % by 2040. SINTEF assumes that the 2040 production volume and export

values will be similar to today's, but that the proportion of the created value delivered from Northern Norway will increase. Activities related to aquaculture and maritime tourism in the Arctic are predicted to have a strong growth, as is maritime industry related to potential offshore developments. The maritime industry is also subject to overall developments within electrification, emergency response and preparedness, and digitalisation for increased efficiency.

Several areas in the northern parts of Norway are being considered for offshore wind energy production, and the report highlights the potential for offshore wind as a renewable source of energy to supply the offshore industry with power.

A global increase in demand for minerals and metals drives an increased interest in mineral mining from the ocean floor. The report underlines the lack of any guarantee that seabed mining for minerals will happen on the Norwegian Continental Shelf in the future, and that a possible commercialisation of this is years away, but points out that Norway's unique competence and experience, for instance from the oil and gas industry, introduces a great possibility that the country may become a supplier of technology within this field.

3.2.3 Climate change reports

The global climate is changing and climate change entails climate risk. In October 2017, a commission was appointed by royal decree to assess climate-related risk and its impact on Norway's economy. The report from the Commission, *NOU 2018: 17 - Climate Risk and the Norwegian Economy*, was delivered to the Ministry of Finance in December 2018 [15]. The report states that the average global temperature has so far increased by 1 °C since pre-industrial times. The climate in Norway has changed significantly over the last century and will continue to change. A warmer and wetter climate is expected and this may result in altered patterns of flooding and snow cover, and shrinking glaciers. A stricter climate policy is required to reach the target under the Paris Agreement. As a small country, Norway is highly dependent on global action, which makes the use of scenario analyses necessary. The report presents three future scenarios: 1) successful climate policy, 2) late transition, and 3) dramatic climate change. Numerous estimates indicate a global GDP loss as the result of global heating which will again affect the Norwegian economy. An appropriate starting point for assessing the climate risk in the long run is to estimate how this may affect Norway's overall production and consumption opportunities over time, and thereby current and future generations' welfare.

Norway has an open economy and a relatively large public sector. There is no clear distinction between climate risk in the private and public sectors, which makes it important to adopt an integrated approach to climate risk. Joint risk management principles and methods across all sectors provide the best basis for sound management of these risks for the Norwegian

economy as whole. The open economy has brought Norway large welfare gains. However, this economy is exposed to the consequences of climate risk in other countries; thus it is important to assess how Norway can strengthen its resilience to such risks in both private and public sectors.

The report points out the that the role of the municipalities in ensuring a climate-adapted society should be strengthened. The local character of climate change places the municipalities 'on the front line' in the face of climate change. Climate change affects many of the municipalities' tasks, such as zoning for construction, choosing what kind of infrastructure should be developed, and how citizens' lives and health can be ensured.

The report concludes that the private sector should focus more on knowledge, scenario analysis, and corporate governance, which is important for climate risk management. Climate risk affects the scope and scale of investment, but by expanding knowledge the climate risk can be reduced. The public sector plays a key role in Norway's climate risk management. The government will in many contexts relieve the private sector of risk, for example through pension and social security benefits, risk sharing in the tax system, state aid and guarantee schemes.

The report *Climate in Norway 2100* was published by the Norwegian Centre for Climate Services in 2015 [16]. The main purpose of the report is to provide an updated scientific basis for climate adaptation in Norway. The focus is on future climate, as well as the development of the climate in Norway since the last glaciation and projected climate change and variability through the 21st century with various assumptions for future emissions of greenhouse gases.

The climate projections are derived from global models run with three emission scenarios: RCP2.6, RCP4.5, and RCP8.5. These are based on results from the *Fifth Assessment Report* (AR5) by the Intergovernmental Panel on Climate Change [17]. The period 1970-2000 is used as reference and climate change is estimated up to 2100. Under the RCP8.5 scenario the report concludes that by the end of 21st century, the annual temperature in Norway will increase by approximately 4.5°C, which is the median value of the interval [3.3; 6.4°C], heavy rainfall events will be more intense and more frequent, and the average sea level will rise by 15-55 cm depending on location along the Norwegian coast. Annual precipitation will increase significantly by 18 %, and the sea ice and number of glaciers will be reduced. Under the scenarios involving smaller increases in greenhouse gas emissions (e.g. RCP4.5 or RCP2.6), the expected changes will be significantly smaller.

The report concludes that the three main uncertainties related to climate projections are future anthropogenic emissions, natural climate variations, and climate models. It is not possible to say which emission scenario is most realistic.

4 Foresight - future of the blue economy in the Norwegian Arctic

The trends presented in chapter 3 show potential and expected growth in the blue industries, but also uncertainties and risks from climate change. In this chapter we present four different scenarios for growth and transition in the Norwegian Arctic towards 2030 and 2050. They take two key drivers into account.

The drivers are:

- Climate change action (y-axis)
- Resilient blue economic growth (x-axis)

The four scenarios are:

1. Green and blue growth
2. Slow transition
3. Depletion
4. Protective/conserving growth

The scenario approach is based on a methodology developed by DNV GL and adapted to the Norwegian Arctic and a sustainable blue economy framework.

4.1 Drivers

The scenarios are built around two key drivers: resilient blue economy and climate change. Other factors will also be important for the future of the ocean and the blue economy, such as finding solutions for the ocean pollution problem, ending illegal unregulated and unreported fisheries, technology development for clean energy generation and storage, and overcoming the biological challenges in aquaculture.

4.1.1 Climate change action for the ocean

How the global community will manage to implement actions to mitigate and adapt to climate change, and how these actions will affect the ocean is of key importance to the future of the Norwegian Arctic. If emissions are reduced to meet the 1.5 °C target, the expected slowdown of the temperature changes will give the oceans better opportunities to remain productive and healthy. Should this not be achieved, the health of the ocean will be under significant threat as a result of ocean warming and acidification. Climate change will also impact on precipitation patterns and freshwater runoff from land, which in turn will affect the productivity of coastal zones.

Implementing the Paris Agreement will require global, national and local actions. This means that changes in societies' sentiments towards actions need to be both bottom up and top down. At the high end of the scale for this scenario driver, society is successful in implementing the required actions to reduce or

limit climate change – a considerable change from the current direction. There are, however, significant time lags between actions and improvements. Irrespective of the forcefulness of the actions taken, the ocean will experience changes in the 2030–2050 timespan and beyond, but the magnitude of the changes will be affected.

At the low end of the scale for this driver, society at large is not capable of making sufficient emission reductions, and the goal set in the Paris Agreement is not attained. The consequence is a future with possible threats to ocean health and ocean productivity due to ocean warming, acidification, melting ice, habitat destruction and biodiversity loss, together with sea level rise and more extreme weather.

4.1.2 Resilient blue economy

The blue economy is more important for the Norwegian Arctic than for most other regions. With all the current and future opportunities provided by the ocean, it can be argued that the region needs an approach that gives long-term yield from the ocean, irrespective of fluctuations in specific industries and markets. This can be denoted as a resilient blue economy. The term 'resilient' has long been used to describe ecological systems' abilities to cope with sudden changes, and has recently also been applied to describe the same characteristics in other systems, such as regional economies [18]. In an OECD paper, economic resilience is defined as 'the capacity of an economy to reduce vulnerabilities, to resist shocks, and to recover quickly' [19].

Introducing the resilience term in this respect means how adaptable the blue economy in the Norwegian Arctic is to change. A blue economy at the weak end of the scale can have strong growth but be dependent on a very limited selection of industry sectors. Such dependency places society and communities in a fragile situation, hindering efficient sharing of resources, ideas, competence and workforce between sectors and companies. This makes for a blue economy that is not readily adaptable to changes in markets or technologies, and increases the vulnerability.

At the strong end of the scale, a resilient blue economy will be one where natural resources are utilised sustainably and at a pace that facilitates sustainable growth, balanced between sectors, with multiple industries having access to human and financial resources. All this is supported by efficient processes for management and production, sound cost-benefit assessments that also take into account the broader implications for society as a whole, as well as efficient regulatory environments. Cluster effects are present and utilised: resources, competence and technologies are shared, and learning is distributed across industries, facilitating experimentation and innovation.

4.2 Scenarios

Based on the combinations of climate change action and different degrees of resilience in the blue economy, four scenarios are developed as illustrated in figure 2.

The scenarios are towards 2030 and 2050. In the near future towards 2030, some changes from the current situation are expected, but as the scenarios move towards 2050 the direction is of much greater importance. Thus, the description of the future is mostly focused on the last part of the time span.

For each scenario the following activities are described:

- Marine industries (includes fishery, aquaculture, bioprospecting, seabed mining)
- Energy (includes oil and gas and renewables)

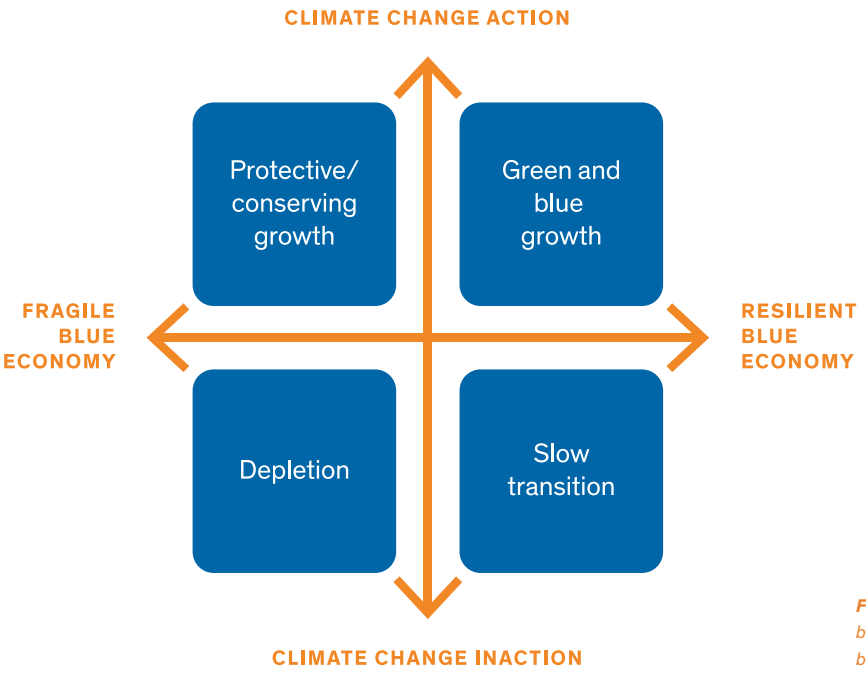


Figure 2. *Scenario approach painting four pictures based on climate change action (y-axis) and resilient blue economic growth (x-axis).*

- Transportation and digital communication infrastructure (includes transport on land, by ship, and by air, and digital communication)
- Competence building and partnerships
- Tourism

4.2.1 Scenario 1: Green and blue growth

'Green and blue growth' is the scenario with strong climate change actions and a successful journey towards a resilient blue economy. The balanced approach reduces the vulnerability of the various blue industries, which may also help keep geopolitical tension levels low.

4.2.1.1 Marine industries

Even though greenhouse gas emissions are reduced, climate change with increased ocean temperature and changes in other properties will impact on fish stocks and their distribution towards 2030 and 2050 and beyond.

It is possible to significantly increase the amount of food that is sustainably produced from the sea. New food products can be introduced to the market towards 2030 and scaled up as generally accepted food sources by 2050. This can for example be achieved through utilising species at lower trophic levels (i.e., further down the food chain) as feed for farmed fish or special products for human consumption. Green and blue growth also means that we need sustainable fisheries with a smaller environmental footprint, well-managed stocks, technology and logistics to process the fish and get it to market. This includes increasing the processing of the fish and optimising the use of what is currently considered waste products but can become resources in the future.

Aquaculture will also move towards more sustainable production. This means more production in closed systems and more production further out at sea. To reduce the climate footprint, production plants are electrified, and service and transport vessels implement hybrid solutions (e.g., electric/gas). In the near future (2030), the vessels can be charged from offshore wind power stations. The processing of the farmed fish will be done locally to a greater extent, packaging will be improved, and a larger proportion of the products will be shipped by train and boat. The problems caused by parasites must be solved with methods that do not involve chemicals that pollute the sea and with technologies that take due regard of fish welfare. The ingredients and value chain for fish feed must be continuously improved towards 2030 and 2050, making them sustainable and part of the circular economy.

Bioprospecting will develop further, and can form the basis for a high-tech bio/pharmacy industry in the region. This will open new opportunities for the aquaculture industry, for example through the development of new sources and properties of fish feed, or through extraction of valuable compounds from marine organisms, to be used for medical purposes. On 1 July 2019, the new Norwegian act on exploration and exploitation of minerals on the Norwegian continental shelf will come into force. This makes it possible to extract raw materials from the Norwegian shelf towards 2030 and 2050, when available resources on land are decreasing. These raw materials can for example be used to make electric cars, smartphones and wind turbines. In this scenario, the region has managed to develop technologies that extract minerals within accepted limits of environmental impact.

4.2.1.2 Energy

The key to Green and blue growth for energy supply in the Norwegian Arctic is effective agreements for CO_2 emission reductions: global climate change agreements, their implementation and enforcement. This will also include the successful implementation of sectoral targets and ambitions for CO_2 reductions such as those of the IMO.

The IPCC 1.5 °C target should be attained, which requires a more than 40 % reduction in CO_2 emissions, compared to levels in 2010, by 2030. By 2050, the CO_2 emissions should be down to net zero compared to levels in 2010. This will require a transition towards renewable energy, greater energy efficiency, and carbon capture and storage.

For the Norwegian Arctic, local emission reductions can be achieved by increasing electrification. Transmission and distribution networks as well as energy storage for balancing the supply to grids will be required.

Globally, offshore wind power has the potential to at least match the energy supplied by offshore oil in 2050. Realising and perhaps exceeding that potential will require accelerated international collaboration to innovate and to set new industry standards [5].

Using 2018 as a reference, recent forecasts suggest a tripling of global installed offshore wind capacity by 2023, and a tenfold increase to 180 gigawatts (GW) by 2030: by 2050 this would be more than 1,000 GW.

Energy sources with lower CO_2 emission than oil, such as gas and biofuel (from plants or waste), will contribute in the transition phase towards a decarbonised energy system. The region's natural gas resources can, by use of carbon capture and storage, be developed into a supply of hydrogen. In addition, energy efficiency measures together with new logistic chains and energy storage will further reduce footprints.

4.2.1.3 Transportation and digital communication infrastructure

Green and blue growth in the Norwegian Arctic will require transportation with zero or low emissions. Transportation will be targeted as a means to achieve a 40 % reduction in CO_2 emissions and hold to the IPCC 1.5 °C target by 2030, and achieve further reductions by 2050.

For private transport, electric cars will become the norm in Norway, replacing the existing car fleet. For public transport and transport of goods there will also be hybrid solutions, for example combinations of electric and hydrogen (fuel cells to

Figure 3. *In the green and blue growth scenario, aquaculture will move towards more sustainable production, for example in closed systems and/or systems placed further out at sea. To reduce the climate footprint, more production plants will be electrified.*

convert hydrogen to electricity) and liquid biogas options. Transport by train can be increased by building new lines connecting the larger cities in the Norwegian Arctic. Furthermore, the Nordland rail line, which is currently diesel-driven, should switch to hydrogen or electricity.

Work is ongoing to develop small aircraft that run on electricity. This should be possible by 2030, and by 2050 also aircraft for short-haul routes should be electric or have hybrid solutions.

The maritime industry has implemented an energy mix consisting of electrification, hydrogen and biogas, and has invested in efficient fairways, new fuel and energy infrastructure and logistic systems. This means electrified green coastal shipping, which Norway got a lead on implementing with regard to maritime and energy technologies, efficient biofuels and hydrogen production facilities, and bunkering infrastructure for deep sea shipping. Together, these have reduced the carbon footprint of goods exported from the region and utilised the competitive advantages of regionally produced blue hydrogen. This has also facilitated growth in the maritime cleantech services and vendor industries.

Fast and reliable digital communication networks will be important towards 2030 and 2050. There are already plans to launch both publically funded satellites in high-elliptical orbit and commercial low-orbit satellites, providing full coverage, redundancy opportunities and high bandwidth in the region.

4.2.1.4 Competence building and partnerships

Green and blue growth in the Norwegian Arctic has to be knowledge-based, and this knowledge must be available close to the industries that need it. The quality of education from primary school to university has to be increased, including the completion rates. This should be achieved well within the 2030 perspective.

Previous studies indicate that 70 % of students in the Norwegian Arctic stay in the region after completing their degree. Investments must be made in schools, universities and research institutions in the Arctic. Further, the education should be focused towards disciplines that can create prospects for work in the Norwegian Arctic.

To be able to address challenges and opportunities in the Norwegian Arctic, such as climate and ecosystem change, it is important to establish community partnerships. These partnerships can explore local problems, identify potential solutions, and propose appropriate policies and measures. More such partnerships should be established well before 2030.

The development of high-tech industries such as bioprospecting, advanced fisheries, clean energy and automation has gone hand in hand with trends at the main universities. Building up internationally recognised expertise enables a sustainable blue economy. In 2030, this has become an export service, with international students and professionals coming to learn and transferring their knowledge locally as well as internationally.

4.2.1.5 Tourism

The uniqueness and beauty of the region attracts many tourists and a substantial increase in tourism is expected in the near future, well within the 2030 perspective.

If not managed correctly, tourism can pose challenges for a sustainable green and blue growth. Hence, in this perspective, all kinds of emissions and negative effects for the communities and nature must be taken into account, including local pollution, greenhouse gas emissions and noise pollution to sea and air. Cruise ships have substantial CO_2 emissions which must be reduced. The first hybrid-powered cruise ships are now being built. Existing coastal vessels must be retrofitted with LNG and batteries.

Figure 4. The uniqueness and beauty of the Norwegian Arctic attracts many tourists but can pose challenges for a sustainable green and blue growth.

Further, the potential impact of a large number of people in sensitive natural environments like Svalbard must be managed. This can be done by controlling the tourist activities and, if necessary, by restricting access to sensitive areas and the size of cruise vessels.

Towards 2030 and 2050 the local income from the cruise industry in the Norwegian Arctic should be increased. Beneficiaries will include local service providers to the tourism industry such as those who offer exclusive 'experience expeditions', caterers who provide local food, etc.

4.2.2 Scenario 2: Slow transition

Slow transition is the scenario in which fossil fuel remains the primary energy source, both on a global and regional level. Emission reduction targets are not reached, and the impacts of climate change are severe. Temperatures are higher, weather is harsher, acidification of the ocean is accelerating, and the coastal zones suffer from runoff and pollution. In 2050, sea ice is no longer present during the summer, which increases the economic activity and attractiveness of the high north for some industries. There is a balance in the blue economy with certain limitations on industries and incentives for transfer of competence, technology and capital within the blue economy sector. This increases the flexibility and knowledge development in the economy, which are important in being prepared for changes.

4.2.2.1 Marine industries

The alterations taking place in the ecosystems due to changes in ocean temperatures and chemistry are affecting life below water, and so is the pollution which has made certain long-lived fish species less suitable for human consumption due to accumulation of harmful substances. There are still large fisheries, but the balance between species is being altered and thus challenged. Fluctuations in stocks in 2030 are larger than previously observed, and continue to increase towards 2050, affecting the fish processing industry and market development. This also puts strains on fisheries management cooperation with neighbouring Arctic states. Due to the increased geopolitical tensions and conflicts with other industries such as oil and gas, shipping and seabed mineral extraction, good solutions and compromises between industry interests are harder to find.

Spatial limitations in the coastal zones, as well as problems dealing with parasites and diseases, push the aquaculture industry further out into more exposed ocean environments and further north. Cooperating with the oil and gas industry on technology development and knowledge transfer is now normal: The industries utilise common technical standards. Due to higher water temperatures, new biological challenges emerge. Coastal areas further south are harder hit by these changes, so the strategic importance of aquaculture in the Norwegian Arctic has risen significantly. This includes Svalbard, which has developed an international aquaculture industry.

Processing of fish is highly automated, enabled by technology development and transfer from other sectors. Together with efficient logistic systems, including large fish export facilities at the airports and new cooling and conservation technologies, the region is an important producer of fish with high reach into global markets by air transport.

Bioprospecting has developed further. The general loss of biodiversity in the ocean has led to an increase in efforts to identify and utilise interesting organisms for high-value products.

Mineral extraction from the sea is a strong growth industry, and the region is combining ocean technology from the blue industries with mineral competence from the mining industry. Several processing plants for refining minerals are established on land.

Figure 5. In the slow transition scenario, the loss of biodiversity has increased the pace of exploration for interesting organisms to utilise for high-value products.

4.2.2.2 Energy

In the slow transition scenario, changes in energy efficiency and electrification are happening, but slowly. The international situation with low success rate at implementing a global climate agreement has reduced incentives for investing in emission reduction measures in the region.

With fossil fuels as the main energy source, offshore renewables and solar have not become a major source of energy in the region. New areas have been opened for oil and gas exploitation, but at limited growth rates. This has led to further development of the oil and gas industry in the region, with new supply bases, remote control centres and an increased demand for subsea expertise as more and more of the installations are placed on the seabed. Some carbon capture and storage technologies are in use to make hydrogen from the natural gas extraction in the region, but the scale is not large, as hydrogen is still not a mainstream fuel.

Figure 6. In the slow transition scenario, new areas are opened for oil and gas exploitation.

4.2.2.3 Transportation and digital communication infrastructure

With sea ice heavily reduced in 2030 and a sea ice-free Arctic Ocean during the summer in 2050, the use of the Northern Sea Route (NSR) has grown significantly. The North-West Passage (NWP) has also seen an increase in traffic, although more modest than the NSR. The Transpolar Sea Route (TSR), sometimes called Trans-Arctic Sea Route, is emerging as a competitor to NSR and NWP. A major shift in traffic between Asia and Europe has taken place, with large deep-sea vessels constantly trafficking the northern region instead of using the Suez Canal. There are more traffic separation zones, more maritime surveillance, and coast guard presence has increased. Search and rescue capacities have also been built up to serve this growth, with tugs and helicopters placed in strategic locations on the mainland and in Svalbard. Other industries such as fisheries, offshore aquaculture, offshore oil and gas and cruise ship tourism are also supported by this infrastructure. With this increase in maritime activity, the maritime service industry, including ports and terminals, has become a major sector with significant growth in employment and revenue. Several new large infrastructure projects have been developed, such as major port infrastructure in Longyearbyen.

Digital communication is continuously increasing in importance. This has led to the commercial development of communication infrastructure such as high-elliptical orbit satellites and others, making the region truly connected. The wilder weather combined with high maritime activity has also increased weather research and forecasting from space.

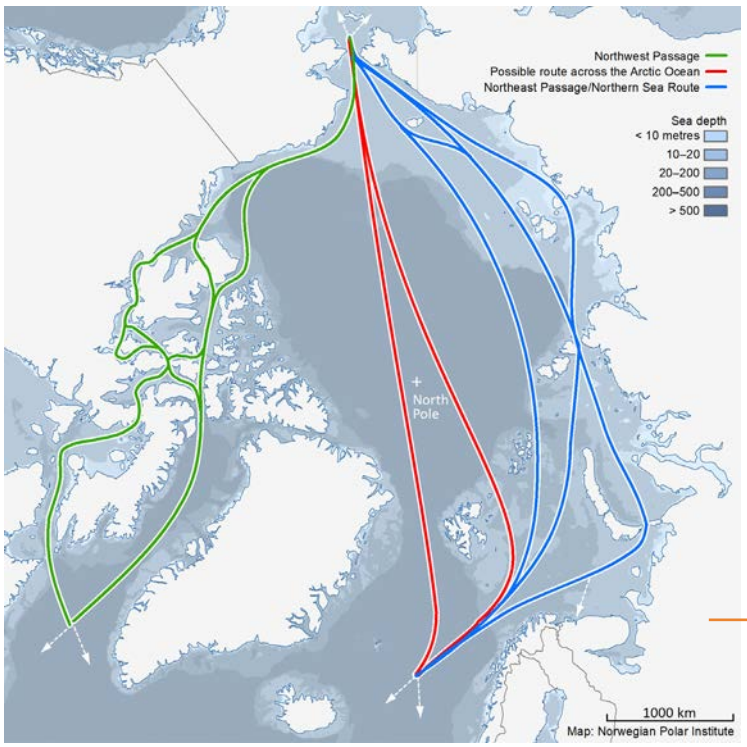


Figure 7. *In an ice-free Arctic Ocean both the Northern Sea Route, the Transpolar Sea Route and the North-West Passage will see an increase in traffic. Illustration: The Norwegian Polar Institute*

Transportation on land has followed its current path with an increasing share of electric, hybrid and hydrogen vehicles, but fossil fuel is still the most important part of the energy mix. The growth in energy and maritime business has led to growth in aviation, with more and larger airports. Rail has also developed further, carrying an increased share of the export goods.

4.2.2.4 Competence building and partnerships

In the slow transition there is a continued need for skilled people within areas such as digitalisation and automation. In addition, the maritime service industry and the offshore oil, gas and aquaculture industries will drive demand for other expertise such as subsea technology, naval architecture and marine engineering.

The impacts from climate change such as extreme weather underline the focus on adaptation solutions for both land and ocean-based industries and society in general. Early climate changes gave the Norwegian Arctic a lead in development of such knowledge, which now is capitalised. Universities are focusing on developing competence and skills in these areas and are facilitating the establishment of knowledge clusters through close cooperation with the industry.

Despite the efficiency effects gained from automation and digitalisation, the asset-heavy industries have a need for competence within practical areas. As a response, the educational systems have tailored the education programmes for youth and are preparing them for the blue industries. There is also a continued focus on reducing school drop-out rates.

The strong job market has stabilised the region's demographic development. Long-term jobs have increased the share of immigrants who become permanent residents, which also shows effects on competence inflow from other sectors and cultures.

4.2.2.5 Tourism

With increased temperatures and reduced biodiversity and productivity along the coastline, the growth in the tourism industry has slowed down. Northern lights and the midnight sun combined with a beautiful landscape still attract international visitors, but the warmer and harsher weather with less snow and ice have reduced the uniqueness and attractiveness of the region.

Cruise vessels are important for the cities and the local communities. Through regulations and cooperation with the industry, local governments have managed to implement models which require vessels and visitors to purchase more supplies and experiences locally, which has increased the region's value creation and the popularity of the industry. Emission reductions have been implemented, but not more than general requirements for the maritime industry.

4.2.3 Scenario 3: Depletion

Depletion is the scenario where emission regulations are limited and there is little willingness to engage in collective actions. Environmental sustainability is challenged, nature and wildlife are poorly protected, pollution of the ocean and coastal zones is severe and there is a considerable loss of biodiversity. Climate change has led to open polar waters, and geopolitical tension has been high for many years due to strategic competition for resources and access to waters.

4.2.3.1 Marine industries

The marine industries are still an important part of the region's culture and identity, but due to temperature rise, lower productivity in the coastal zones and acidification, life below water has been significantly reduced. Patterns of marine life are changing from traditional stock shifts, facilitating entry of new species

into the region. This may stimulate overharvesting by countries that know that fish stocks over time will migrate out of their exclusive economic zones. Moreover, since fisheries management suffers from lack of trust and cooperation between the Arctic nations, fish stocks have been reduced and agreeing on long-term sustainable management strategies is very difficult.

Markets do not view fish from the region as much more sustainable than fish from other sources; thus the regional industry has lost competitive power. Reduced volumes also create challenges for logistics and processing, and an increasing share of the fisheries that remain harvest offshore and export the catch without processing.

Aquaculture has been limited by the changes in the coastal zones but has had some success in moving offshore. However, a new main challenge has arisen: feed shortage. The reduction of wild fisheries has limited the available marine resources for fish feed production, and on the global scale climate changes have led to a world with more food shortages and more hunger, which impedes use of soybeans and grains for fish feed.

An aggressive approach to minerals extraction from the seabed has led to a build-up of this industry, but the environmental consequences are not taken into full consideration in the choice of methods.

4.2.3.2 Energy

As the world is unsuccessful in making global agreements in emission reductions, energy transition is severely hampered and fossil fuels are a main source of energy. In the Norwegian Arctic, the harsher weather creates opportunities for some renewables, but of limited scale and only to support local needs.

Oil and gas extraction is very important. After many years of development and production, the industry is dominant in the region. Exploration and development of new fields and methods have high priority, which generates a lot of activity and jobs but limits the supply of qualified workers to other sectors.

4.2.3.3 Transportation and digital communication infrastructure

Reduction of sea ice in Arctic waters gives good conditions for trans-polar shipping as well as shipping along the Northern Sea Route and through the North-West Passage. There are some challenges due to geopolitical tensions reducing cooperation and creating some barriers to efficiency, but a major growth in ship traffic has taken place during the last decades.

Cooperation difficulties between Arctic nations have curtailed the development of shared digital communication infrastructure, leading to more expensive solutions and thus not utilising the full efficiency potentials offered by digitalisation and automation.

Aviation is growing, but without incentives to implement low-emissions technologies. Railroad transport is not particularly relevant, as the investment costs are high and willingness to invest in carbon-efficient transport is low.

4.2.3.4 Competence building and partnerships

Competence building efforts have prioritised the needs of a few selected industries, such as mineral extraction, maritime activities, and oil and gas. This has led to strong insight and expertise, but little flexibility and resilience towards sudden changes in the markets, making society vulnerable to shifts.

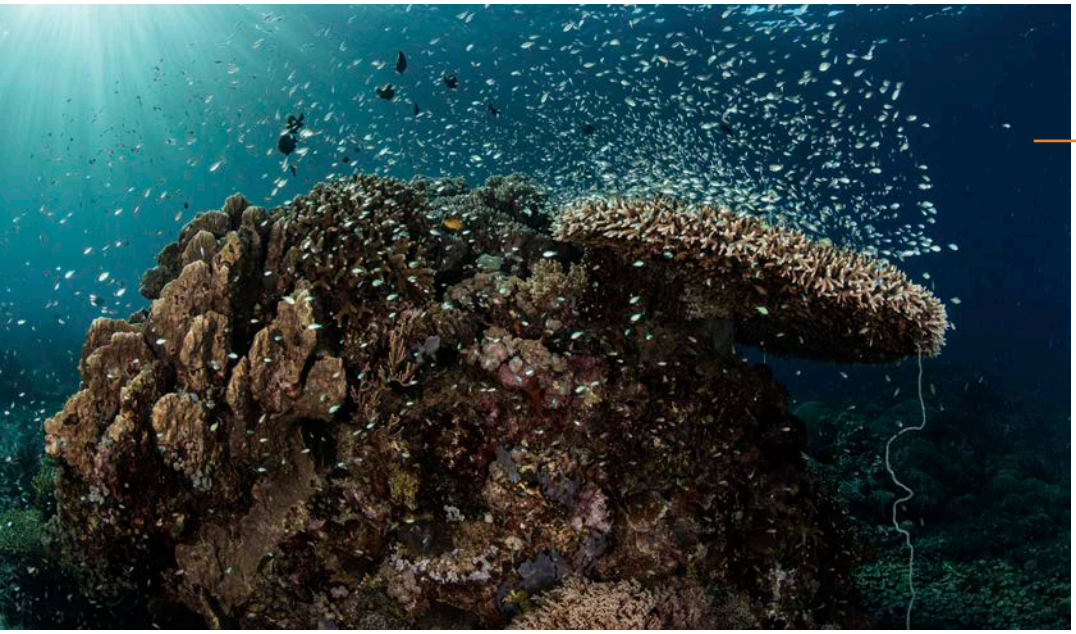


***Figure 8** . Due to temperature rise, lower productivity in the coastal zones and acidification, underwater life has been significantly reduced in the depletion scenario.*

Figure 9. *In the depletion scenario, development of the tourism sector has been unregulated, increasing the trend that large cruise ships enter the area.*

In this setting, there is also a tendency that power becomes centralised to a handful of organisations that are of key importance for society and can use their power as leverage on decision makers. This increases efficiency in some decisions but hampers democratic participation and exchange of opinions.

4.2.3.5 Tourism

Tourism is less important than the large mineral-based industries. Management of the tourism sector is thus not a focus area and the industry's development has been unregulated. This has increased the trend that large cruise ships enter the area and operate under environmental regulations no more stringent than the general international regulations. This industry contributes significant employment opportunities, especially for persons with little education, who work at hotels, airports, restaurants, and in local transportation.

Climate change has led to loss of biodiversity, reduced productivity in the coastal zone, and harsher weather. The marine litter and pollution problem has grown worse, which together with the other changes has reduced the exclusivity and uniqueness of the Arctic cruises. The northern lights and the midnight sun still attract tourists, but the price premium achieved decades ago is no longer present.

The changes to the coastal zones have had consequences for the tourist fishing experience as well; with reduced fisheries near land, conflicts between professional fishermen and fishing tourists have increased.

4.2.4 Scenario 4: Protection and conservation before growth

'Protection and conservation before growth' is the scenario where changes to the climate and ocean are relatively small, but the region must tolerate a fragile economic situation in in order to protect the region's uniqueness and its vulnerable environment. Coupled with a high focus on effective recycling and energy efficiency, raw material and energy consumption is kept at a moderate level. Low growth reduces the availability of jobs in the region, increasing the trend towards population reduction and demographic imbalances.

Figure 10. *In the protection and conservation before growth scenario, local society accepts a fragile economic situation in order to protect the uniqueness of this vulnerable region.*

Due to the limited climate changes, some of the summer ice remains, and the Transpolar and Northern Sea Routes are not available year-round for most ships. This has reduced the strategic importance of the area, and also reduced interest in cooperation and sharing of resources.

4.2.4.1 Marine industries

As a part of the general global climate change adaption and the new generation's focus on healthy diets, vegetables from the ocean have become a central component of the diet. The carbon footprint of food is very important; thus, obtaining protein and nutrients locally from pelagic species and macro algae such as seaweeds is key to filling the region's dietary needs. The long coastal zone has regained productivity and is now cleaner and more attractive for wildlife.

Fishing is limited. The maximum sustainable yield concept has been replaced by a more careful approach where natural fluctuations in stocks and the relationships between them are given higher priority in fisheries management. Coastal fisheries are of great importance. Fishing is done from new generation of low-emission fishing vessels with focus on factors such as using fishing gear with low impact on the seabed and minimising bycatch.

The aquaculture industry has transformed from traditional fish farming to multi-trophic aquaculture where seaweed and seabed species such as sea cucumber are increasingly integrated with the fish in a circular approach where all farmed species gain benefits from each other. Volumes of farmed fish are smaller than previously. The total production from aquaculture is significantly reduced, and Atlantic salmon is no longer a dominant species. The introduction of novel aquaculture species provides some growth, but it is difficult to achieve economies of scale in this industry due to the relatively low degree of automation.

Bioprospecting is important and advanced, but this industry is also affected by the generally cautious approach to the environment, which means that the exploration of new areas is limited. On the research side, this industry's importance has grown and it is seen as a source of environmentally friendly and pure pharmaceuticals and additives.

Extraction of minerals from the seabed is seen as an activity with too much environmental impact and is very limited.

4.2.4.2 Energy

Offshore wind and other ocean-based renewables have been developed. However, due to a general increase in energy efficiency in society, energy needs have not grown much and may even have been reduced. Renewables for export have been developed to some degree, but the large installations are not popular and kept at a bare minimum to keep nature untouched. New ways of optimising existing hydropower plants have also reduced the need for additional development of renewables for local power consumption, although some ocean wind assets are exploited.

No new exploration and development of oil and gas resources is commissioned, and the industry now faces demanding environmental requirements, reducing profitability and curtailing expansion in the region.

4.2.4.3 Transportation and digital communication infrastructure

Connectivity is important as a mean to reduce time-consuming and polluting commuting, and facilitate offsite working. This has also limited the growth of cities, both in terms of business/commercial districts and housing areas, giving people in the region a choice to live near nature out on the countryside. Large transportation infrastructure projects such as highways or railroads are thus difficult to make profitable, and they are not in line with the sentiment in the society. These trends are further strengthened by the negative population development.

At sea, search and rescue (SAR) capacity is still an issue, and the low growth in the activity levels of the region's maritime sector has not given good enough arguments for such resources. Aviation with traditional fuels causes unacceptably high greenhouse gas emissions, and expensive biofuels and synthetic fuels are standard. This restricts air traffic to shorter routes, which reduces both the inflow of visitors and the travelling habits of the region's population.

4.2.4.4 Competence building and partnerships

Natural science and sustainable societies and businesses are key topics of the educational system from elementary school to universities. The region is famous for its caretaking of the wildlife and developing low-emission solutions, attracting interest from other parts of the world where these topics have not advanced to the same degree. This specialisation has given the universities of the region a strengthened international position in research and advanced studies. Leading research areas include climate recovery, and how species' adaptivity develops through changes is a key area of research, giving the bioprospecting industry important knowledge.

4.2.4.5 Tourism

Tourism in the area builds on the four cornerstones midnight sun, northern lights, rich biodiversity in the coastal areas, and a society that has adapted to live in harmony with nature. This has a key consequence: limitations on visitors. The area is regarded as unique and expensive, and only small numbers of high-paying guests are accepted.

Cruise vessels operate under strict restrictions with regard to emissions, and the onboard all-inclusive style for passengers is not accepted. The traffic is distributed by local governments in such a manner that more of the region is utilised, but at very low intensity rates. The limitations on aviation and the relatively low availability of other means of transport has led to a trend where tourists stay much longer than previously, giving the local tourist experience industry a new range of opportunities.

5 Opportunities - achieving a sustainable blue economy

This chapter contains suggestions for opportunities and strategies for achieving a sustainable blue economy in the Norwegian Arctic. The potential developments towards 2030 and 2050 are discussed and the fit towards the four scenarios assessed. Recommendations are provided on what steps can be taken to make these developments likely to occur before 2030 and before 2050.

The opportunities discussed in this chapter were mainly identified in workshops throughout the project. A broad selection of participants from blue industries, research, NGOs and governmental agencies participated in these workshops. Additional opportunities have been collected from other comparable projects or ongoing market and technology development.

Table 1 shows suggestions for opportunities and strategies for achieving a sustainable blue economy in the Norwegian Arctic sorted by type of activity. In the following chapters (5.1 to 5.5) the different suggestions are described in greater detail. This is a selection of relevant suggestions, not an exhaustive list.

TITLE	DESCRIPTION	SOURCE
Marine industries		
Aquaculture development	The environmental impact of aquaculture could be reduced through further development of the industry. One possibility is to move the fish farms further offshore, out of the fjords and away from coastal areas. Other opportunities are electrification of the land-based plants for fish farming and more local processing.	Workshop / DNV GL

Harvesting from lower levels of the marine food web	So far, we mainly consume organisms at the upper level of the food web in the sea. But there is enormous potential for good proteins from for example copepods and mesopelagic fish further down in the food web.	Workshop
Mineral resource extraction from the seabed	There are indications of substantial amounts of minerals on the Norwegian continental shelf around Svalbard, Jan Mayen and other areas. Extraction of these minerals from the seabed could support the green shift– for example, the electrification of transportation requires metals for batteries.	Workshop / DNV GL
Production of hydrogen from natural gas	The Norwegian Arctic is strong on natural gas. The coming green shift towards use of hydrogen as fuel could be a major opportunity for the region, as hydrogen can be extracted from natural gas.	DNV GL
Polar ocean energy technology research centre	A research centre for cold climate ocean technologies with focus on harvesting energy from the ocean in the future.	DNV GL

Energy

Production of hydrogen from natural gas	The Norwegian Arctic is strong on natural gas. The coming green shift towards use of hydrogen as fuel could be a major opportunity for the region, as hydrogen can be extracted from natural gas.	DNV GL
Polar ocean energy technology research centre	A research centre for cold climate ocean technologies with focus on harvesting energy from the ocean in the future.	DNV GL

Transportation and digital communication infrastructure

Emission-free air transport for remote communities	For people living in remote communities in the Norwegian Arctic, transport is difficult. It is not possible to have a road network that reaches every residence. Emission-free air transport would be one way to improve the transport options.	DNV GL
Port and maritime services development for the Northern Sea Route	The Northern Sea Route (NSR) offers a substantially shorter distance from Europe to Asia and vice versa. This traffic is expected to grow in the future and is an opportunity for the ports of the region to become important service providers.	Workshop

Competence-building and partnerships

International education as means of profiling	Executive MBA, BSc, and MSc programmes focused on the ocean and targeting international students from countries such as China, Germany and USA will help in profiling the Norwegian Arctic and encourage more students to stay and work in the region after graduation. This will also help reduce the competence gap of the region.	Workshop/ McKinsey [20]
Local partnerships and local ownerships	Establish multi-stakeholder partnerships at local level to secure continuous development and economic growth in the Norwegian Arctic.	DNV GL / Workshop
Ecotourism	Base the tourism in the Norwegian Arctic on the principles of ecotourism.	DNV GL / Workshop
Stronger local revenue from tourism	Ensure that most of the income from tourism in the Norwegian Arctic stays in the region.	Workshop

Each suggested opportunity is assessed in relation to the four scenarios (green and blue growth (1), slow transition (2), depletion (3) and protective/conserving growth (4)). The assessment describes how probable it is that the suggested opportunity will contribute to a sustainable blue economy under each scenario. Table 2 shows the scale for the assessment of the suggested opportunities.

Table 2. Scale for assessment of suggested opportunities

High	The opportunity has a high probability of contributing to a sustainable ocean economy under this scenario
Medium	The opportunity has a medium probability of contributing to a sustainable ocean economy under this scenario
Low	The opportunity has a low probability of contributing to a sustainable ocean economy under this scenario

5.1 Marine industries

Aquaculture development

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Medium	Low	Medium

Aquaculture has the potential to be a continuing and growing industry towards 2030 and 2050. To achieve this, the ongoing work to reduce the environmental impact of aquaculture must continue and be intensified.

There is interesting work ongoing to move the fish farms offshore and out of the fjords and coastal areas. This aquaculture strategy, denoted 'ocean farming', employs more robust installations that will be more difficult for fish to escape from and more resistant to sea louse infestation than conventional installations, thus reducing the biological pressure on fjords and coastal areas that are currently used for fish farming. Other activities in the coastal zone will have limited impact on these farms, which will also have more stable water temperatures and water quality.

Work is also ongoing to shorten the production time of the fish in the sea to reduce the need for treatment against lice. Furthermore, closed plants are being developed that have no direct discharge to the sea. In such plants the water is cleaned and recirculated.

The climate impact is reduced by electrification of plants for fish farming. Live fish carriers can be equipped with hybrid solutions (electric/gas). The live fish carriers can be charged at offshore wind installations.

To minimise the environmental impact of aquaculture, there will be more local processing, improved packaging, improved transport/logistics (more transport on train/boat) and other new technologies that will give stronger fish, better growth and less disease. Better cooling technologies for keeping the fish fresh longer will enable longer transportation time, thus favouring train/boat in comparison with road. Another important task will be to change consumers' perceptions, to convince them that frozen products have food qualities comparable to those of fresh products, but with a much smaller climate footprint.

Goal by 2030: Diseases and sea louse infestation reduced by 50 %, achieved by new production and processing methods. CO_2 emissions from aquaculture reduced by 50 %.

Goal by 2050: Diseases and sea louse infestation reduced by 90 %, achieved by new production and processing methods. CO_2 emissions from aquaculture reduced by 90 %.

Figure 11. *One of the concepts for Ocean farming is a 430-metre-long and 54-metre-wide farming vessel, which can accommodate 10,000 tonnes of salmon. Source: https://www.nordlaks.no/havfarm*

Harvesting from lower levels of the food web in the sea

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Medium	Low	High

The lower levels of the food web in the sea contains large amounts of food/nutrients (lipids, carbohydrates, proteins) and can be an important source of nutrition for the planet's growing population.

Fish that we catch today, such as salmon and cod, have typically consumed 3-5 times their own weight, which means that a lot of protein is used to create the tissue we eat when we consume fish from high up in the food web.

Consuming species from the lower end of the food web also means lower intake of persistent organic contaminants. Owing to their shortlife cycles, species at low trophic levels accumulate less organic pollution than species higher up in the food web. In the Norwegian Arctic there is potential for harvesting of mesopelagic fish and copepods such as Calanus finmarchicus, which was recently opened for experimental fishing. A more detailed description of mesopelagic fish and copepods is given in the status report.

On a global scale, estimates indicate a mesopelagic biomass of perhaps 10,000 million tonnes. The total world fish biomass has been estimated to be somewhere between 800 and 2,000 million tonnes.

Goal by 2030: Products from the lower levels of the food web constitute 20 % of the food from the sea

Goal by 2050: Products from the lower levels of the food web constitute 50 % of the food from the sea.

***Figure 12**. A copepod of the genus Calanus. Photo: Galice Hoarau, Nord University. Source: https://www.nord.no/no/aktuelt/nyheter/Sider/Raudate-forskning-vekker-internasjonal-oppsikt.asp*

Mineral resource extraction from seabed

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	High	Medium	Low

Future need for mineral resources is expected to increase as a result of the population growth on Earth, (we are expected to be 9.8 billion people in 2050), economic growth, and the green shift, where metals are essential for technology development and supply of green value chains.

Norway's total mineral resources at the seabed within the Norwegian continental shelf have not yet been quantified. Mapping of the seabed on the Norwegian continental shelf is underway to discover new metal deposits, as a basis for estimating the supply of metals on the Norwegian continental shelf. Studies carried out so far have been promising, and they have concentrated mainly on the mid-ocean ridges on the shelf where metal-containing minerals have been found. Investigations done lately indicate that there are also deposits of such resources outside the ridges.

One can expect that, as a result of rising mineral prices and less access to minerals on land, at some point it will be profitable to extract subsea minerals. This is more likely to occur towards 2050 than 2030. At the same time, it is important to obtain more knowledge about how biodiversity and the ecosystem at great depths are affected by mineral extraction.

Figure 13. *Mineral sample from 3,000 m water depth outside Jan Mayen on the Norwegian shelf. Photo: MarMine (NTNU) – Lars Ivar Tumyr*

5.2 Energy

Production of hydrogen from natural gas

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Medium	Low	Low

The region has substantial amounts of gas in the offshore reservoirs. The Norwegian Petroleum Directorate estimates that the Barents Sea contains more than 2/3 of the undiscovered oil and gas resources on the Norwegian Shelf and there is currently high exploration activity in the area. Today, there are two production fields for gas north of the Arctic Circle:

- The Snøhvit field in the Barents Sea, situated 140 kilometres northwest of Hammerfest, Norway. The Snøhvit field is operated by Equinor on behalf of six gas companies owning licenses. The gas from the field is transported by pipeline to Melkøya outside Hammerfest where the gas is processed to liquid natural gas (LNG) before it is shipped out. The field was opened in 2007 and is planned to produce for about 30 years (until 2037).
- The Aasta Hansteen field is located 300 km off Bodø in the Norwegian Sea and is operated by Equinor. From the Aasta Hansteen platform the natural gas is exported through the Polarled pipeline to the Nyhamna processing plant and further to the markets in Europe. The field was opened in December 2018.

Hydrogen is most commonly produced by natural gas reforming, using high-temperature steam (700 °C–1,000 °C). When exposed to steam and heat, carbon (C) atoms separate from methane (CH_4). After two successive reactions, the atoms reform separately to produce hydrogen (H_2) and carbon dioxide (CO_2). The exergy losses in natural gas reforming, where natural gas is the only source of exergy input, comprise approximately 22 % of the total exergy input of natural gas [21].

In the Norwegian Arctic, there would be a possibility to produce substantial amounts of hydrogen from natural gas coming from

Figure 14. Hydrogen fuel cell bus. Source: http://ballard.com/images/default-source/Bus-Market/altoona-floating.png?sfvrsn=3

the Barents Sea area. This will also require CO_2 storage by using carbon capture storage technology (CCS), for example reinjection.

Hydrogen is a clean fuel with no emissions. Hydrogen fuel cells can for example be used in transport vehicles like buses, and hydrogen is expected to be one of the solutions for the massive emission reductions required in the maritime industry.

Goal by 2030: Hydrogen production from natural gas in the Norwegian Arctic

Goal by 2050: Hydrogen has replaced all other fossil fuel in the Norwegian Arctic

Polar ocean energy technology research centre

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Low	Low	Medium

The region's proximity to harsh waters while remaining within range of land-based logistics could provide opportunities for doing research, and testing and experimenting with new ocean energy technology at a dedicated research centre in open and coastal waters. The region's natural close relationship with the ocean and the presence of a broad range of blue industries in growth may facilitate this. Such a centre should not be competing with the Ocean Space Centre in Trondheim, but rather identify a niche where knowledge gaps in cold water technologies could be filled.

This research centre could specialise in developing and testing technologies for renewable marine energy sources such as:

- Offshore wind energy
- Wave energy
- Tidal energy
- Ocean current energy
- Energy derived from temperature differences at various ocean depths (ocean thermal energy conversion)
- Energy derived from the different salt content of fresh-water and saltwater (osmotic power)

The technologies could in theory meet the energy needs for the whole planet. However, there are major challenges related to these technologies. They are difficult to develop and operate,

Figure 15. Energy Department-supported 'Azura' wave energy converter is installed at a U.S. Navy test site in Hawaii. Photo courtesy of Northwest Energy Innovations. Source: https://www.energy.gov/articles/capturing-motion-ocean-wave-energy-explained

saltwater corrodes steel and other metals, and the cabling to the grid is extremely complicated. But these are technologies that would be almost ideal as energy sources for the Norwegian Arctic.

Research funding for these marine energies (except wind) is low compared with funding supporting solar and other renewable forms of energy, and the process of experimentation and refinements with different designs is generally not as well developed.

A research and test centre in the Norwegian Arctic for renewable marine energy sources and high-tech solutions could for example be co-financed by the EU and be a boost for these technologies.

Goal by 2030: A high-tech research centre for renewable marine energy is established.

Goal by 2050: The research centre has developed renewable marine energy technology that can provide 20 % of the electricity consumed in the Norwegian Arctic.

5.3 Transportation and digital communication

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Low	Medium	High

Emission-free air transport for remote communities
Despite the relatively high degree of urbanisation in the region, many people in the Norwegian Arctic live in remote communities with sometimes long and complicated transport to service centres, hospitals, etc.

Today, emission-free air transport concepts are being developed for shorter distances and for only one or two passengers. One example is the Airbus Vahana project. The project's goal is to develop a self-piloted electric helicopter. The vision is that such a helicopter should cost about as much as a car. The core focus of the design is on the automation of the helicopter so that anybody can fly it.

While Vahana is primarily for transport of humans, the design is also intended for cargo delivery, emergency services, and the search and rescue industry.

Goal by 2030: Emission-free air transport is possible in the region

Goal by 2050: Emission-free air transport will be as common as emission-free car transport

Figure 16. *The Airbus Vahana. http://evtol.news/2019/02/22/airbus-vahana-picks-up-speed*

Port and maritime services development for the Northern Sea Route

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
Medium	High	High	Low

At present there is very little traffic from Europe to Asia and vice versa along the Northern Sea Route (NSR). When sea ice in the Arctic melts, this traffic is expected to grow owing to the shorter distance from Asia. More traffic will make the region's ports important service providers. Businesses in the region will also develop concepts where they deliver goods and services actively, using the NSR, thus changing today's reactive approach where they are on the receiving end of the supply chain. A more detailed description of the Northern Sea Route (NSR) is given in the status report.

The Northern Sea Route is an opportunity to develop ports and support hubs in the Norwegian Arctic. This can contribute to development of the local infrastructure, create local employment, and attract a diversity of new supporting businesses. For a future scenario, the Transpolar Sea Route (TSR), sometimes called Trans-Arctic Route, should also be mentioned. This is a future Arctic shipping route that could become available when the central parts of the Arctic Ocean become ice-free. The route runs from the Atlantic Ocean to the Pacific Ocean across the centre of the Arctic Ocean close to the North Pole. This would be an even shorter route between Europe and Asia than the Northern Sea Route.

Goal by 2030: Develop at least one port as a support hub for the Northern Sea Route

Goal by 2050: Develop at least three ports as support hubs for the Northern Sea Route

***Figure 17**. The Northern Sea Route.*

5.4 Competence building and partnerships

International education as a means of profiling

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	High	Medium	High

One way of attracting more students to the Norwegian Arctic is to offer international education programmes. The University Centre in Svalbard (UNIS), UiT The Arctic University of Norway and North University are examples of higher education institutions that are successful at attracting both Norwegian and foreign students. UNIS had 772 students from 43 countries in 2018. The university centre offers studies at the undergraduate, graduate and postgraduate level in arctic biology, arctic geology, arctic geophysics and arctic technology. Students at UNIS are formally enrolled at universities in mainland Norway. Foreign students who arrive without any direct connection to a Norwegian university are enrolled at UiT the Arctic University of Norway.

Offering international education with executive MBA, BSc and MSc programmes in subjects that are relevant for the Norwegian Arctic, such as fishery, aquaculture, maritime transport, and tourism, will attract students from Norway and abroad. Offering subjects that are of importance for the region will hopefully mean that more students stay and work in the region after graduation. This will also help to reduce the competence gap of the region.

Goal by 2030: Increase the number of student places and students in the region by at least 50 % compared with today. Have at least 70 % of the students stay on after graduation.

Goal by 2050: At least double the number of student places and students in the Norwegian Arctic compared with today. Have at least 70 % of the students stay on after graduation.

Figure 18. *Fieldwork for students at UNIS. Photo: S. Coulson/UNIS https://www.uarctic.org/member-profiles/norway/8835/university-centre-in-svalbard*

Local partnerships and local ownerships

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	High	Medium	High

One of the conclusions in the status report was that in order to secure continuous development and economic growth, the Norwegian Arctic is dependent on peace and stability. This requires multi-stakeholder partnerships at several levels – from international cooperation to local community partnerships. However, there are few partnerships at local level: such cooperation should be further encouraged.

Local partnerships can be achieved by offering cultural facilities and arenas where people can meet. This should also stretch across borders to Russia, Sweden, and Finland. Events could be related to sports, theatre and gastronomy. It is important that these be arenas where all can meet, and that regard is shown for the local societies and indigenous rights.

Goal by 2030: Have a functioning programme for local partnerships in the Norwegian Arctic

Goal by 2050: Have functioning programmes for local partnerships in the whole Arctic

Figure 19. *Snowshoe competition at the Arctic Winter Games in Whitehorse, Yukon, Canada http://www.canadianutilities.com/Our-Commitment/Community/_layouts/mobile/dispform.aspx?List=62825e1b-8d77-4c68-aaeb-4bdb-ddf0e2b0&View=2479af1d-227d-4544-a438-49481eed8a2a&ID=29*

5.5 Tourism

Ecotourism

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Low	Low	High

The Norwegian Arctic has a lot to offer for tourists. Tourism can create a substantial amount of employment in the region. It can have a green profile and be based on the principles of ecotourism.

Ecotourism is defined as responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education [22].
The principles of ecotourism according to The International Ecotourism Society (TIES) are:

- Minimise physical, social, behavioural, and psychological impacts.
- Build environmental and cultural awareness, and respect.
- Provide positive experiences for both visitors and hosts.
- Produce direct financial benefits for conservation.
- Generate financial benefits for both local people and private industry.
- Deliver memorable interpretative experiences to visitors that help raise sensitivity to host countries' political, environmental, and social climates.
- Design, construct and operate low-impact facilities.
- Recognise the rights and spiritual beliefs of the Indigenous People in your community and work in partnership with them to create empowerment.

It is recognised that many international visitors travel great distances to visit Norway, usually by plane. In the future, low-emission aviation and alternative means of transportation should be endorsed in order to achieve sustainable tourism. Regardless, implementing ecotourism in the Norwegian Arctic is an important part of a green and blue growth scenario.

Goal by 2030: All principles of ecotourism implemented in the Norwegian Arctic

Goal by 2050: All tourist transport is done with zero CO_2 emissions

Figure 20. *Ecotourism. Photo: Lies Ouwerkerk. https://www.transitionsabroad.com/listings/travel/articles/arctic-ship-expedition-travel.shtml*

Stronger local revenue from tourism

Green and blue growth	Slow transition	Depletion	Protective/conserving growth
High	Medium	Low	High

Tourism is growing in the Norwegian Arctic and has the potential to generate substantial revenue in the region. However, there are several challenges, such as some aspects of cruise tourism. In cruise tourism, most of the revenue stays with the cruise company itself, as it provides the tourists with both lodging and food during their entire journey in the Norwegian Arctic.

This calls for new and innovative tourism where the local population is more involved and can offer services that are attractive to the tourists. This could for example be stays with locals at fishing villages or reindeer farms where they can come in close contact with local culture. Further, there is an increasing interest in outdoor activities like hiking and skiing in the Arctic. By offering and professionalising tailor-made activities in their own home environment, the local population could find an additional source of income. This also calls for development and implementation of standards, and for quality and environmental control in the industry.

Goal by 2030: 50% local revenue from tourism in the Norwegian Arctic

Goal by 2050: 75% local revenue from tourism in the Norwegian Arctic

Figure 21. *Dog sledding under the northern light.*

6 Conclusions

6.1 Pathway towards a green and blue future

The foresight study shows that to deliver on the ambition of securing a sustainable blue economy in the Norwegian Arctic in 2030, and 2050, the scenario 'green and blue growth' has to be the goal. To reach this scenario, substantial changes and investments need to be made. The eight most important changes and investments for the Norwegian Arctic are assessed to be:

1. Work towards even more sustainable fisheries with smaller footprints, well-managed stocks and improved technology and logistics to process the catch in local communities and efficiently transport it to markets.

2. Aquaculture must become more sustainable, for example through production in closed systems where what is currently considered waste is used as a resource, production further out to sea, and improved methods to treat fish for parasites.

3. Change the energy mix. Increase electrification by producing more energy from sources with zero CO_2 emissions (e.g, wind power and solar energy), and energy sources with lower CO_2 emissions than oil, such as gas, biofuel and hydrogen.

4. Transportation should generate zero or lowest possible CO_2 emission. Replace traditional fuel with electric, liquid biogas, hydrogen or hybrid solutions.

5. Infrastructure for rapid, secure digital communication is important towards 2030 and 2050. Investments to ensure this include launching more communication satellites to give full coverage and high bandwidth.

6. Increase competence-building. Improve the quality of education from primary school to university, including the completion rates, and focus education towards disciplines that can create jobs in the region.

7. Improve infrastructure for transportation and communication (roads, railway, shipping, power lines), and for better search and rescue capacities.

9. Form community partnerships to be able to address challenges and opportunities. They can explore local problems, identify potential solutions, and propose appropriate policies and measures.

The opportunities might serve as an inspiration for how the sustainable blue economy in the Norwegian Arctic can be achieved. Efforts to realise one or several of these opportunities should begin with an analysis of costs and benefits.

6.2 Synergism rising from a cross-sectoral approach

A successful future and a sustainable blue economy for the Norwegian Arctic is totally dependent on cooperation between the different sectors. Without such close cooperation the possibility of attaining the goals and opportunities described for 2030 and especially for 2050 will be very severely hampered.
We can illustrate what is meant by cooperation between different sectors with a practical example: Offshore electrified aquaculture plants can get their energy from offshore wind installations. The offshore wind installation can also supply other electric or hybrid electric vessels in the area with energy. The waste products from aquaculture cages at the offshore plant can be sent to land and refined to valuable products such as biofuels. The local tourist agencies can arrange trips to the offshore aquaculture plants for tourists to see how fish farming is carried out.

Meanwhile, research institutions can gather data and cooperate with the industries for research and education, especially engaging young people. Importantly, relevant local and traditional knowledge should be used. The benefits from such coordination of activities can give lower energy consumption and reduced emissions, increased income and knowledge production, a circular economy, reduced tensions between industries regarding matters such as area conflicts, and broaden the citizens' understanding of ocean industries, thus easing the social license to operate and govern.

This is just one example, but it illustrates how close cooperation between different sectors can create win-win situations that develop society in a sustainable manner. This can be achieved in many ways. For example, establishing public-private networks and partnerships that seek coordinated actions may spark new holistic solutions. Another possibility could be to establish public-private full-scale case projects where coexistence solutions aiming at synergism are tested. Collaboration between management, business, academia, entrepreneurs and venture capital will be key. Public authorities, funding agencies and politicians can show stewardship in establishing such cooperative initiatives. An integrated approach like the one described above will require decision-makers to take into account benefits for others than their own organisation or sector when assessing strategies, projects and investments.

We foresee that in 2050 there will be activities like shipping, fisheries, aquaculture with more offshore installations, tourism, offshore wind farms, oil and gas production, ports and maritime services, and installations on the seabed, for instance cables and pipelines. In addition, new activities can be introduced such as tidal and wave energy production, deep sea mining, and potentially other new industries that build on capabilities and technologies developed in other blue industries, such as remote operations and marine technology. In the future, we will have a new composition of ocean activities and their relative economic and societal influence will be different from what it is today. This new situation must be met by developing new solutions based on solid knowledge and a holistic approach that rests on a strong willingness to cooperate across sectors.

Figure 22. *Public-private networks and partnerships that seek coordinated actions and solutions may spark new holistic solutions. Photo: Statsbygg, UiT The Arctic University of Norway, campus Harstad.*

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