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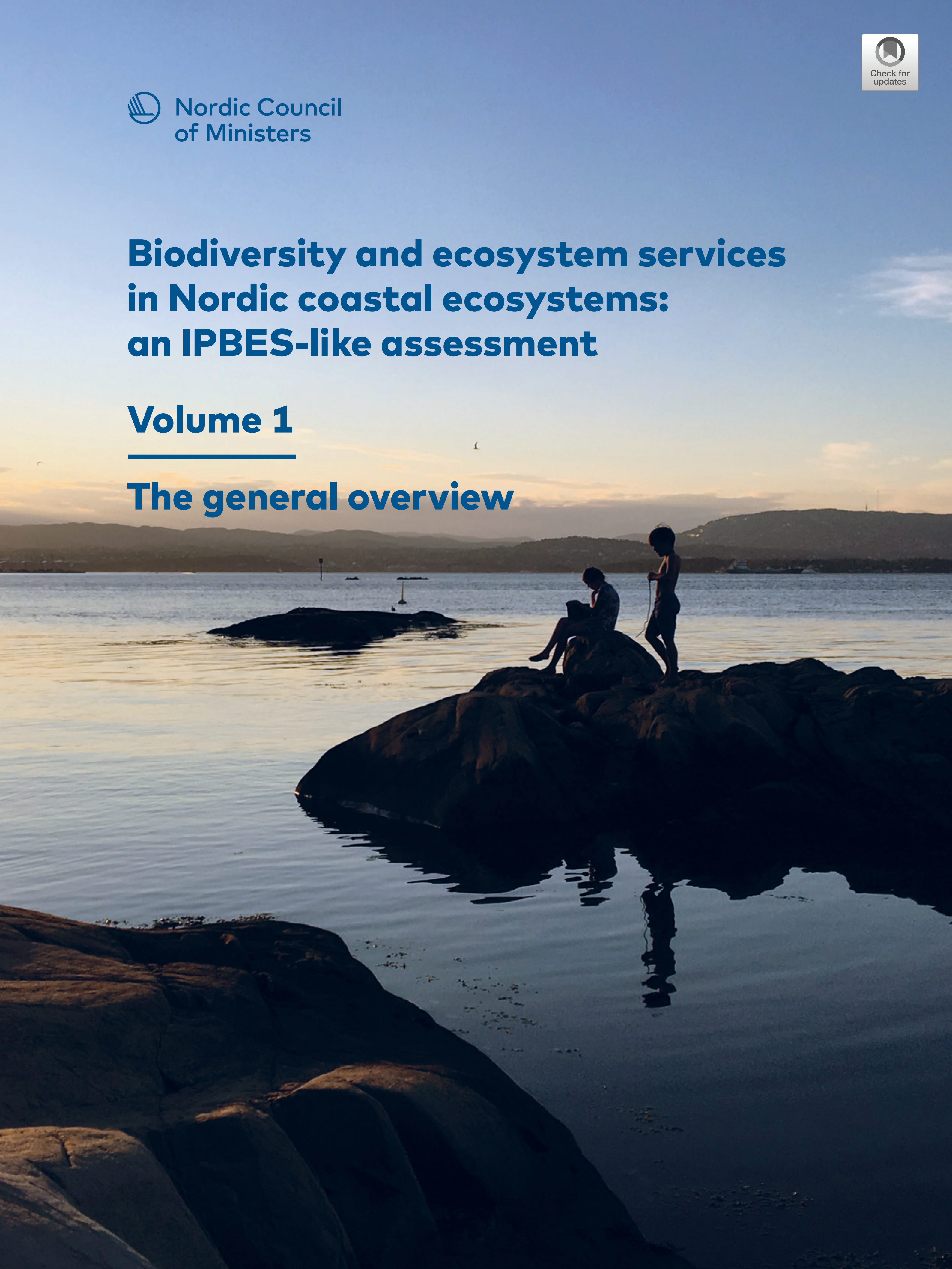
Nordic Council of Ministers

Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment

Volume 1

The general overview



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Contents

Foreword

This study has been inspired by the methods and procedures from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), to assess and compare information on biodiversity and ecosystem services in Nordic coastal ecosystems. A synthesis is provided in a Summary for Policy Makers (http://www.naturvardsverket.se/978-91-620-8799-9). The project is a collaboration between Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and Åland. The Nordic Council of Ministers financially supported the project.

This report describes the status and trends of biodiversity, and ecosystem services in the Nordic region, the drivers and pressures affecting them, interactions and effects on people and society, and options for governance. The main report consists of two volumes. Volume 1 The general overview and Volume 2 The geographical case studies.

Sweden, May 2018

Andrea Belgrano
Editor Volume 1

Gunilla Ejdung
Project leader

Håkan Tunón
Editor Volume 2

Summary

This study has been inspired by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES). The aim of the assessment was to describe the status and trends of biodiversity and ecosystems in the Nordic region, including the drivers and pressures affecting these ecosystem components, as well as the effects on people and society and options for governance. Ultimately, this study provided an opportunity to aid the process of utilizing scientific results in the policy and decision-making realm, thus forwarding the science-policy interphase. The Nordic study is structured as closely as possible to the framework for the regional assessments currently being finalized within IPBES. This assessment has been based on information provided by the following case study areas in the Nordic countries: Näätämö/ Neiden basin, Kalix Archipelago, Kvarken/the Quark, Puruvesi Lake in North Karelia, the Lumparn area, Öresund, Helgeland coast, Faroe Islands (Føroyar), Broddanes West Fjords and the coastal areas of Húsavík (Iceland) and Disko Bay (Greenland).

The objectives of the assessment were to address the following questions:

- What are the main drivers and pressures affecting biodiversity, ecosystem services and ecosystem function?
- How does global, regional and national policy influence biodiversity, ecosystem services and human well-being in the Nordic region? What opportunities exist in policy-making?
- How can we better integrate indigenous and local knowledge (ILK) perspectives on biodiversity, ecosystem services and nature's contributions to people (NCP) in decision-making? How can we apply their culture and traditional management methods to support decision-making?
- What opportunities exist for sustainability and nature-dependent human well-being in Nordic societies?
- What biodiversity and ecosystem values define NCP in the Nordic coastal region?
- How can data sources such as Earth Observation and GIS spatial data be used in assessments to support decision-making?
- What are the major gaps in data, knowledge, management and decision-making systems? How can these gaps be minimized?

The outcomes from the assessment has been summarized in the following key messages:

- A. The Nordic coastal region has many natural assets and provides numerous ecosystem services:
  - A1. *The Nordic coastal region is unique due to the variability in nature types and biodiversity.* Its coastal areas support examples of many different habitats spanning the temperate to the Arctic zone. This diversity supports considerable biodiversity that people depend on for their livelihoods;
  - A2. *The Nordic coastal region contains several globally important species and habitats.* These include the wintering bird assemblages in the shallow seas around Denmark, the unique habitats of the Baltic Sea (the largest brackish water area in the world), the kelp forests and breeding seabird colonies on offshore islands and cliffs in northern regions along the Norwegian coast, the recovering populations of whales in the North Atlantic Ocean, the assemblages of Arctic species and the recovering stocks of cod and other species in the North Sea and further north;
  - A3. *Most of the region's biological value is in the form of large concentrations of fairly common species.* The region houses habitats and assemblages of species that are typical of temperate seas warmed by the Gulf Stream, along with the Arctic and the Baltic Seas, parts of which are seasonally frozen. The strong seasonality also results in long and short distance migration of many fish, birds and mammals using the coastal and marine systems in the region. These include globally important winter concentrations of migrant seabirds and shorebirds in the southern part of the region and similarly important summer concentrations in the northern and Arctic regions;
  - A4. *The ecological status in the North East Atlantic and Bothnian Sea is good.* The status is moderate in the Arkona Basin and the Sound, but poor in the Baltic Proper and Gulf of Finland;
  - A5. *Many biological values of the region are slowly recovering from very low values following past overexploitation.* These biological values include populations of fish-eating sea birds and white-tailed eagle, grey heron, crane and several geese species in the Baltic Sea. It also includes cod, herring, mackerel, ringed seal, grey seal, harbor seal, hooded seal, North Atlantic fin whale and bowhead whale along the Norwegian coast, along with wintering and breeding populations of geese and swans in Danish coastal areas. In the Baltic Sea, and particularly in the Bothnian Bay, there is a slow recovery from DDT and PCB pollution events. However, pollution from heavy metals and contamination from persistent toxic chemical and radiation events remains a challenge;
  - A6. *The network of marine and coastal protected areas is important for preserving biodiversity and ecosystem services in the Nordic region*. Regulations to accomplish sustainable use of these areas are under development;

- A7. *The coastal natural resources in the region have provided food for people living in the Nordic region for thousands of years.* They continue to provide this today, especially from fisheries in the shallow seas, but also from animals feeding on the coastal habitats and birds breeding on the coastal cliffs. These resources are under various management regimes; some traditional going back at least hundreds of years and others with a more recent natural science basis;
- A8. *The diversity of Nordic coastal and marine ecosystems continues to deliver goods and services that are vital to the livelihoods of many people in the region*. Beaches and other coastal areas are important leisure resources for tourists from other countries. Particularly holidaymakers and weekend visitors from within the Nordic countries frequent the southern parts of the region. There are also continuing traditions and systems of using coastal and marine resources across the Nordic region. These are integrated into the modern lives of people living both in the rural areas and, increasingly, in cities throughout the region;
- A9. *The Nordic coastal regions support communities with strong traditional ties to nature, which provides opportunities for resource management based on traditional use, management and governance regimes*. These communities include both Inuit/ Greenlandic and Saami peoples in the north, coastal communities along the seaboard of Norway, Sweden, Finland and Denmark, as well as populations in the Faroe Islands and Iceland;
- A10. *The coastal natural resources of the region provide inspiration for the people living in the Nordic countries.* Some are strongly embedded in cultural identities and ways of living. These cultural values provide a powerful bond between people and nature and are a major reason for the persistence, and in some cases recovery, of natural resources in these coastal regions.

- B. The coastal Nordic region is under pressure:
  - B1. *Some species are still in decline in the region despite conservation actions aiming to assist their recovery.* This includes the globally important populations of breeding auks (puffin, razorbill, common guillemot, Brünnich's guillemot) and some breeding seabirds (e.g. kittiwake). There has been a considerable decline in sea grass meadows, kelp forests and fucoid algae/or brown seaweeds in different parts of the region. Due to population crashes in the past century, species like sturgeon and lamprey in the Baltic Sea remain at very low populations;
  - B2. *The Arctic – also the parts within the Nordic region – is the part of the planet most heavily affected by climate change and is warming at a far higher rate than any other region on earth*. This is having and will continue to have dramatic impacts on ecosystems and their services, including through ocean acidification. Throughout the region, there are emerging impacts of climate change. Northern species of birds, fish and bivalves cease to breed in southern countries like Denmark, migrating northward and expanding their

breeding grounds along the coasts of Norway, Sweden and Finland. Fish e.g. mackerel, herring and tuna, are moving to more northern waters around Iceland and Greenland. There are changes in the coastal food web, potentially impacting food sources for some of the largest marine creatures in the region, e.g. humpback whale. Ocean warming is having negative impacts on the extensive kelp forests in the western oceans off Norway;

  - B3. *Chemical pollutants, eutrophication and plastics are affecting the coastal waters of the region.* The historical heavy industrial and nuclear radiation pollution is still affecting parts of the Baltic Sea. The situation has greatly improved over the past 30 years. In other parts of the region, there is considerable run-off of agricultural fertilizers and pesticides, although the amount has been reduced from past levels. Eutrophication of the coastal waters remains a problem, evidenced by impacts to species composition in many areas. In recent years, fears have emerged on what consequences the high quantities of plastics and nanoparticles in the oceans may lead to. It will take many centuries for these particles to degrade in the regions' colder northern waters, and their impact on marine life is negative;
  - B4. *Invasive species pose serious challenges to parts of the Nordic coastal ecosystems.* Significant challenges arise from the Japanese rose (*Rosa rugosa*) on coastal foreshores and sand dune areas in Denmark and southern Sweden. Challenges also arise as a result of a variety of invasive marine animals and plants, including the round goby in the Baltic Sea and in the North Sea, and king crab in the Bering Sea. Measures against alien invasive species may mitigate the effects of these species. Such measures may include the implementation of legislation and/or physical measures to remove already established species;
  - B5. *Infrastructure development in marine and coastal areas poses challenges.* The Nordic region is a global frontrunner in near- and offshore wind turbine technological development and installation. However, wind power plants have impacts on e.g. migratory birds and bats. In addition, there are impacts associated with the construction of the large bridges between Denmark and Sweden, and Denmark and Germany. The trend to set aside coastal or near-coastal areas for building summer cottages brings challenges of reduced access, increased disturbance and the need for water treatment. There is oil and gas exploration and mining industry in the northern seas that has potential to impact these areas. Of particular concern is the slow break-down of pollutants in cold waters of low biological capacity.
- C. Building resilient futures in the Nordic coastal region:
  - C1. *The political and governance systems of the Nordic region are transparent and fair.* There is a broad interest within the Nordic countries to pursue development pathways to reduce local and global impacts on natural resources. There is good access to coastal areas and strong emphasis on the use of nature and natural areas for livelihoods and recreation. These values

and traditions need to be maintained to continue to provide space for nature and to allow people to benefit from natural coastal areas. Nordic countries are able to implement and maintain systems for improved coastal management and sustainable harvesting of species, habitats and resources;

- C2. *There are good examples of indigenous and local peoples participating in coastal nature management in the northern regions.* This is critically important for continued subsistence use and for maintaining ecosystem services in the north. Better integration and support of indigenous and local knowledge within conservation management and in governance of resource use in the region would be beneficial;
- C3. *Ongoing progress to clean up pollution and reduce eutrophication in rivers, lakes, coastal areas and open seas needs to be continued*. This relates to all the countries in the Nordic region and is equally important on national, regional and international scales. This can be achieved through catchment-based management approaches, as eutrophication is mainly caused by run-off from land. There have been intensive efforts to reduce the secondary environmental impacts from the large marine aquaculture industries (e.g. salmon farmed in the Norwegian fjords), shell fish farming (e.g. blue mussels on poles and other structures in Danish and Swedish seas), along with the emerging seaweed farming industries;
- C4. *Some fish stocks and populations of marine mammals are recovering in the region.* Further recovery can be accomplished through careful review and changes to policies as required. However, some populations (e.g. seals) have recovered to the point where they are causing problems. For those fisheries and populations of marine mammals that are still in decline, further efforts are required to help return populations to a healthy state;
- C5. *Cooperation among the Nordic countries is needed to improve coastal zone planning and management.* Policies and their implementation need to balance the needs of the natural system and human development in coastal areas (e.g. summer houses, urban areas, industry). Examples can be drawn from ongoing marine spatial planning initiatives;
- C6. *Coastal resilience to rising seas needs to be enhanced, e.g. through nature-based solutions offered by natural or moderately modified ecosystems*. Changes in the coastal regions may be dramatic in the future due to climate change and related sea level rise, flooding, extreme weather events and increased run off from inland water bodies and melting ice;
- C7. *The legal frameworks in most Nordic countries have national laws, EU directives and regulations and follow regional marine conventions including HELCOM and OSPAR*. These are often developed from agreed targets of international non-binding agreements, such as those under the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. This legislative framework is strong, but can always be

further developed to enhance the outcomes for nature and people in the coastal regions.

The following options for policy makers have been proposed:

- Evaluate the costs and benefits of existing environmental policies, prioritise and streamline them to help overcome the high density of policies;
- Where possible, coordinate the implementation of policies across the Nordic region to reduce policy conflicts;
- Identify and adjust policies that counteract incentives for conservation and the sustainable use of biodiversity in coastal areas;
- Increase political focus on the status of marine biodiversity and the influence of human activities on species and habitat diversity. This is closely related to work with the UN Sustainable Development Goals (SDGs);
- Involve science-based assessments and priorities in policymaking in terms of identifying most needed conservation and management policy initiatives;
- Safeguard the right to public access of coastal areas as access to nature maintains access to a number of non-material nature's contributions to people, such as identity, physical and psychological experiences, knowledge and inspiration, as well as material benefits such as food and ornaments. This collectively helps maintain society's sense of duty to protect the environment;
- Implement ecosystem-based adaptation to increase the coastal region's resilience to climate change;
- Draw benefits from technological developments that reduce the region's ecological footprint; and
- Identify pathways to achieve the 2050 vision of the Strategic Plan for Biodiversity and implement the Sustainable Development Goals and their targets.

1. Setting the scene

Lead author: Petteri Vihervaara. Contributing authors: Andrea Belgrano, Gunilla Ejdung, Anna-Stiina Heiskanen, Minna Kallio, Cecilia Lindblad, Eva Roth, Håkan Tunón.

Box 1: Summary

Biodiversity loss can degrade ecosystems and impact the ability of ecosystems to contribute to people. The last 20 years of ecosystem service research has increased society's interest in fighting the consequences of ecosystem degradation. During the last decades, attitudes towards conservation have been shaped in many ways. According to Mace (2014), "nature for itself" was a key principle during 1960s–1970s supporting concepts such as protected and wilderness areas. Human pressures on nature during the 1980s and early 1990s resulted in extinctions, habitat loss, and pollution, which made it urgent to act for "nature despite of people". That period was followed by a "nature for people" period, in which biodiversity challenges were mainstreamed via concepts such as ecosystem approach, ecosystem services and economic values. The latest paradigm, which was developed by Mace (2014) is called "people and nature". Key concepts in conservation circles include environmental change, resilience, adaptability and socio-ecological systems.

Several assessments of the state and trends of biodiversity, ecosystems and ecosystem services have been carried out via various initiatives, such as Millennium Ecosystem Assessment (MA, 2005), followed by the Economics of Ecosystems and Biodiversity (TEEB) assessments and the Aichi biodiversity targets of the Convention on Biological Diversity (CBD). In Europe, Mapping and Assessment of Ecosystems and their Services (MAES) has generated a lot of new knowledge on the quantification of ecosystem services and use of this information in decision-making. Today, more and more open data is available through research infrastructures, for example, remote sensing data through the Copernicus programme of the European Union and European Space Agency. Nature-based solutions and green and blue infrastructure are becoming popular in landscape planning and highlight different aspects of the socio-ecological (synon. coupled human-environment) systems and their sustainable management.

The most significant attempt to highlight the importance of biodiversity and ecosystem services globally, has been the establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). IPBES has launched a series of thematic and geographical assessments. The European and Central Asian regional assessment has been ongoing parallel to this Nordic IPBES-like assessment that has focused on coastal ecosystems and their services. This assessment covers the Nordic countries, i.e. Denmark, Finland, Iceland, Norway and Sweden, and autonomous areas such as Åland, Faroe Islands and Greenland, which are a unique "biocultural" piece of Earth with unique nature values and well-established societies. This report consists of two volumes: I) a general overview and II) case studies (Tunón (Ed.), 2018). The chapters of volume I include: Setting the scene and describing the methods used in the report (Ch. 1), the significance and development of NCP (Ch. 2), biodiversity and ecosystems (Ch. 3), drivers and pressures (Ch. 4) and the integrative synthesis of them (Ch. 5), as well as governance and policy analysis (Ch. 6). In volume II, ten case studies illustrating different aspects of the Nordic key ecosystems and their influence onthe society are presented. Drivers and pressures that human activities cause to nature are also demonstrated. Each case has been analyzed using the IPBES approach, and where possible, Indigenous and Local Knowledge (ILK) aspects are emphasized. We

have followed the IPBES methodology already described in the scoping study for the Nordic region (Schultz *et al.*, 2016). The coastal focus was selected because of its significance to the history and development of the Nordic countries. Coastal areas also highlight the important linkages between the regions, but also interactions of land and sea. The first chapter introduces the assessment, data sets and methods, along with the important role of ILK data alongside novel data sources such as Earth Observations in comprehensive socio-ecological systems analysis.

1.1 Context of the Nordic coastal zone assessment

This Nordic IPBES-like assessment of Nordic coastal ecosystems and their services analyses the relationship between nature and people. It aims to strengthen the science-policy interface for biodiversity and ecosystem services, as well as the conservation and sustainable use of biodiversity and long-term human well-being. Governance aspects are assessed in the Nordic region, e.g. fiscal issues and how governance systems in one country might affect the whole region, or governance structures that need to be better linked due to the governance of commons in the Nordic region. Nordic coastal ecosystems have a very important role for all Nordic countries, while there are also great differences between the areas depending on abiotic, biotic and social circumstances and histories. This aim of this first chapter is threefold: 1) to introduce the Nordic environment and its major characteristics, 2) to introduce the reasons for this IPBES-like assessment and 3) to introduce the structure of the report, including some methods used in various chapters and the synthesis of results in Chapter 5.

1.1.1 Why is this assessment important?

Biodiversity loss is one of the biggest challenges threatening the future of mankind and may even be more serious than climate change (e.g. Rockström *et al*. 2009, 2016). The gradual loss of biological functions is difficult to observe, but changes may lead systems to tipping points, after which ecosystem changes may be irreversible and the delivery of ecosystem services altered dramatically. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012 to support the conservation and sustainable use of biodiversity and ecosystem services, and it is administrated by the United Nations Environment Programme (UN Environment). The aim of this platform is to gather relevant knowledge on the status and trends of ecosystems and their services, in order to change the direction of unwanted development in nature e.g. the loss of biodiversity and degradation of ecosystem services.[1]

The serious loss of biodiversity and degradation of ecosystem services has been observed globally (MA, 2005) and economic impacts have been partly quantified (e.g. via TEEB[2]). Regionally, some positive trends in the environment have occurred (see

[1] https://www.ipbes.net/

[2] http://www.teebweb.org/

e.g. EEA ,2015), but in general, habitat loss, climate change, pollution and the unsustainable use of natural resources are the key drivers for negative trends in biota, which often leads to a decrease in human well-being (MA, 2005). However, there are some positive initiatives in society, such as mainstreaming of the protection of ecosystem services to several new sectors and policies. However, better knowledge and new governance tools are needed to improve the sustainability of our societies under current drivers of change.

The first step toward changing the direction of unwanted development for the future is to gain accurate knowledge on the status and trends of ecosystems and their services. Currently, IPBES is developing regional assessments of the four UN regions (Europe and Central Asia, Africa, the Americas, and Asia-Pacific), and a global assessment of ecosystems and their services. In addition, thematic assessments on pollination and land degradation have been completed and there are plans for further thematic assessments on valuation, invasive species and sustainable use.

The IPBES work inspired the Nordic countries to start planning for this "Nordic IPBES-like assessment" in early 2015, when the Nordic Council of Ministers founded a pilot study for scoping the Nordic IPBES contribution (Schultz *et al*. 2016). Based on that study, a mutual interest to specify assessment toward coastal areas was identified. The three-year ecosystem assessment took a coastal focus, including considerations of land-sea interactions. *Coastal* is defined very flexibly and more detailed descriptions are given in chapters or case studies. In this assessment, *coast* includes both the terrestrial part of the shoreline and the shallow near-shore aquatic parts. The open sea area is not included in this assessment.

1.2 Previous assessments and the conceptual "IPBES" framework

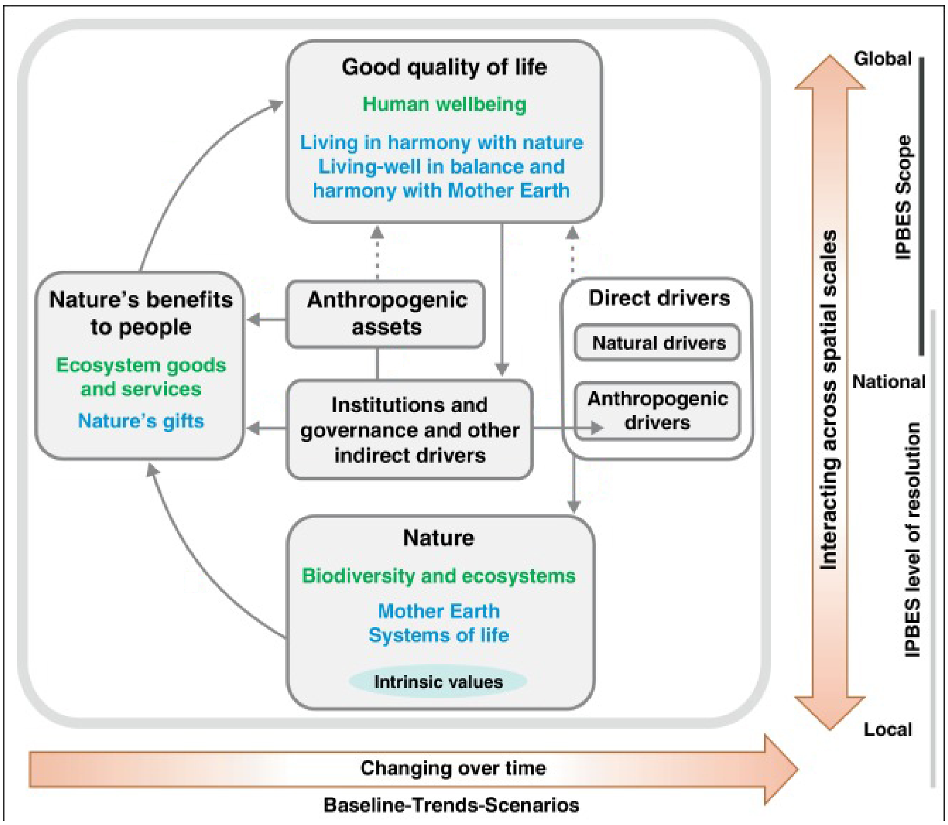
European ecosystem assessment work, such as Mapping and Assessment of Ecosystems and their Services (MAES) of the European Commission's Biodiversity Strategy, has focused mainly on terrestrial ecosystems. However, coastal and marine ecosystems and their services have been explored recently in two publications: *Marine ecosystem services in Nordic marine waters and the Baltic Sea – possibilities for valuation* (Hassler *et al*., 2016), and *Ecosystem Services in the Coastal Zone of the Nordic Countries* (Gundersen *et al*., 2016). These publications, together with some earlier reports including the TEEB Nordic evaluation on the socio-economic importance of ecosystem services in the Nordic Countries (Kettunen *et al.* 2012), gave a good starting point for this Nordic coastal IPBES-like assessment. In addition to these previous ecosystem service studies, there are plenty of marine studies published by, for instance HELCOM.[3]

IPBES Plenary 2013 adopted a conceptual framework for the Platform (Fig. 1). The "nature's benefits to people" were set out with a classification of those benefits, renamed "nature's contributions to people" (NCP) (Díaz *et al*., 2015, Pascual *et al*., 2017,

[3] http://www.helcom.fi/

Díaz *et al*. 2018). The concept of NCP is proposed to increase inclusiveness and to facilitate reporting. It is considered to reflect key improvements to the original Millennium Ecosystem Assessment classification (2005), based on more than a decade of scientific progress in interdisciplinary thinking, with increasing involvement from the social sciences. NCP is fully consistent with the IPBES conceptual framework and it is recommended for use in IPBES regional assessments and in the global assessment.

Figure 1: The conceptual model for the IPBES approach



Note: During the assessment, nature's benefits to people were changed to "nature's contributions to people". This definition allows pluralistic views such as ecosystem goods and services, nature's gifts etc.

The Nordic assessment follows the IPBES conceptual framework that includes six interlinked elements constituting a socio-ecological system operating at various scales in time and space: nature, nature's contributions to people, anthropogenic assets, institutions and governance systems, along with other indirect drivers of change, direct drivers of change and good quality of life (Fig. 1). In this report, we have followed the IPBES recommendation and taken NCP as a general term that includes definitions for different worldviews and interpretations, such as western thinking "ecosystem services (ES)" and nature's gifts of indigenous people, for instance. The Multidisciplinary Expert Panel of IPBES also proposes that the term Nature's Contributions to People can be used when referring to "Ecosystem Services" (ES). Both concepts are used throughout the report.

1.3 The Nordic model for ecosystem assessment

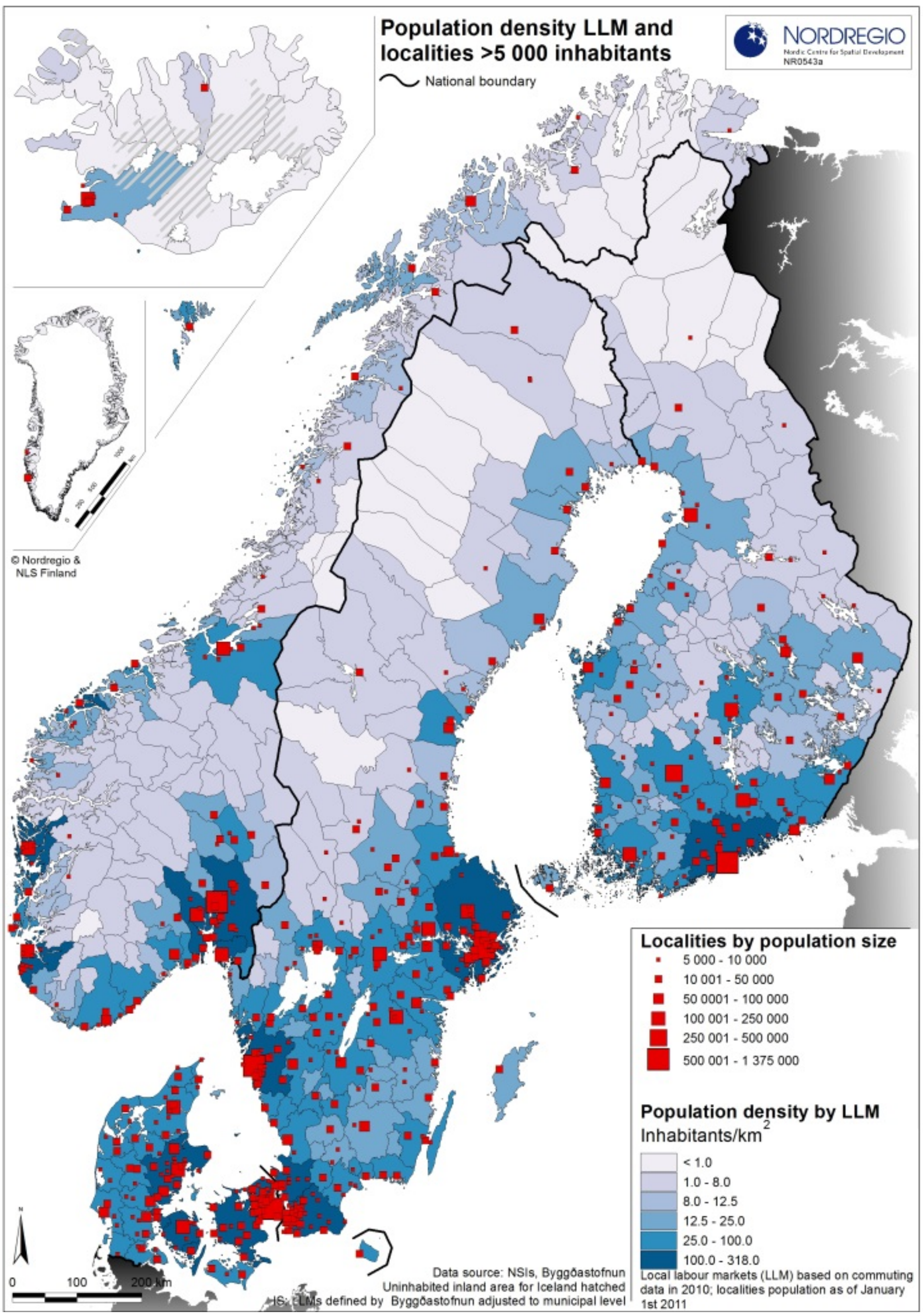
1.3.1 Characteristics of the Nordic region

Figure 2: Study area of the Nordic IPBES-like assessment (yellow regions)

Source: DeLorme, Lat Long: ESRI 2013.

The Nordic region includes Denmark, Finland, Faroe Islands, Greenland, Iceland, Norway, Sweden and Åland (Fig. 2). Unique characteristics of the region are a result of the continuum of human influence – from hunters and gatherers of the ice-age, towards wealthier modern times and increasing urbanization during which land use has changed remarkably. Forests of southern areas such as Denmark and southern Sweden have overturned to agricultural areas. Mires and peatlands have been heavily ditched to support forestry, but have affected run-off to adjacent waters. Fishing technologies and governance systems have changed drastically. During the last hundreds of years, the Nordic societies have become prosperous and stable democracies in a global comparison. Throughout history, coastal areas have played a special role for societies in the Nordic region: they have been used as transport and exchange routes of ideas and natural resources, and as a source of basic human needs. Today, the area is inhabited by ca. 26.9 million people and also includes the indigenous people of the Saami and Kalaallit (Inuit Greenlandic), as well as several national minorities. There are densely populated areas as well as areas with few inhabitants (Fig. 3).

Figure 3: Population density in the Nordic countries in 2011



Source: Nordregio. (Available at: archive.nordregio.se)

Nature

Biogeographically the Nordic countries are part of the Palearctic region, with conditions spanning from Atlantic to continental (see below). The Nordic area supports a variety of aquatic and terrestrial habitats including e.g. marine, brackish water, freshwater, wetlands, forests and agricultural landscapes. The Nordic coastline is about 150,000 km long with large geomorphological and climatological variation. The coastal zone, including seashore habitats and connecting wetlands, acts as a "filter" between land and open sea. Nutrients, organic matter and anthropogenic substances are transformed and retained along the land –sea continuum.[4]

Nordic countries belong to five biogeographical zones:

- Arctic (Norway, Iceland, Greenland);
- Alpine (Finland, Sweden, Norway);
- Boreal (Finland, Sweden, Norway);
- Atlantic (Norway, Denmark);
- Continental-nemoral (Sweden, Denmark).

In addition, there is a transition zone between the temperate deciduous forests of the nemoral zone and the coniferous forests of the boreal zone, the boreo-nemoral zone (or hemiboreal vegetation zone) (Kettunen *et al.*, 2012; Fig. 4).

The Nordic region can be divided in to marine biogeographical regions according to EEA:[5]

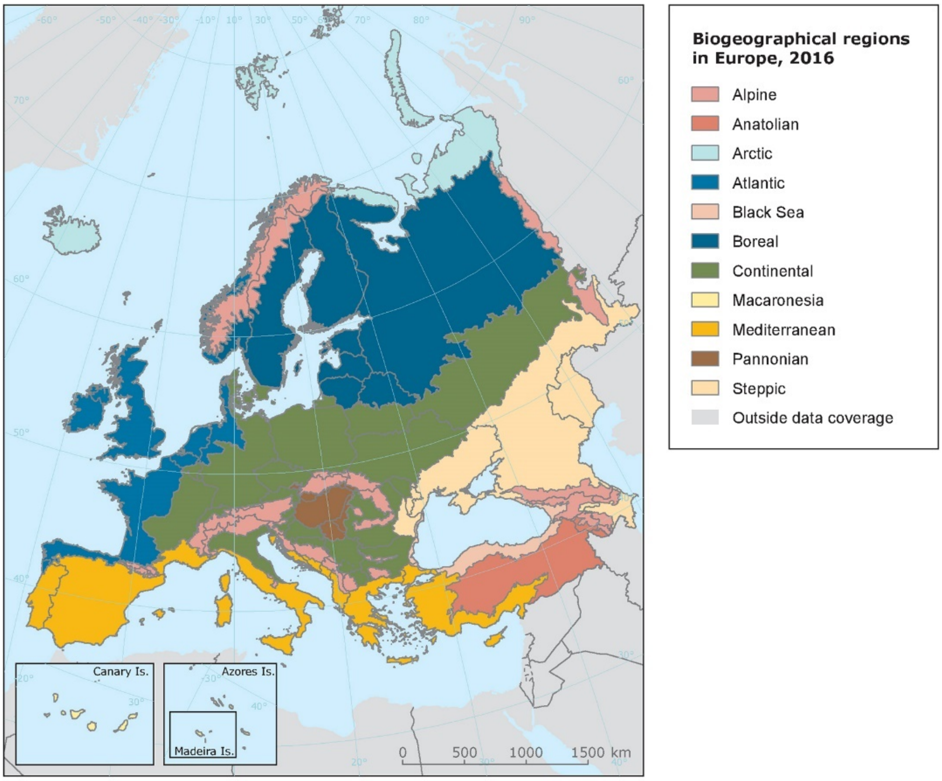
The two EEA marine biogeographical regions[6] are:

- Marine Atlantic;
- Marine Baltic.

Baltic Sea data and management of it is hosted by the regional agreement of HELCOM, while the North Sea and Norwegian Sea are hosted by the regional agreement of OSPAR.

[4] See e.g. https://www.bonusportal.org/projects/viable_ecosystem_2014-2018/cocoa
[5] https://bd.eionet.europa.eu/activities/Natura_2000/chapter1
[6] https://bd.eionet.europa.eu/activities/Natura_2000/chapter1

Figure 4: Biogeographical regions in Europe



Note: Nordic bio-geographical regions have unique characters and they differ significantly from the southern regions of Europe. This influences also the composition of available ecosystem services.

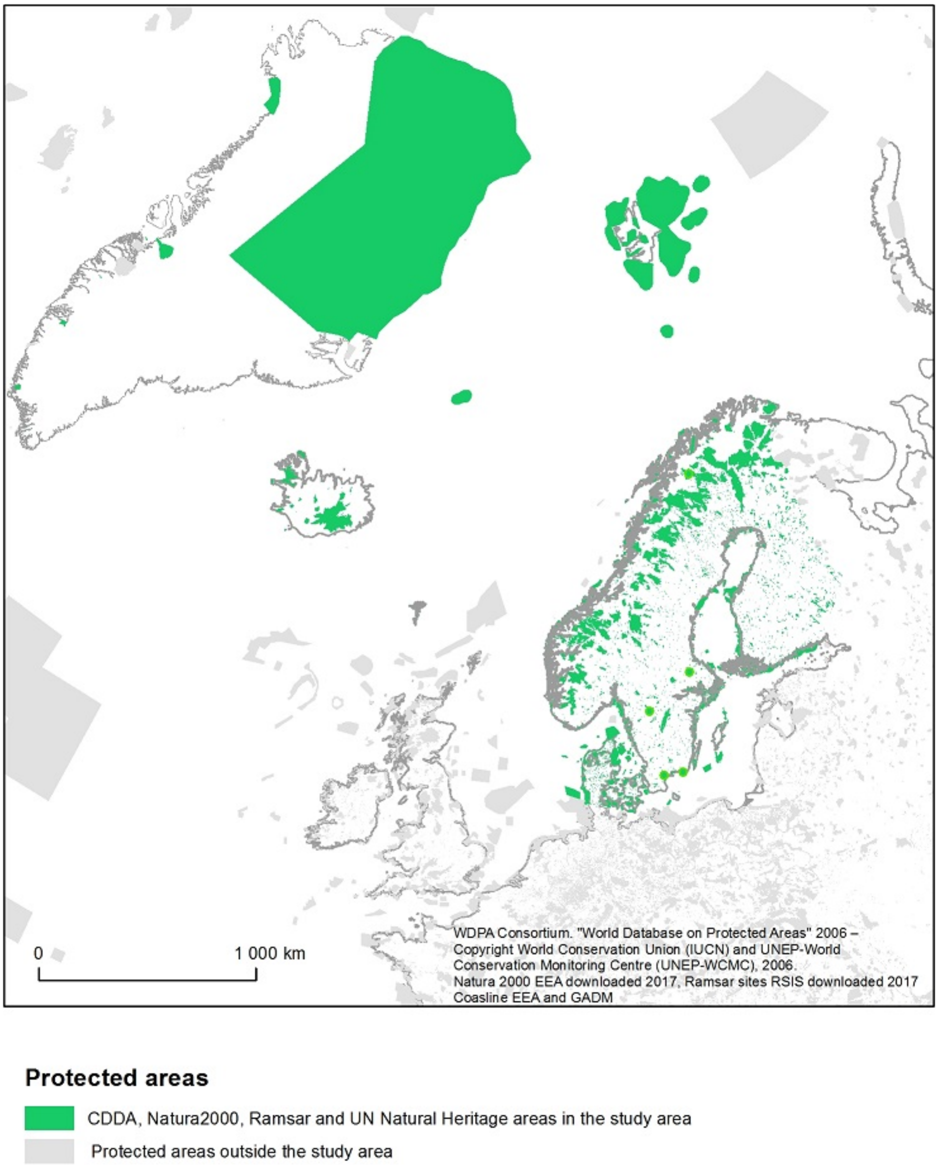
Source: EEA, Copenhagen, 2016.

Land cover in the Nordic countries varies from broad-leaved forests in the south of the region, to Arctic tundra and polar deserts in the north, and from boreal forests adapted to continental climate in the east, to the high slopes of the fjords in the west characterized by high annual precipitation. Greenland is dominated by glaciers, but also has tundra and marine ecosystems with diverse fauna and flora. There are unique archipelago areas typical for the Swedish west coast and the archipelago sea in the central Baltic between Sweden, Åland and Finland. Waters are typically brackish and the mosaic landscapes on thousands of islands have a variety of terrestrial habitats (NMR 2001).

The Nordic countries are surrounded by marine waters of North-eastern Atlantic Ocean origin i.e. the Baltic, Barents, Greenland, Iceland, North and Norwegian Seas, the Skagerrak and Kattegat, and the Arctic Ocean. Salinity together with morphological (such as depth) and physical features (such as currents, tidal range and wave impacts) are the main factors affecting the structure of the various aquatic ecosystems. The Baltic Sea is one of the world's largest brackish water areas. It is a shallow inland sea with almost freshwater conditions in the northernmost part and an increasing salinity towards the south and the Kattegat. True oceanic conditions prevail in the Atlantic coastal areas.

In a study by Gundersen *et al.* (2016), four key ecosystems were selected to be examined for their services. These were kelp forests, eelgrass meadows, blue mussel beds and shallow bays and inlets. These ecosystems have also been included in this assessment because they provide important nursery habitats for many fish species, along with several key processes and functions that regulate e.g. coastal erosion, nutrient cycling, carbon sequestration and water purification. Some of these ecosystems and other valuable habitats are protected by conservation areas, forming important networks of valuable ecosystems. Protected areas in the Nordic countries consist of areas of different conservation categories, from Natura 2000 sites to national parks and marine protected areas (see HELCOM; Fig. 5).

Figure 5: Coverage of the protected areas (green) in the Nordic region

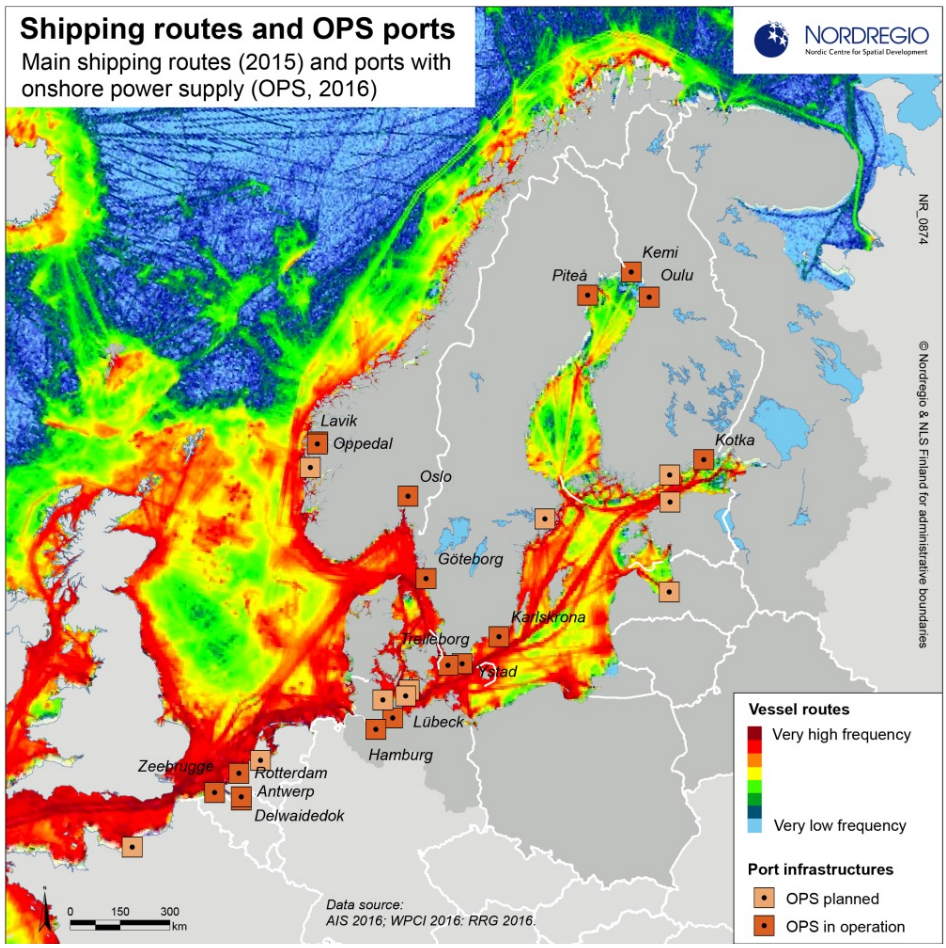


Source: World Conservation Union (IUCN) and UNEP World Conservation Monitoring Centre (UNEP WCMC), 2016.

Drivers and pressures

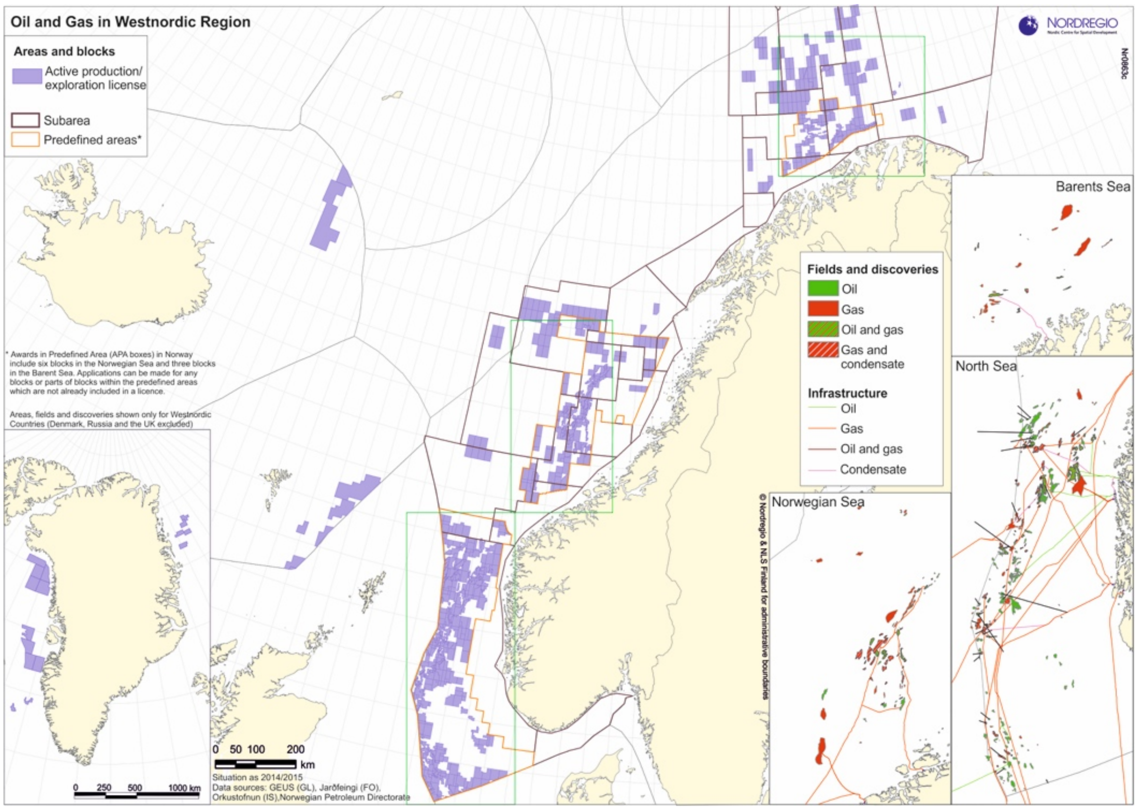
The Nordic countries share a long history, with their socio-ecological systems connected to one another via the sea. Today, coastal regions are still very important traffic routes, which affects pressures on ecosystems, for instance around the Sound and Gulf of Finland (Fig. 6). Coastal regions are crucial for many economic sectors such as fisheries, aquaculture, tourism, energy (e.g. wind turbines), natural resources (e.g. sand and gravel, oil and gas fields, particularly around Norwegian and Greenlandic coasts, see Fig. 7) and industrial processes. Agriculture is also adjacent to many coastal catchments affecting the water quality in shallow waters with restricted water exchange, such as the Baltic Sea (see Fig. 8). Drivers and pressures are discussed comprehensively in Chapter 4. The importance of regulating services has increased significantly. For instance due to climate change, effective carbon sequestration is necessary to consider for sustainable management of landscapes and seascapes.

Figure 6: Shipping routes as an example of pressure to coastal and marine areas 2015



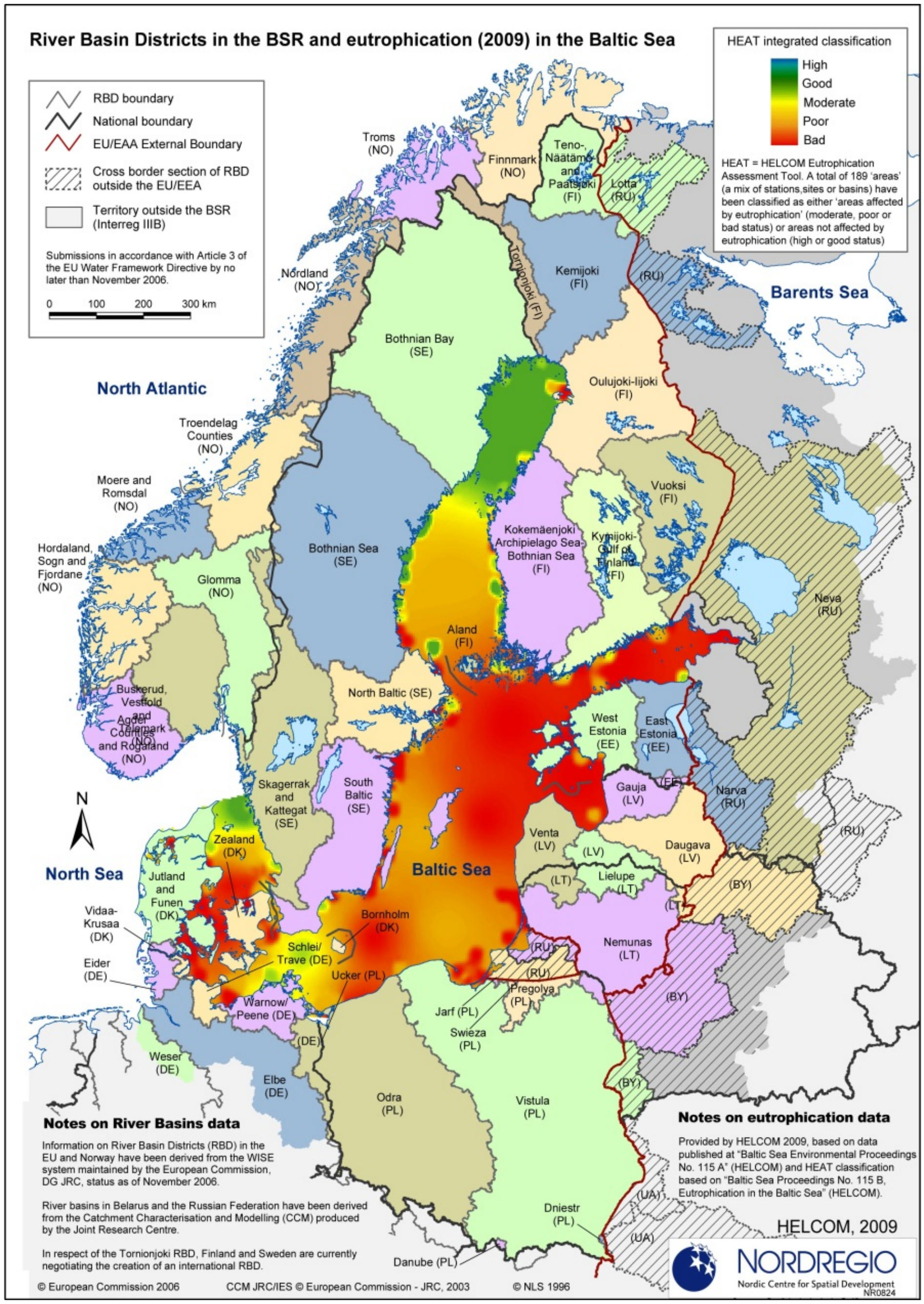
Source: Nordregio. (archive.nordregio.se)

Figure 7: Oil and gas fields in the Nordic region showing possible risks and pressures to the sea ecosystems



Source: Nordregio, 2016. (archive.nordregio.se)

Figure 8: River Basin Districts in the Baltic Sea region and eutrophication (2009) in the Baltic Sea



Source: Nordregio. (archive.nordregio.se)

People and governance

Societies in the Nordic countries are well established. People give high value for nature and rights of public access. The majority of the population live in the coastal regions (cf. Fig. 3). The political systems are quite similar in all the countries. National, regional, international and EU legislation (e.g. Habitat Directive, Water Framework Directive, Marine Spatial Planning Directive, Common Fisheries Policy) is implemented to govern nature and natural resources. These and other examples of governance aspects are described comprehensively in Chapter 6.

Accessibility to nature is an important value for the Nordic people and everyman's rights are a unique part of the Nordic outdoor culture. The extent of the right to public access varies among countries and in certain regions within a country, there are different public access rights, such as between Åland and Finland. In contrast to most parts of the world, the landscape outside settled areas is accessible and people do not rely as heavily on protected areas for outdoor recreation. However, discussions on ecosystem services and for instance, nature-based tourism, has highlighted the need for assessing and updating rules on how to balance different demands and needs that stakeholders and citizens have for nature.

Along the Nordic coasts there are many different stakeholders, some of them indigenous peoples or local communities. The Nordic countries and the EU have procedures for stakeholder consultations in decision-making and certain rights of the public (individuals and their associations) with regard to the environment. Some of these are laid down in the Aarhus convention (EU, 2017) and in national legislations. However, further development is needed to ensure implementation of participatory mechanisms. This Nordic IPBES-like assessment intends to take a step forward toward various information sources describing human-environment relationships.

Best practice can be learned from the ILK systems. For instance, the indigenous peoples such as the Saami people and the Inuit (Greenlanders), form a crucial part of the Nordic societies with their unique biocultural aspects and knowledge systems, which so far have been poorly integrated in standard environmental monitoring schemes and decision making today. Local communities along the Nordic coasts have local knowledge systems and their customary use of coastal and marine resources has high potential value for the development of policies for long-term sustainable use of coastal ecosystems. When it comes to the local use of biological resources, the concept of "tragedy of the commons" is often referred to, but in local use, there is or has been traditional governing systems in order to ensure the common good. One example in the Nordic context is the often-overlooked Saami siida system that covered approximately half of present day Scandinavia. This was a system of self-regulated fisheries, hunting and reindeer pastures within the Saami society. It contained limitations to prevent overharvesting. Today, the only surviving siida system is preserved amongst the Skolt Saami (Mustonen & Mustonen, 2013).

1.3.2 Data sources – a focus on GIS and Earth Observation data

Various spatial and statistical data sets were used in this assessment. The overall assessment is based on scientific literature and expert knowledge. Furthermore, we tried to highlight the importance of GIS, Earth Observation (EO) and ILK, and test and demonstrate their use in ecosystem assessments. National, regional and European Union data (e.g. INSPIRE Geoportal[7] and Copernicus services[8]) have been used. Improved technological solutions are needed for spatially-explicit monitoring of ecosystems and NCP (cf. Holmberg *et al*., 2016; Vihervaara *et al*., 2017). This is of particular relevance in the Nordic countries, with their low population density, high social costs and rapid environmental changes due to, for instance, climate change. Many resources are allocated toward producing high quality and harmonized datasets, but further application is still somewhat rare. Especially the full potential of the use of EO data, such as remote sensing data, is not harvested today in ecosystem monitoring and assessments (see also Tolvanen *et al*., 2016).

Examples of data and their limitations

There are plenty of data sources available that could be used in IPBES-like assessments, for instance:

- Official data for multilateral environmental agreement such as the CBD are available in the most of the countries;
- Some EU policy tools, such as status reports under the Habitats, Birds, Water Framework and Marine Strategy Framework Directives;
- The marine status reports of the HELCOM (Baltic Marine Environment Protection Commission – Helsinki Commission) and OSPAR;
- Assessments and reports that have a more general focus, such as the EU MAES work and ESMERALDA project, Global Biodiversity Outlook and the Nordic countries' own assessments and reports, such as reports by the Arctic Council (e.g. Protection of the Arctic Marine Environment (PAME) working group[9]), and national TEEB studies[10];
- Nordregio[11] has collected and shared numerous maps of the Nordic countries, which are used to illustrate the general features of the study area.

Data sets are not always consistent across data providers. For example, the distribution of common eider (*Somateria mollissima*), which was reviewed in Chapter 3, differs between HELCOM map services, EMODnet biology, IUCN Red List species range and EEA Bird Directive data.

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[7] https://inspire.ec.europa.eu/
[8] http://www.copernicus.eu/
[9] https://pame.is/index.php/document-library/pame-reports
[10] http://www.teebweb.org/
[11] http://www.nordregio.se/en/Maps/

The development of spatial data-sharing infrastructure enables the exchange of information, also outside the governmental public organizations. Marine data is dispersed in different services, both in collections of GIS data and EO products. For all the Nordic countries, data was drawn from multiple sources. HELCOM[12] and OSPAR[13] complete national datasets for their assessment products. The OSPAR Convention members cooperate to protect the North-East Atlantic marine environment. The data collected contains various environmental monitoring themes. The physical features of the sea, such as salinity and sea floor temperature, were drawn from The Operational Mercator global ocean analysis for Chapter 3. Most of the data is grouped, covering the globe and the Arctic Ocean, Baltic sea and European North-West Shelf Sea regions.

Copernicus services provide increasing amounts of data that can be used in environmental assessments. However, applicability is limited. For instance, data from the Copernicus Marine Environment Monitoring Service is at a global scale, but lacks details. Similarly, European Space Agency's (ESA) GlobCover[14] data is outdated and coarse.

Spatial land and sea cover information

Spatial land and sea cover information on European ecosystem types are available at EEA,[15] EMODnet Seabed Habitats[16] and in regional seas data and map services[17] (Fig. 9). The EEA data on MAES ecosystem types is produced by combining the Corine Land Cover 2000 raster data with EUNIS habitat classification. That data aims to represent probabilities of EUNIS habitat presence in ecosystem types. The extent of the data in this study area covers Finland, Sweden, Denmark, Iceland and Norway. MAES data has many classes for shore types, but limited information on sea habitats. The applicability of MAES datasets in this Nordic IPBES-like assessment is evaluated in subchapter 1.6 and the findings are presented in Chapter 5. Conservation status of habitat types and species (Article 17, Habitats Directive 92/43/EEC) was also used.

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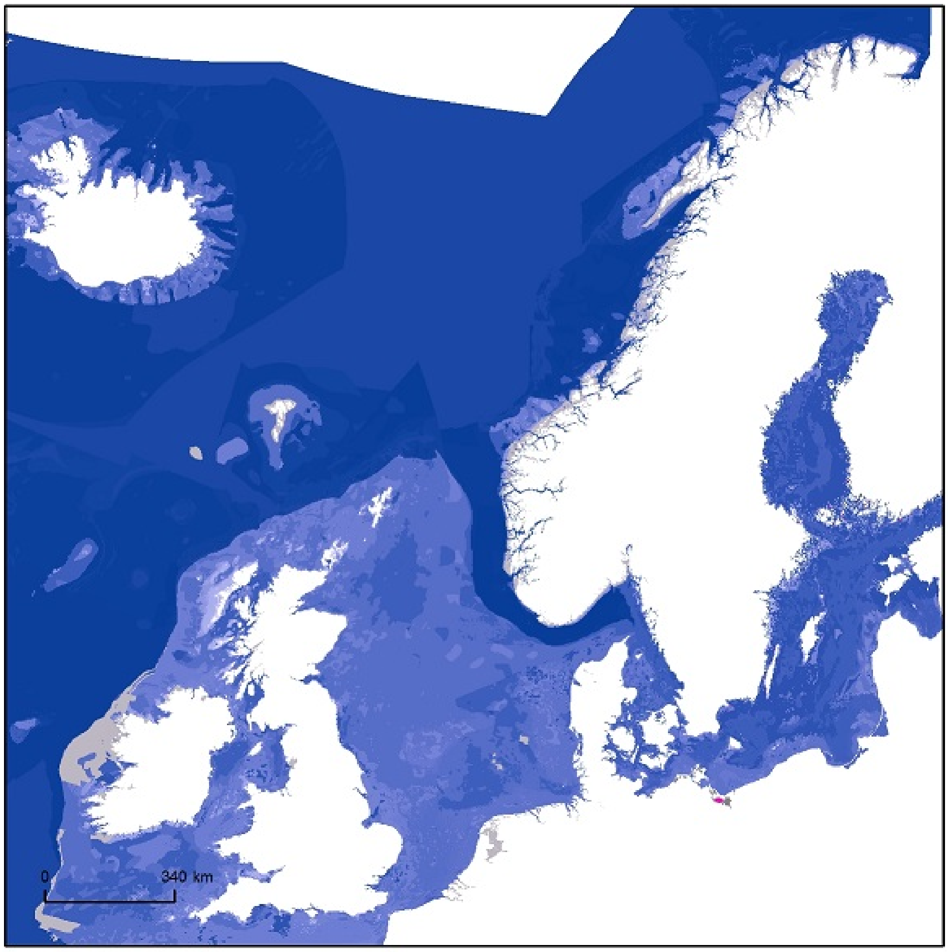
[12] http://www.helcom.fi/
[13] https://www.ospar.org/
[14] http://due.esrin.esa.int/page_globcover.php
[15] https://www.eea.europa.eu/data-and-maps/data/ecosystem-types-of-europe
[16] http://www.emodnet.eu/seabed-habitats
[17] http://www.helcom.fi/

Figure 9: Emodnet Seabed Habitats dataset uses the same EUNIS classification, but is also combined with several environmental variables



Note: According to the confidence maps, the data quality varies in different parts of the dataset. For example, there are data gaps near the Norway coastline. The dataset covers the marine areas except western Greenland (Disko bay).

1.3.3 Highlighting ILK in the Nordic circumstances

General introduction – what is ILK?

ILK helps to frame an IPBES-like assessment. Local communities possess knowledge about the functioning of complex ecosystems, which they apply in their daily lives (Berkes, 2012). Indigenous knowledge has been referred to as a "knowledge tradition of its own" (Helander, 1999), which highlights its internal context, connection to a place and relevance in a socio-ecological matrix. In the IPBES context, the most frequent description of ILK or actually *traditional ecological knowledge* is that of Berkes and colleagues:

> "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (e.g. Berkes *et al*., 1995, 2000; Gadgil *et al*., 1993; Berkes, 2012)

This kind of knowledge is most often attributed to communities with historical continuity in resource use in an area, often described as "non-industrial or less technologically advanced societies, many but not all of them indigenous and tribal" (Berkes *et al*. 2000). In IPBES terms, ILK has come to describe traditional knowledge within indigenous peoples as well as within local communities. ILK includes "knowledge of social institutions and governance systems as well as environmental observations, interpretations and practices" (Tunón *et al*., 2015b; Berkes & Turner, 2006; Gómez-Baggethun *et al*., 2013; IPBES, 2017).

The CBD has developed general characteristics to describe "local communities", the most common of which was self-identification of one's characterisation. Some of the characteristics regarding ILK communities are also described in the IPBES assessment on pollinators (IPBES 2016, Box 5.1):

> "Local communities are groups of people living together in a common territory, where they are likely to have face-to-face encounters and/or mutual influences in their daily lives. These interactions usually involve aspects of livelihoods – such as managing natural resources held as 'commons', sharing knowledge, practices and culture. Local communities may be settled together or they may be mobile according to seasons and customary practices. Self-identification is also the key determinant of whether people consider themselves to be local communities."

What characterise indigenous and local knowledge communities?

In this Nordic study, ILK communities can be characterised by having:

- Local knowledge gathered through own observations and experiences over long time periods, usually combined with knowledge transferred from earlier generations, providing a long term view of place-based status and changes over time;
- Exchanges of place-based knowledge with neighbours, relatives and other local knowledge holders in the community, but also exchanges of knowledge with other local communities in the Nordic countries and in the EU (e.g. exchange with other coastal and island residents in the EU);
- A place-based identity, where one's quality of life is linked to the status of the local ecosystems and the possibilities for own agency to influence this status;
- Knowledge of changes both in biodiversity and biotic factors along the coast and in governance structures driven by local, national and EU directives and how these affect local life.[18]

[18] Tunón *et al.*, 2015b; Kvarnström & Tunón, 2018.

According to IPBES, ILK communities are knowledge holders, experts and stakeholders and there is no clear boundary between local knowledge holders and other stakeholder groups. In our study however, we have not focused on the knowledge and actions of larger NGOs or associations like farmer or fisher associations, but on knowledge of local, place-based communities and knowledge holders. As the IPBES Multidisciplinary Expert Panel states, "knowledge systems of many indigenous peoples and local communities, as well as relational approaches in environmental-social sciences and humanities, conceive the linkages between nature and people without strict boundaries between them and in relations based on reciprocity, with human obligations towards the non-human parts of the world." This is also true for the ILK communities in the Nordic region, which means that the different categories of NCP or ecosystem services are usually interlinked for the local communities. Local fishing, for example, is both a material contribution (food) and a non-material contribution, in that fishing defines local identities by providing "a sense of place, purpose, belonging, rootedness or connectedness, associated with different entities of the living world" (IPBES-5-inf-24).

The question of validation

Within the CBD and in IPBES, it is stated that academic knowledge and ILK should be considered as equally valid and valuable. In an ILK community, ILK is validated in a similar way as in the scientific community, with a continuous "peer review process". Statements and practices are continuously validated by, for instance other farmers, fishers, and hunters. The most suitable validation method when evaluating ILK is a broad participation process in which many practitioners can give a combined view on the matter discussed.

In the Arctic Climate Impact Assessment (Arctic Council, 2005), the Finnish Saami reindeer herders worked together with scientists to convey observations of weather change, the arrival of new species, rain-on-ice events and other impacts of northern change. This major assessment reflected that scientific findings were much in line with the Saami indigenous knowledge. Saami knowledge on climate change has also been validated in a cooperative project between researchers and reindeer herders (Riseth *et al*., 2011) and compared regarding land use and biological diversity (Blind *et al*., 2015).

There is an increasing number of community based monitoring system projects (CBMS) around the world, which could be applied as ILK data sources. CBMS can be compared to citizen science projects, in that the non-scientific community reports observations that scientists can analyze and present. These data types are included in this assessment. The ILK aspects are described in more detail throughout the other chapters and case studies (see Tunón (Ed.), 2018) of this assessment.

Recent reviews of climate change impacts and biodiversity assessments (Arctic Council, 2005; IPBES, 2016) point to the undisputed value of having more dialogue between ILK and science. A new emerging trend is also the capacity of ILK to provide ecological baseline information in the context of ecological restoration (Mustonen 2013). Sites of change, the extent and scope of damage from negative land uses, along with good practice methods for restoring habitats can be found in ILK.

1.4 Stakeholders in the Nordic context

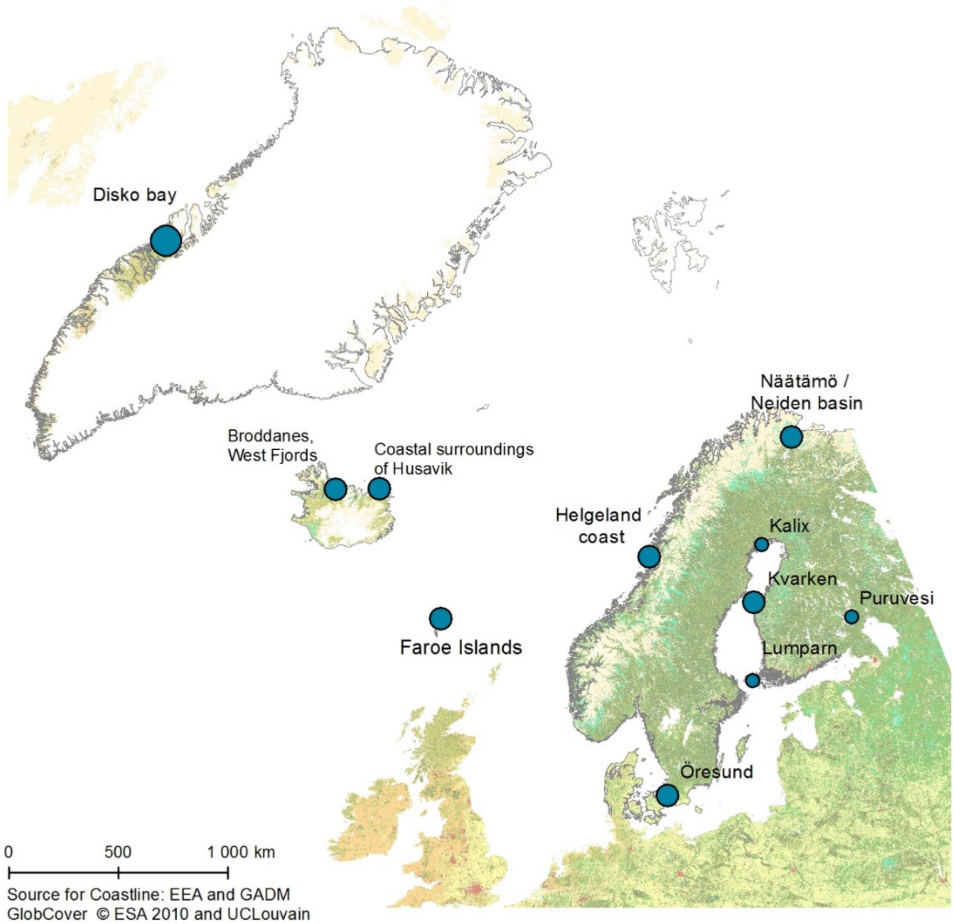
Stakeholders can be classified in two categories: 1. *contributors*, such as scientists, practitioners and ILK holders and 2. *(end-)users*, such as national administrators, governments, reporteurs to environmental agreements (e.g. CBD), research institutes, NGOs, businesses, the general public, along with the European Commission, United Nations and other international organisations.

The local and indigeneous peoples are both extractors and beneficiaries, but in many cases they are "affectees", while their role as influencers is increasing (Newton & Ellliot, 2017). The messages in this report aim to target all of them. Besides indigenous peoples, other rural groups (e.g., farmers, fishers, hunters) constitute important holders of traditional knowledge about the environment (Hernandéz-Morcillo *et al*., 2014; Tunón *et al*., 2015a; Prop. 2004). In the present Nordic IPBES-like assessment, we argue for a wide and inclusive definition (cp. Tunón *et al*., 2015b), which is in line with the conclusions made in the IPBES Assessment report on Pollinators, Pollination and Food Production (2016): *Our treatment of ILK systems here is guided by definitions that recognize the complexity, diversity and dynamism of human communities, and that self-identification, rather than formal definition, is the key* (IPBES, 2016).

1.5 Introduction to Nordic case studies where the IPBES approach is tested

The core material for this Nordic IPBES-like assessment is derived from ten case studies located all over the Nordic region (Fig. 10) (Tunón (Ed.), 2018). Case studies listed from east to west are 1) Neiden/ Näätämö (Finland-Norway, ILK), 2) Kalix archipelago (Sweden, ILK), 3) The Quark/ Kvarken (Finland-Sweden), 4) Puruvesi (Finland, ILK), 5) Lumparn area (Åland), 6) The Sound/ Öresund (Denmark-Sweden), 7) Helgeland, an Atlantic archipelago (Norway), 8) Faroe Islands, 9) Iceland: a) Gendered Landscapes of Northern Icelandic Coasts and Rural Areas, b) "We're not the enemies of the seal": Seal hunters of Iceland, and 10) Disko Bay (Greenland). Some of these cases, such as Kvarken, Sound, Helgeland and Lumparn cover all aspects of IPBES-like assessments, i.e. ecosystem services, biodiversity, drivers and pressures, while others such as Näätämö, Puruvesi, Kalix and Iceland have a stronger focus on ILK aspects. Disko Bay and Faroe Islands have strong ILK components, but also include general land cover based assessments. The two Iceland case studies focus solely on ILK issues.

Figure 10: Ten case studies describing various socio-ecological systems and environmental conditions were conducted



Note: The size of the circle reflects the size of the case study area: Disko bay is the largest, while Kalix, Puruvesi and Lumparn are the smallest.

Source: EEA and GADM. GlobCover, ESA 2010 and UCLouvain.

1.6 Methods and approaches

1.6.1 The assessment procedure

A team of over 35 experts were selected following IPBES procedures to a certain extent. Invitations to join the assessment were advertised in each Nordic country, with the aim of covering different disciplines during the nomination process. The data sources of this Nordic assessment include academic and grey literature, as well as ILK insights.

1.6.2 Case studies

The main part of the assessment material comes from case studies that are summarized in the findings of this report. A full description of the case studies is found in the Case areas report(Tunón (Ed.), 2018). They are presented following the overall structure of the report's chapters 2–4 and 6, i.e. ecosystem services, biodiversity, drivers and pressures, and governance and policy issues. In addition, a matrix approach (see Burkhard *et al.* 2014) was tested in some cases. The MAES ecosystem classes that occurred inside the case study areas were listed based on the land and sea cover data, and their role in ecosystem service delivery were evaluated by local experts. In addition, the condition of these ecosystem classes were assessed to a certain degree. Outcomes are synthesized in Chapter 5. A more general view of different chapter topics was compiled based on a Delphi survey and MAES ecosystem type matrix assessment, in addition to the bottom-up approach of comparative integration of findings from case studies.

1.6.3 Delphi survey

A qualitative comparative analysis based on experts' judgements was carried out using a Delphi Analysis approach. This provided the following information on NCP across the case studies:

- Criteria selection for ranking NCP;
- How well are NCP connected to human well-being and good quality of life, data availability/coverage (temporal and spatial) for NCP indicators;
- How functional changes in ecosystem components affect NCP;
- Impacts of drivers of change on NCP;
- How changes in governance and programme of measures affect NCP, including trade-offs.

The information provided by ILK was also integrated in this synthesis.

1.6.4 MAES matrix approach

Literature surveys and case studies form the basis of this assessment. In addition, "the MAES approach" (Mapping and Assessment of Ecosystems and their Services) was tested by:

1. Listing land cover types for all case study areas using MAES (including EU's harmonized EUNIS habitat categories) land cover classes and EMODnet seabed data;
2. Expert assessments of how habitats affect the delivery of ecosystem services, following the marine-adjusted ecosystem service classification specifically compiled for this study, that is modified and combined from CICES (Common

International Classification of Ecosystem Services), TEEB (The Economics of Ecosystems and Biodiversity) and MA (The Millennium Ecosystem Assessment) (Liquete *et al.*, 2013; Garpe, 2008). A three-step classification was used: 0 = MAES class with no/very little functions of which this ES is dependent (Negligble importance), 1 = MAES class with little/some functions of which this ES is dependent (Low importance), 3 = MAES class with many functions of which this ES is dependent (High importance) (Galparsoro *et al.*, 2014).

1.6.5 Ecosystem condition

It is important to use harmonized measures to assess ecosystem condition and its effect on the ecosystems' capacity to deliver NCP (EU, 2016). Thus, in addition to the MAES matrix assessment, the case study experts were invited to fill in an ecosystem condition assessment table using red (i.e. poor condition)-yellow-green (i.e. good condition) colour codes. Information was also added on the structure of, functions by, trophic levels of biota in, and pressures to particular habitat types (Fig. 40; Ch. 5). The spatio-temporal framings of how the condition assessment was evaluated were flexible, as this is a pilot study defined by case study experts. These are described in more detail in the case study descriptions.

Table 1: Examples of four selected condition categories for different ecosystem types

MAES ecosystem	Structure of	Functions by	Trophic levels of biota in	Pressures to
Deciduous woodland	Age structure, coverage	Nutrient uptake, carbon sequestration	Information about number of red list fungi species related to this ecosystem, changes in population trends	Logging, urban sprawl along coastlines
Mesic grasslands	Temporal landcover change	Sea bird feeding grounds (e.g. Geese)	Shore bird data	Reduced grazing
Infralitoral seabed	Oxygen levels of seabed	Fish feeding and spawning	Number of seabed invertebrate species and their abundances	Eutrophication, ocean darkening, building

Note: Illustration of possible measures do not mean that such data was implicitly used in the assessment, but rather depends on experts' knowledge on the topic. There was not enough knowledge available for all ecosystem types (marked as "not assessed").

1.6.6 Methodologies regarding ILK-inclusion in the assessment

The empirical material on ILK-perspectives in this assessment is mainly secondary to academic-based knowledge, due to limits in time and economy. For full and effective participation of indigenous peoples and local communities in the coastal areas of the Nordic region, continuous participatory workshops, field visits, discussions and collaborations would have been required (as suggested in Tunón *et al.*, 2015b). An important issue when it comes to ILK is the question of free prior informed consent

(FPIC), where indigenous peoples and local communities are able to give their consent to the interpretation and use of the information provided by them. For the present assessment, it has only been partly possible to fulfill the requirements for FPIC. This work thus relies on:

- Empirical data from the scoping study phase 2015 (Tunón *et al*., 2015b);
- The assessment phase 2016–2017 (Kvarnström & Tunón, 2018);
- ILK-case studies;
- Previous experience from the Swedish work in the National Programme of Local and Traditional Knowledge related to Conservation and Sustainable Use of Biodiversity (NAPTEK, 2006– 2014);
- Knowledge and experience from the Snowchange Co-op (2000-on-going) that has a geographical focus oriented toward Finland, Sápmi and other parts of the Arctic (e.g. Siberia, Alaska, Canada);
- Nordeco, a Nordic NGO that has been collaborating with the local communities on Greenland/Kalaallit Nunaat.

Many of the ILK and CBMS projects across the Arctic are reviewed in Johnson *et al.* (2015).

One joint Nordic ILK-workshop was held in Uppsala 1–2 June 2015 and local ones in Sweden and Finland, as well as many parallel consultative processes in during 2016–17. The scoping phase had a broad approach regarding ILK in all different ecosystems, while the assessment phase focused on ILK in coastal and archipelago ecosystems (Tunón *et al*., 2015b). A joint Swedish and Finnish workshop was held in Uppsala 23–24 November 2016. Several more informal contacts and field visits to different areas have also been made during the assessment in order to enhance participatory mechanisms (Kvarnström & Tunón, 2018). Three different questionnaires were sent out to relevant people and organizations in order to get the diversity of inputs necessary for the ILK-analysis: one broad questionnaire in 2015 and more ecosystem-focused ones in 2016.

In order to bring in the ILK-perspective in to the subregional assessment, certain case studies have particular emphasis on ILK, i.e. Näätämö and Puruvesi in Finland, Kalix in Sweden, Húsavík on Iceland, as well as Faroe Islands and Disko Bay in Greenland/Kalaallit Nunaat with self-government arrangements under the Danish Realm. Also, several of the other case studies in the assessment contain ILK issues (Tunón (Ed.), 2018).

1.7 The structure of the Nordic assessment and the core questions

This report follows the overall structure of regional IPBES assessments and aims to answer the core questions presented below. The assessment is divided in two parts, 1) Analysis – describes general issues across the region, 2) Case-studies – ten case studies from Nordic countries (Tunón (Ed.), 2018).

The general and Nordic specific questions to be answered by this assessment:

1. How do biodiversity and ecosystem function and services affect Nature's Contributions to People (NPC) in the Nordic region, especially in coastal areas? (Ch. 2);
2. What are the status, trends and potential future dynamics of biodiversity and ecosystem function, specifically in coastal ecosystems? (Ch. 3);
3. What are the drivers and pressures creating changes in biodiversity, ecosystems and their function and services? (Ch. 4);
4. What are the actual and potential impacts of various policies and policy instruments on biodiversity and ecosystem services? What potential is there in policy-making? How do these impact human well-being in the Nordic region? (Ch. 6);
5. How could ILK and data sources, such as Earth Observation and GIS data, be used in assessments and to support decision-making? (All chapters);
6. What are the perspectives for future sustainability and nature-dependent human well-being in Nordic societies? (Ch. 5, all chapters);
7. What are the major gaps in data, knowledge, management and decision-making systems, and how can they be reduced? (Ch. 5, summary);
8. What are the key messages to various stakeholders based on the findings of this assessment? (Summary).

The structure of the Nordic report follows IPBES assessment chapter division and consists of the following six chapters:

- Chapter 1) (this chapter) Setting the scene – introduces the assessment and the themes;
- Chapter 2) Nature's contributions to people and human well-being in a Nordic coastal context – describes the role of ecosystem services to human well-being;
- Chapter 3) Status and trends of biodiversity and ecosystem function – describes the key issues of biodiversity change in the past and present and its influence on ecosystem function;
- Chapter 4) Direct and indirect drivers of change in the context of different perspectives of human well-being (quality of life) – gives an overview of direct and indirect drivers and pressures to Nordic coastal ecosystems and their services;

- Chapter 5) Analysis of interactions between nature and human societies – synthesizes the findings of previous chapters and case studies, resulting in an region-wide Nordic assessment. This includes the outcomes of the Delphi questionnaire;
- Chapter 6) Options for governance – institutional arrangements and private and public decision-making across scales and sectors – embeds the findings of earlier chapters into the policy-framework, including analysis of relevant governance tools used today in the Nordic countries.

Further, knowledge from the Nordic case studies along with ILK is included in the chapters. Recommendation for decision-makers, other stakeholders and the wider public are suggested based on the chapters.

1.8 References

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2. Nature’s Contributions to People and Human Well-being in a Nordic coastal context

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Box 2: Summary

In this chapter, essential ecological and societal aspects of the Nordic coastal environment are highlighted. These show that local communities and stakeholders need to be more involved in decision-making because their needs and their ecological knowledge are essential to this process. This also relates to Aichi targets 14, 15, 16 and 18 (see Lucas *et al.*, 2015). There is the need to improve the monitoring of all types of NCP or ecosystem services and to critically review existing indicators that may be used to track the development of biodiversity and NCP. Only by actively analysing data and creating syntheses, is it possible to understand changes in the ecosystem linking biodiversity and NCP.

2.1 Introduction

IPBES assessments intend to promote conservation and sustainable use of biodiversity, long-term human well-being and sustainable development (UNEP, 2006; Böhnke *et al.*, 2016). The key elements of the conceptual framework in IPBES assessments are nature (to which human beings belong), the contributions that people gain from living in and interacting with nature and a high quality of life (Diaz *et al.*, 2015; Maes *et al.*, 2013; 2014). The regional focus of the current assessment is the Nordic coastal environment, which includes both the land-side of the coastal zone, as well as the marine environment. Nordic coastal environments are assessed using this IPBES platform (Gundersen *et al.*, 2006), nature’s contributions to people (NCP) and human well-being by exploring and describing the connections between the natural coastal and marine world and human societies in these biocultural environments. The seascape and the landscape, as well as the species composition in most of these areas, are the results of both the physical constitution and human resource utilisation, including the cultural aspects of harvesting of NCP (Haines-Young & Potschin, 2010).

In the context of science, the natural world includes biodiversity and ecosystems, ecosystem productivity and functioning, evolution, humanity and biocultural diversity (e.g. Bridgewater, 2017). To other knowledge-systems, it includes categories such as Mother Earth and systems of life (IPBES 2017). It is essential to emphasize that humans are an integrated part of all studied Nordic coastal areas, not only as agents behind direct and indirect drivers of change, but with their socio-cultural diversity affecting and promoting biodiversity (Hasler *et al.*, 2016).

2.1.1 What is human well-being and good quality of life?

Human well-being is often defined as the state of physical and mental health of individuals (Chan *et al.*, 2016). Common indicators of human well-being, such as income and per capita gross domestic product (GDP), are informative because average values per person per country are often correlated with child mortality, life expectancy and the human development index (Diaz *et al.*, 2015). Nonetheless, they are often criticised for only capturing a small proportion of the many attributes of the current concept of well-being.

Some indicators covering the various aspects of well-being are now available, including the genuine progress indicator, inclusive wealth index, OECD good life indicator and the coefficient of living standard among others (Duraiappah & Muños, 2012; Kubiszewski *et al.*, 2013; Costanza *et al.*, 2014). Freedom of choice and action is influenced by other constituents of well-being and is also a precondition for achieving different components of well-being, particularly concerning equity and fairness (MEA, 2005).

IPBES intends to offer indicators on the ethical and ecologically sustainable utilization of nature as key components of the concept of human well-being (Diaz *et al.*, 2015). "Good quality of life" can be described as the accomplishment of a fulfilled human life. A "good quality of life" is multidimensional, with both material and immaterial components. The case studies (Tunón (Ed.), 2018) in this Nordic IPBES-like study, tell how essential the coastal regions are to the Nordic countries (Table 1). In all case studies, fishing is a characteristic NCP, both for the provision of food and in a cultural context. The majority of people in the Nordic countries dwell in the coastal zone (Eurostat, 2017). Also, the coastal zones are economically wealthier and the employment situation is better than inland areas in all Nordic countries (as GDP per inhabitant; Eurostat 2017). In Denmark and Norway, the value of the seafood industry is among the highest in the EU, indicating that this NCP provides a considerable economic benefit for these nations. In Norway, particularly aquaculture has high commercial value. Further, the regulatory, recreational and cultural significance of coastal and marine environments are vital in the Nordic countries and elsewhere in the Baltic Sea littoral states (Czajkowski *et al.*, 2015).

Table 2: Comparative table of nature's contributions to people that are highlighted in the case studies

Nature's Contribution to People	The Quark	Kalix	Nätäämö	Lumparen	Puruvesi lake	The Sound	Helge-land	Faroe Islands	Disko Bay
Provisioning									
Fishing and other sea products	x	x	x	x	x	x	x	x	x
Herding		x	x			x		x	
Agriculture	x	x	x	x		x	x		
Energy	x					x	x		x
Livelihood	x	x	x		x	x	x	x	x
Regulatory & supporting									
Climate & biochemical cycles	x	x		x		x	x		x
Resilience	x	x				x	x	x	x
Biological functions	x	x	x	x	x	x	x		x
Cultural									
Recreational & aesthetical	x	x		x		x	x		x
Tourism	x	x		x		x	x	x	x
Social life, wellness	x	x	x	x	x	x	x	x	x
Existential	x	x	x		x		x	x	x

Source: Volume 2, page 16, Table 1, Tunón (Ed.) 2018.

2.1.2 *Description of the Nature's Contributions to People (NCP)*

IPBES defines three broad categories of nature's contributions: regulating contributions, material contributions and non-material contributions. NCP include *provisioning services* such as food and water, *regulating services* that affect climate, floods, disease, waste and water quality, *cultural services* that provide recreational, aesthetic and spiritual benefits, and *supporting services* such as photosynthesis and nutrient cycling. In the Nordic coastal case studies, NCP are related to a plethora of services:

- *Wild living resources* such as fish, marine invertebrates, mushrooms, berries, birds and mammals constitute a vital part of NCP in all case studies and especially in the ILK studies. Fishing, hunting and picking of berries and mushrooms for the provisioning of food is an important aspect, as well as a prerequisite for many recreational activities, an intergenerational transfer of knowledge and a part of cultural behaviour (Bridgewater 2017);
- *Energy production* from the coast by wind, wave, algae (gas production through fermentation of harvested epiphytes) and the use of seawater heat storage are increasingly important aspects of coastal NCP;
- *Mediation of waste and toxins*: mediation by biota and ecosystems such as mussel beds, kelp forests and eelgrass or *Chara* meadows, the ability to remove or store pollutants;
- *Physical, spiritual, symbolic, aesthetic and intellectual interaction with biota, ecosystems and landscapes*: All studied Nordic cases include ILK that underscore the significance of the cultural heritage, diversity and experience of silence,

beauty and relaxation. These NCP also underpin services in leisure, recreation and tourism;

- *Regulatory services*: Coastal seas may mitigate variations in the local climate and recycle nutrients. For instance, predatory fish play a regulatory role by mitigating eutrophication through preventing trophic cascades, leading to too high an epiphytic production (Moksnes *et al.*, 2008).

2.1.3 The history behind the term NCP

IPBES decided in March 2017 to rename nature's benefits to people to nature's contributions to people. This decision was based on two arguments: 1) The word "benefits", with its strongly positive connotation, wrongly conveyed the idea that negative contributions from nature towards people's good quality of life would be excluded; 2) The different meanings of the word "benefits" in common speech in different languages as well as in the social sciences and the valuation literature represented potential sources of confusion. It was therefore proposed that the name nature's benefits to people would be changed to nature's contributions to people (NCP), while retaining the same meaning and conceptualization as in Díaz *et al*. (2015), in accordance with the IPBES conceptual framework.

2.2 Relationships and impacts of changes regarding nature's contributions to people

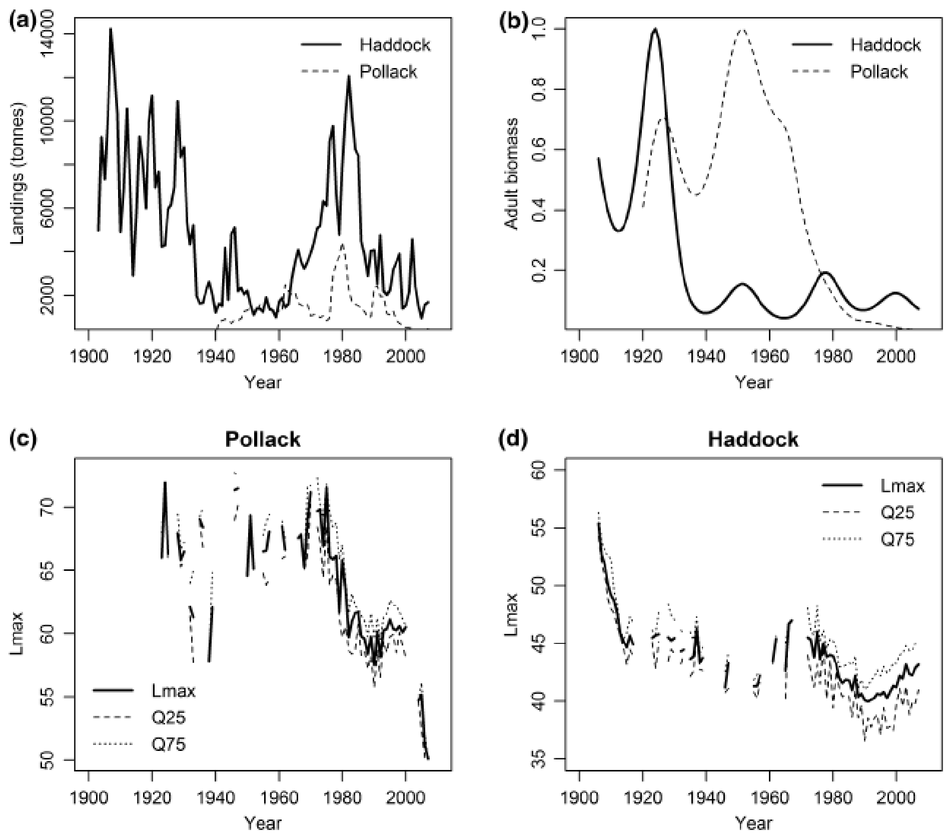
2.2.1 Food security

Food security concerns both whether the food we eat is safe and healthy, and whether there is a long-term supply of food for our needs (FAO, 2002). Currently, the supplies of food are secured through domestic production and import in the Nordic countries. However, there are still threats to food security due to the spread of hazardous substances in the marine environment, such as mercury and dioxins, which remains a matter of concern for health reasons (e.g. Sheehan *et al.*, 2014). Plastic is an increasing challenge; it is harmful to seabirds that pick plastics from the sea surface such as fulmars (*Fulmarus glacialis*; Trevail *et al.*, 2015). Microplastics in the Arctic is of increasing concern, partly related to climate change, as sea ice extent is becoming reduced and thus releasing microparticles (Lusher *et al*., 2015).

Climate change may threaten food security by changes in productivity, distribution of species, expansion of parasites etc. (see Chapter 4). Also, the depletion of fish stocks is a matter of concern. For several decades, various fish stocks from different parts of the Nordic seas have been overfished, such as the large spring spawning Norwegian herring stock (*Clupea harengus*) (e.g. Dragesund *et al.*, 2012). Fishing also drastically reduced the predatory fish stocks along the Swedish west coast in the late 20th century and to this day, no recoveries have been recorded (Svedäng, 2003; Svedäng & Bardon, 2003; Cardinale *et al.*, 2012, Fig. 11). In the Baltic Sea, cod (*Gadus morhua*) stocks (ICES,

2017) and coastal species such perch (*Perca fluviatilis*) and eel *(Anguilla anguilla*) are in a low-productive state (e.g. Svedäng & Hornborg, 2017).

Figure 11: Historical trends of (a) total official ICES landings, (b) adult biomass [in relative scale], and (c–d) average maximum length (Lmax in cm with 25 and 75 percentile) for haddock and pollack in the Skagerrak and Kattegat



Source: Cardinale *et al.*, 2012.

For the people around the Baltic Sea, on Greenland and the Faroe Islands, consumption of for instance, pilot whale, fatty fish and seabirds has become an apparent health risk due to storage of lipophilic pollutants in fatty tissues (e.g. Sørensen, Roto, & Tunón, 2018). This shows that far distance pollution may threaten the local use of biological resources and consequently the local food security. The lion part of these pollutants is from more distant and heavily industrial countries of Western Europe. The problem of persistent organic pollutants has been addressed for several years in Arctic Council work, especially amongst the Inuit, who in similarity to the Faroese, use a lot of game (wild marine animals and birds) as their food source. The Arctic Monitoring and Assessment Programme (AMAP, 2011), as well as the Inuit Circumpolar Council, have in campaigns in the villages in Nunavut demonstrated the need for safe foods and maintaining traditional practices.

Exploitation of coastal areas and displacement of small-scale fisheries by recreational fishing, as well as by offshore large-scale professional fishery, is problematic as job opportunities and livelihoods are being diminished in coastal regions. In the past, there were many households and small-scale fishers along the coast. Fishery was an essential basis for survival, both regarding the nutritional and economic value along the coasts. Moreover, fishing was seldom the sole occupation, but one of several economic activities within a household. Over the last decades, fishing practices have been specialized and reserved to a few professional fishers with consequences for subsistence fishing, which has almost disappeared as a phenomenon in coastal areas all over the Nordic countries.

2.2.2 Energy security

Energy is a provisioning NCP. Beside nuclear, hydroelectric and wind power, fossil resources are still vital to our economies and welfare. It is however, for many reasons of paramount importance, that the use of this NCP is reduced. It is crucial to mitigate the climatic consequences of exploiting fossil carbon reserves by eliminating CO_2 emissions where possible. While the development of coastal wind power, wave and tidal energy can reduce dependence on fossil fuels, such exploitation, both on land and at sea, may significantly reduce the value of scenery as well as severely modify biodiversity and ecosystem function. Energy security is costly and reduced use of energy is one of the best options for securing another NCP. Furthermore, energy saving is often the most cost-efficient and feasible way of solving energy demands (e.g. Oikonomou *et al*., 2009). This is however depenent on whether the reduced energy consumption for one purpose is directed towards other forms of consumption or not. "Alternative" ways of producing energy are ingrained with difficult trade-offs and conflicts on environmental issues. In our Nordic studies, the location of offshore wind power in the Sound is an example of the competition for space. On the other hand, if wind farm construction only minimally disturbs marine life, they have the potential to function as marine protected areas because fishing activities are reduced in wind farm areas (Ashley *et al*., 2014).

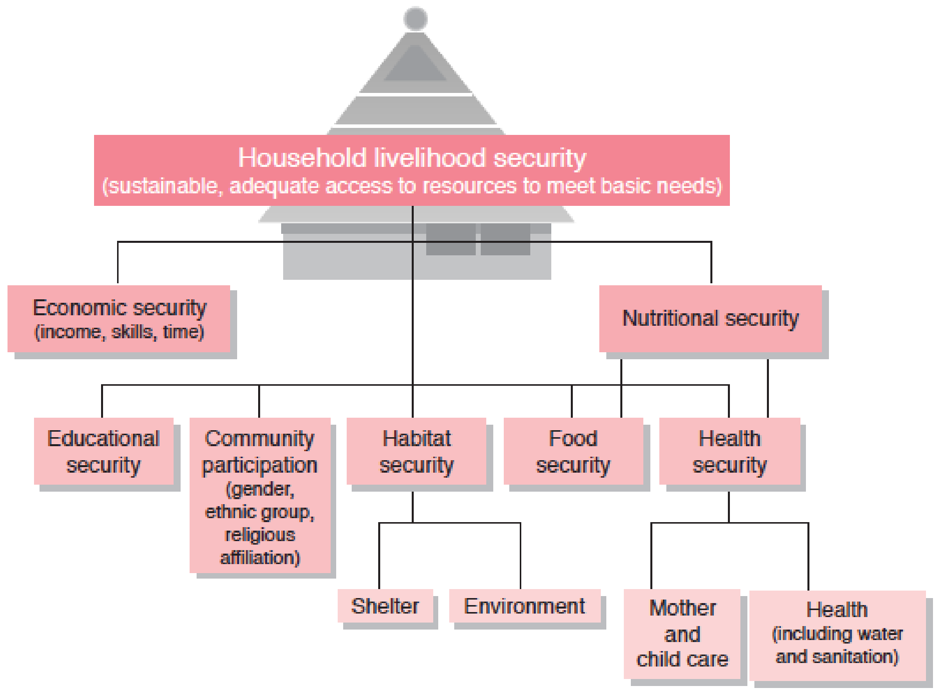
2.2.3 Livelihood security

Livelihood security is of paramount importance and much concern at the political level.

The *household* livelihood security model puts emphasis on household actions, perceptions and choices (Fig. 12). Food is one among several priorities that people pursue. People are regularly required to balance food procurement against the satisfaction of other necessary material and intangible needs such as clean water, health facilities, educational opportunities, housing, time for community participation and social integration, as well as existential and spiritual needs (Maxwell & Frankenberger, 1992).

The struggle for livelihood security in a broad sense is a significant driver behind the current trends in urbanisation and depopulation of remote areas in the Nordic countries. As livelihood security is perhaps increasingly decoupled from local NCP, economic and social constraints may lead to an abandonment of remote settlements.

Figure 12: The household livelihood security model



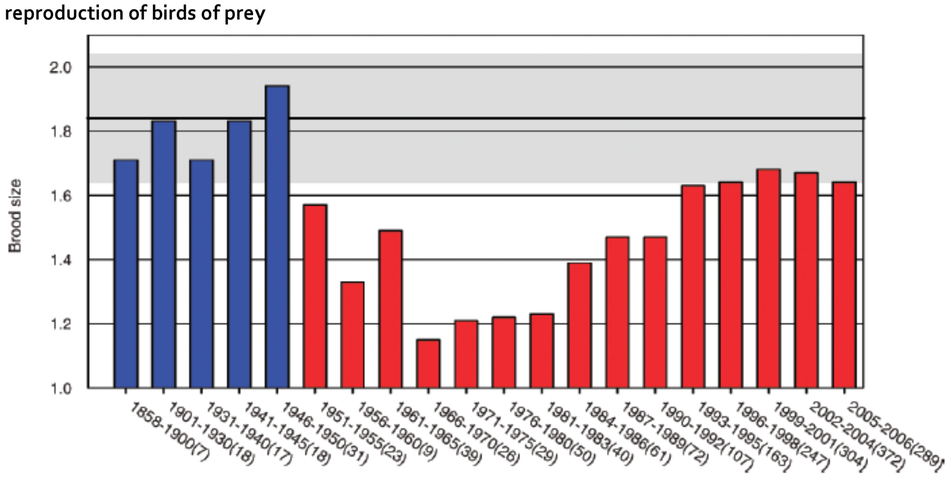
Source: Frankenberger & McCaston, 1998.

Indigenous peoples and local communities with traditional lifestyles are heavily dependent on local biological resources, e.g. through fishing, hunting and harvesting of wild plants and berries, and are more likely to be affected by declining populations of important species (Gadgil *et al*., 1993; Tunón, 2004, 114–115). In modern societies such as those in Nordic countries, the concept of *traditional lifestyles* becomes a gradient from customary to a more modern small-scale use of local resources; yet, the good status of local ecosystem functioning and local biological resources is essential (c.f. Tunón (Ed.), 2018; Tunón, 2004, 114–115; Hernandéz-Morcillo *et al*., 2014). Rural people might be more or less dependent on the local biological resources for their subsistence, while the urban population to a large extent is detached from local dependencies and relies on the global market for everyday living. Consequently, the issue of dependence on local NCP can be seen as a question dividing rural and urban lifestyles. Even if the number of professional small-scale fishermen is going down, rural household fishing is still important since it opens an opportunity for comfortable living even below living wages (Tunón *et al*., 2015, and the ILK-process within this assessment, cp. Kvarnström & Tunón, 2018).

2.2.4 *Health security*

Health security may be seen as a part of household livelihood security (Fig. 12), such as contaminant-free food supply. In this Nordic coastal context, the issue of secure food often concerns the intake of toxic substances through seafood. Arguably, it also incorporates access for swimming, fishing and other forms recreational activities and cultural services. In this context, it is worth highlighting the importance of cultural contextualization to indigenous and local communities in their creation of a cultural and ethnic identity. This process is often formed in the context of customary use of local biodiversity or residing in the land. Albeit perceived as recreational activities, such activities are important carriers of tradition, culture and social health. Exploitation of the coast for housing and infrastructure may severely limit open-air recreational activities. For many people, the coastal environments are very crucial for their well-being and the privatisation of the most appreciated parts of the natural environment is both irreversible and ongoing. Housing and privatisation of coastal areas also pose a problem for reindeer herding (see e.g. the Kalix case study in Kvarnström & Boström, 2018). Therefore, public access to coastal areas and the seashore should be very high on the political agenda.

Figure 13: The spread of pesticides such as DDT and its derivates had a severe impact on the reproduction of birds of prey



Note: Mean clutch size (number of juveniles per nest with nestlings) for white-tailed eagle (*Haliaeetus albicilla*) on the Swedish Baltic coast from the 19th century to 2008.

Source: Helander *et al.*, 2008.

As mentioned in the previous section 2.2.1 on food security, marine commercial species exhibit varying levels of different harmful substances depending on, for instance, contamination source and trophic level. The substances may accumulate through the food-chain and be transferred to the people consuming them, which may lead to illness, impaired immune systems, hormone disorders and fertility problems, such as in white-tailed eagle (*Haliaeetus albicilla*) (Fig. 13). On the other hand, seafood is an important source of nutrients, including essential nutritional components such as fatty acids. The most successful way of minimising the risks without losing the health benefits is to limit consumption of fish species with a high methylmercury and other lipophilic pollutants content (EFSA, 2015).

Radioactivity has also been traced in sea plants as far away as in western Greenland. The Baltic Sea is considered one of the most radioactively contaminated seas in the world (Livingston & Povinec, 2000). The largest source of radioactivity in fish, bladderwrack and aquatic organisms in the Baltic Sea is still the aftermath of the Chernobyl nuclear accident in 1986, more than three decades ago. Furthermore, in the Baltic region there are still remains left from the Soviet Union, including dumped chemicals and nuclear-powered lighthouses. The concentrations of radionuclides such as Cesium-137 in fish have declined considerably since the early 1990s and continue to decline. It is expected that adequately low concentrations of radioactive substances in biota and water may be achieved in all of the Baltic Sea by 2020 (HELCOM, 2017)

2.2.5 Sustainability perspective

Sustainable development has three interdependent and mutually reinforcing pillars – economic development, social development and environmental protection (Long *et al.*, 2015). Sustainability is considered to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (cf. Brundtland, 1987). The political will is to ensure that environmental management, protection and conservation are integrated into sustainable development planning and management, by mainstreaming sustainability into society. For instance, Nordic parliamentarians suggest new laws in their focus on how to fight climate change. Many Nordic countries, including Åland, aim to mainstream sustainability into their daily life and the management of the environment and natural resources. However, this political ambition also has to be balanced with other aspects, e.g. economic growth, the spread of cities, the need for more energy, etc.

It is widely recognised, both politically and academically, that local communities with traditional lifestyles are more sensitive to changes in the natural world, due to their direct dependence on local living resources (e.g. the preamble of the UN Convention on Biological Diversity, 1992). For instance, a diminishing fish stock in a given area has a much stronger impact on local, small-scale artisanal fishers, than it has on larger, more industrial fishing vessels with the option to fish in other waters or follow the fish stock. A local farmer with grazing animals on islets in the Baltic archipelago often has more difficulties in finding alternative grazing than a large-scale farmer on the mainland with alternative grazing lands or means to buy additional fodder. Consequently, local fishers and hunters need to be more cautious in their fishing than visiting recreational anglers or hunting tourists, since they often are dependent only on local stocks and can follow population changes over time, while the latter quickly can choose to go to other places. There is a need for policy that maintains sustainable customary use in order to sustain the rural population in the future. Policies should build on the fact that the use of local biological resources goes beyond providing food and livelihoods,and constitutes an arena where cultural identity and inter-generational relationships are formed.

On the other hand, people in rural communities involved in small-scale farming, fishing and other locally based economic activities, are often less dependent on open market relationships and monetary subsistence than urbanised sections of the population. Many times, it is the possibility to use several different biological resources that is the reason why local cultures have developed and survived in marginal areas. However, as this way of living is less dependent on monetary income, it could be endangered if challenged by competition from other users, changed regulations or decline of the target species. Urban people often have larger incomes and better possibilities to invest in properties – also in rural areas – and are therefore competing with the young rural population. Consequently, local users of biological resources are being substituted by seasonal visitors and rural areas are being deserted during large parts of the year. Furthermore, the customary use of local resources in indigenous and local communities is, to a large extent, the core of the lifestyle and a matter of quality of life.

2.3 Identifying aspects of biodiversity and ecosystem services critical to social relationships, spirituality and cultural identity

2.3.1 Technological change

Local economies built on the use of natural, often living, resources are fragile to technological development that might change the local biological composition or the cultural construction of the community. The number of people involved and employed in agriculture, forestry, fishing, hunting, mining, industry and so on, have inevitably become less and less numerous over a long time. On the one hand, by becoming more efficient and specialised, our society as a whole becomes prosperous. These changes result in reshaping of the social and cultural organisation in the local communities, which also involves changing the customary governance systems related to the use of local biological resources.

2.3.2 A sense of place

A technological transformation might lead to a loss of sense of place and context for local people. Factors important for maintaining biodiversity, cultural diversity and other NCP are therefore severely affected by the constant economic, social and technological changes that are sweeping through our societies (e.g. Kvarnström & Tunón 2018). In the Kalix area of the Bothnian Bay, local fishers and reindeer herders emphasize that their quality of life, sense of place and deep connection with the land is intimately linked to their possibilities to continue traditional, customary practices of fishing and reindeer herding (Kvarnström & Boström, 2018). In Northern Iceland, the local women interviewed describe the importance of leaving the nearby mountain areas without disturbance in order to respect and maintain their sacredness. They also talk about "the hidden people", the non-human entities and beings of these sacred mountains

(Mustonen, Mustonen & Oddsdottir, 2018; Mustonen *et al*., 2018). On the Faroe Islands, the local inhabitants describe that to feel Faroese, one has to be brought up on the islands, have adapted to them, and felt the influence of the rough and changeable nature, the unpredictability of the weather, the beauty of the local nature, the possibility to wander freely and continue customary use of biodiversity in a sustainable way (Sørensen, Roto & Tunón, 2018). Similar statements and sentiments are found in most of the case studies in this assessment (Tunón (Ed.), 2018).

In some cases, it is possible to take advantage of the increasing recreational value of birds, seals, whales, etc., as an alternative or complementary way of creating a new livelihood for people in the countryside or small towns. Tourism is, however, connected with many side-effects that may result in profound societal change. The industry is also dependent on continued economic growth, along with a wealthy urban population creating the financial opportunity.

As social relationships, cultural identity and spirituality often are closely tied to traditional ways of living, local and customary economic activities are encouraged and supported in some areas. Encouraging examples include fishing of the vendace at Kalix in the Bothnian Bay, which has been successfully maintained as a local industry. Similarly, the traditional communal seining (pulling) net fishing tradition is still surviving in the Puruvesi area (Mustonen, 2018b), and so is the seal hunting of coastal fishers in Iceland, as well as the pilot whale hunt in the Faroe Islands (Mustonen *et al*., 2018; Sørensen, Roto & Tunón, 2018).

For indigenous people, such as the Skolt Saami and other Saami peoples, recent studies have documented that the Saami languages, practices and dwelling on traditional territories combined provide a biocultural landscape. Suggestively, a "Saami ecosystem". It reflects customary habits and traditional land and water occupancies with cultural-spiritual links to the place, which form an inseparable whole that is more than the sum of its parts.

Subsidies given to agriculture and fishery may in many cases however, be rather counterproductive. For example, the natural resource (e.g. a fish stock) is depleted as the cost is lowered by subsidies given as a lifeline to commercial users (e.g. Sterner & Svedäng, 2005). Subsidies to farming could be equally destructive. For instance, in the Quark area the practice of preparing naturally acid soils with dykes to support agriculture has led to discharges of acidic water that destroy fish stocks in rivers and inshore areas (Ilvessalo-Lax *et al.*, 2018).

2.3.3 Legislation, guidelines, administration of biodiversity

Governance and rules for the management of biodiversity do not always meet the reality on the ground (see also Chapter 6). For example, local fishermen have good knowledge of when and where fishing should be carried out for various species. They often argue that they could protect different species in a more nuanced way, if only they could have some impact in governance.

Fishing and hunting in small local communities is regulated by external governance systems, making it hard for indigenous people to live as they once did. Several of the species that have been the basis of their livelihoods are no longer harvested due to strict regulations. Collaborative management and shared governance are emerging to address and alleviate this situation (e.g. Bryhn *et al.*, 2017). However, due to the decline in abundance of many species, few options besides harvest restrictions are available.

2.3.4 Traditional land use on the coast

Land use has changed profoundly in most Nordic countries, affecting biodiversity and NCP to a very large extent (e.g. Cui *et al.*, 2014). The large-scale transformation of the Swedish Baltic landscape has had severe effects on biodiversity and NCP, not least in coastal areas (Eriksson & Cousins, 2014; Fredh *et al.*,2017; Kritzberg, 2017).

The traditional way of life in most coastal areas in the Nordic countries (excluding Greenland due to the climatological conditions for cultivation) have consisted of a mixture of activities with fishing, agriculture and animal husbandry at the core, with hunting and gathering on the side. In some areas, the conditions for agriculture have been very favourable, but most often the soils have been poor and fields have been small. Animal husbandry has had better potential. Grazing of domestic animals, mainly sheep or goats, has been a necessity for subsistence reasons. Along the coasts of the Baltic Sea, fisher-farmers have had their cattle, sheep and goats grazing on islands and islets. The animals have had to be regularly moved from island to island to provide enough fodder; a time-consuming activity. However, today this custom is very rare. In the Faroe Islands, sheep farming on semi-natural pastures is still an essential part of traditional everyday land use, both from a subsistence and social/ cultural point of view (Fig. 14). Historically, it was necessary to have sheep, hunt and fish to be able to make a living, but nowadays it is more of a supplement to the household economy, a social and cultural aspect and a widespread family tradition. The conditions for cultivation are not very favourable, as only some 4% of the terrestrial area is suitable for agriculture. The principal crops are hay, potatoes and rhubarbs (Sørensen, Roto, & Tunón, 2018).

Figure 14: Most of the Faroese landscape consists of open pastures that have been grazed for centuries by sheep

Source: Håkan Tunón, 2017.

There have also been intricate grazing systems on the coastal heaths in western Norway and Sweden. Grazing of sheep and cows in the summer has been alternated with the harvesting of heather (*Calluna vulgaris)* for winter fodder and bedding for the animals. When the heather has been too old, the grazing areas have been burned to stimulate the growth of grass and herbs. Today such areas are scarce and traditional management regimes are mainly performed for nature conservation. Grazing also used to be common on islands and isles in the Baltic Sea archipelago, as well as in other coastal areas in the Nordic region, but has during the last century become scarcer due to cost structure rationalisation. The result is more overgrowth and changes in biodiversity, where, for instance, less competitive plants are disappearing (Tunón *et al.*, 2015).

Traditional land use has also undergone shifts. The archaeologist Noel Broadbent argues that the Baltic coastal seal hunt has its roots in a Saami siida territory use. Later in historical times when the Swedish/Finnish settlement expanded into the North Baltic coasts, the Saami switched or adapted to high mountain hunting, fishing and herder systems to alleviate resource pressure from the lost and occupied territories of the coast, but still retained the distinct siida governance.

2.3.5 Cultural values and biodiversity

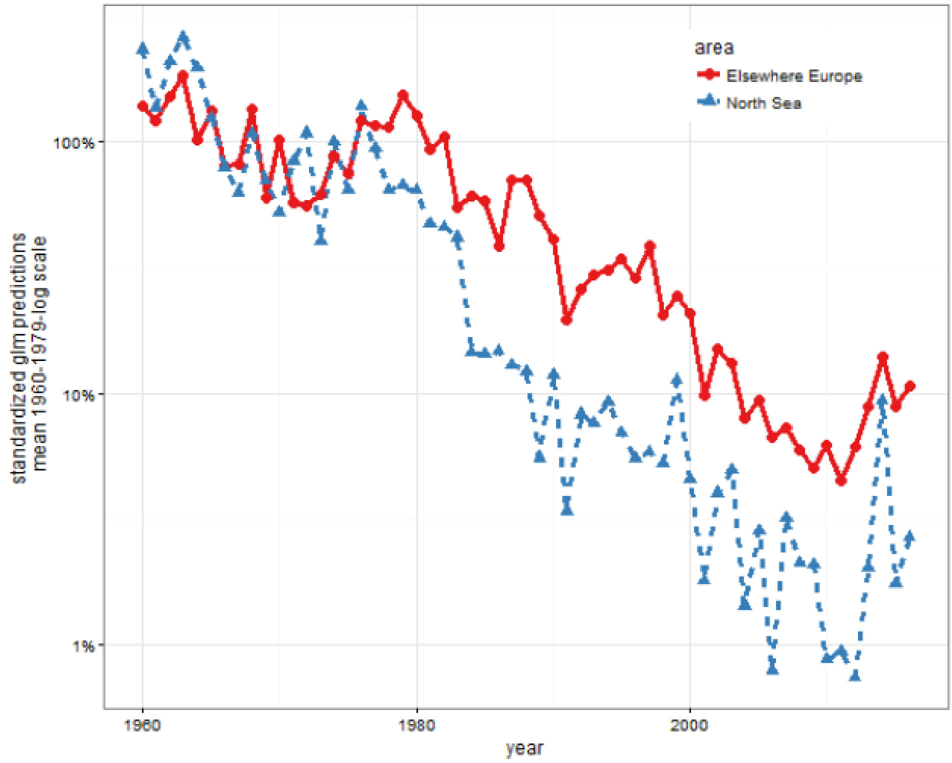
Landscapes and geological formations, as well as the biological diversityin a particular area, play a major role in shaping the cultural history of local communities and the local customary practices. Fishing methods, hunting techniques and other practices, which used to ensure the daily subsistence for the local community, have been developed in relation to the local landscape and its biodiversity. Together, this has contributed to what forms the local cultural heritage and identity, both materialistically and spiritually. The yearly cycle of physical and biological phenomena has developed a local calendar of customary practices, depending on resource availability and weather conditions. Consequently, there are cultural values closely linked to the harvest of particular biological resources (Tunón *et al*., 2015, and the ILK-process of this study, cp. Kvarnström & Tunón, 2018). Today such events are subject to major social and cultural interest, but they are also essential for quality of life and for upholding a sense of identity in the local communities. They might be of importance for livelihoods but are in some cases of even higher symbolic value. These culturally important species may be significant locally and nationally, and in some some cases even internationally renowned. Below are some examples of species-specific social and cultural contexts.

2.3.6 Culturally important species

Eel

The eel (*Anguilla anguilla*) population span from northern Europe in to the Mediterranean and the Black Sea. It is a fish of some folkloristic importance in the Nordic countries, especially in southern Scandinavia. The fish is consumed all year round, but nowadays especially at Christmas. However, at the "eel coast" at Hanö Bay in eastern Scania in Southern Sweden, the traditional fishing and eating of eel has taken spectacular forms with "eel feasts" (ålagillen), where a variety of eel dishes are prepared and ceremonies take place during autumn. The eel culture in the area has been proposed as a cultural heritage to be listed nationally within the UNESCO Convention for the safeguarding of the intangible cultural heritage from 2003. Since 2007, a fishing license is required for eel fishing due to the endangered status of the European eel (Fig. 15). While current eel stock could sustain the cultural traditions in eastern Scania, the present eel fishing intensity as a whole is not sustainable (Svedäng & Gipperth 2012). Although eel fishing occurs all over Europe, the Nordic impact on the eel stock is likely to be significant, as both Sweden and Denmark are two major European eel fishing nations (ICES 2016). Furthermore, the remaining eels in the Baltic might be one of the last more substantial living reserves.

Figure 15: Eel (*Anguilla anguilla*) recruitment in Europe based on the ICES (WGEEL) recruitment index



Note: It shows the geometric mean of estimated glass eel recruitment for the continental coasts bordering the North Sea and Elsewhere [in] Europe till year 2016. The model was fitted with 33 time-series comprising either pure glass eel or a mixture of glass eels and yellow eels and scaled to the 1960–1979 average. No time-series are available for glass eel in the Baltic area. Note the logarithmic scale on the y-axis.

Source: ICES, 2016.

Vendace

Vendace (*Coregonus albula*) is a small salmonid fish, whose roe is very esteemed and marketed as caviar (löjrom). Vendace is common in the brackish Bothnian Bay, where local roe fishery has existed for generations. The vendace roe from the Kalix archipelago, the "Kalix löjrom", has been harvested since the 1950s and received a protected designation of origin (PDO) by the EU in 2010. The fishery takes place in late September and October. Kalix löjrom is often served at the Nobel Banquet and other distinguished events. Consequently, the local communities in the area are very proud of their fish and their product (Kvarnström & Boström, 2018).

Vendace is also the iconic fish of the Puruvesi winter seiners on the large Saimaa Lake system. Also, a home to the freshwater seal and land-locked Atlantic Salmon, Puruvesi is a sea-like ecosystem housing a traditional fishing community. The vendace of Puruvesi has an EU Geographical Indicator for the traditional harvest, which is a seal-friendly and of particular biological quality. The traditional harvest with seining does not affect the seals negatively (no entanglement or by-catch issues). The clear water of

Puruvesi, with visibility being very good, has affected the softer bone structure and high Vitamin D contents of the vendace, making them stand out compared toother stocks of the same species even on neighboring lakes. The oral culture of the Puruvesi winter seiners is currently under consideration for nomination as an intangible cultural heritage of UNESCO (Mustonen, 2018a).

Eider

Historically, spring hunting of migrating seabirds was common in the Nordic region. Today, due to the EU Species and Habitats Directive, most countries no longer have any hunting during spring. However, Åland has an exemption to hunt male seabirds in the spring, especially common eider (*Somateria mollissima*), and is still arguing for its continuation. Only adult males are shot during the hunting season, which occurs over a two-week period.

The hunt takes place when the mating season has ended and when the female is nesting. In the old fisher-farmer communities, spring seabird hunting was a matter of survival. Today the hunt, while no longer crucial for survival, is still an important part of life and culture. The spring hunt also gives the local communities incentives for conservation efforts beneficial to the seabird populations, e.g. predator control.

Another example of the relationship between man and common eiders is in the Vega archipelago in Norway. Due to the high value of eider down, the local people started to tend female eiders and protect them against predators at the nests in order to ensure a viable population. This relationship between the birds and the bird tenders is of a unique character, preserved as a socio-culturally significant UNESCO world heritage site. The down is still harvested and made into exclusive quilts sold all over the world. Unlike most down products, here it is possible to collect the down in an entirely non-destructive way (Hancke *et al*., 2018).

In recent years, the eider population in the Baltic Sea has declined (Ekroos *et al*., 2012). The decline has been related to high mortality of the newly hatched *pulli* (Fig. 16). The death of the young birds is due to deficiency of thiamin (vitamin B1), however the reason why this deficiency develops in a number of Baltic species, still remains unknown (Mörner *et al*., 2017).

Figure 16: Herring gull (*Larus argentatus*) attack on an eider gathering at Vållholmen in the Blekinge archipelago (Sweden)

Note: Due to thiamin deficiency, leading to brain damage among other symptoms, the *pulli* neither dived nor ran away and were thus an easy prey to catch

Source: Mörner *et al.*, 2017.

Whale hunting

Figure 17: Pilot whale hunting (Grindadráp) on the Faroe Islands, the traditional harvesting of long-finned pilot whales (*Globicephala melas*)

Source: Nazuna Nakao.

Pilot whale hunting (Grindadráp) in the Faroe Islands (Fig. 17) is a thousand-year old tradition that takes place at irregular intervals. It involves the harvesting of long-finned pilot whales (*Globicephala melas*) and occasional dolphins. This traditional hunt is passive in the sense that the hunters wait until a shoal of whales is approaching. The whales are not actively seeked, but when spotted while carrying out fishing at sea and hunting conditions are favorable, a grindadráp is organized. It is an important social event for the local community and engages many of its inhabitants. Whale still constitutes a fair share of the meat consumption in the Faroe Islands, but problems with contamination of hazardous pollutants have led to discussions regarding local health issues (Sørensen, Roto & Tunón, 2018).

Cetacean and seal watching

For many people, cetacean animals, i.e. whales and dolphins, are very attractive and in many places around the world, they can be seen in the wild. For instance, around twenty years ago, packs of killer whales (*Orcinus orca*) started feeding on herring during late autumn in Norwegian Tysfjord, which is easily accessed. Consequently, whale-watching tours were arranged and now more and more companies are offering their services. In Iceland, the former whale-hunting communities, e.g. Húsavík, have turned to whale watching instead. People tend to refer to an almost spiritual feeling when experiencing these large marine mammals. Furthermore, as seals have become more abundant over the last decades in the Baltic Sea, small companies along the Swedish coast have started seal safaris to give people an opportunity to view seals in the wild.

2.4 Innovations and conflicts with biodiversity

2.4.1 Innovation

Wind parks

Intensive planning and building of offshore wind parks is increasing along Nordic coastal areas. Construction activities should be avoided in critical recruitment areas for marine mammals and fish because these localities are sensitive to disturbance. Similarly, actions to reduce exposure to damaging noise levels should always be undertaken. To minimize impacts on migrating species, construction activities should not take place during biologically sensitive periods of the year. Avoiding harmful noise levels during spawning season should be prioritized due to the limited mobility of younger life stages.

One challenge for marine spatial planning is to assess the effects of trade-offs on a broader geographical scale. The potential harmful impacts of offshore wind parks can be minimized within the planning process, by avoiding crucial recruitment areas and by timing construction activities outside the main breeding seasons. Offshore wind farms can help preserve fish stocks and other marine life by restricting the access to some parts of the sea (Asley *et al*., 2014). For example, in regions where bottom-trawling has formerly been the dominant fishing method, some beneficial effects on local benthic species are often noticed following wind park construction (Lindeboom *et al.*, 2011).

Wave power

The use of wave energy for electricity generation might expand in some areas in the region. However, today there are only a small number of experimental wave generator plants in operation and more research is needed to get some real conclusions about this kind of energy production. Effects on the environment have been suggested to mainly occur during the construction phase. Similar to windmill parks, the delimitation of some sea areas around ocean energy installation may function as de facto marine reserves (Gasparatos *et al*., 2017).

2.4.2 Nature-based solutions

Changes in land-use such as drainage, use of artificial fertilizers and grazing, may seriously affect the coastal environment. It is therefore of great importance to recirculate nutrient losses from land to coastal waters (e.g. Grant *et al.*, 2007). "Green infrastructure", such as the restoration and construction of wetlands for nutrient retention purposes, are now rather wide-spread in Nordic countries (e.g. Hansson *et al.*, 2005; Hoffmann & Baattrup-Pedersen, 2007). Many times, if appropriately constructured, such created wetlands may also contribute to restoring former biodiversity. There is an increased interest in using some animal species as a means for decreasing the occurrence of heavy metals, hydrocarbons, nutrients and persistent organic pollutants, particularly in an aquatic environment. Recent examples include the harvest of fish to remove polychlorinated biphenyls (PCBs) from the Baltic (MacKenzie *et al.*, 2004). Cultivation of blue mussels (*Mytilus edulis*) has been suggested as a means to remove nutrients in the Baltic Sea, as well as in the Kattegat and Skagerrak (Lindahl *et al*., 2005).

2.4.3 Job market impacts

All the case studies (Tunón (Ed.), 2018) and the ILK studies (Kvarnström & Tunón, 2018) give a clear vision regarding the importance of NCP for the entire local society, including the job market. Even if it is not necessarily a question of traditional fishing and farming, many other contributions can be the basis for income. For example, nature-based tourism, recreational fishery, diving, hiking and so on, also deliver earnings that can be crucial to the survival of small societies with only small possibilities for other kinds of jobs.

2.5 Biocultural diversity

Biocultural diversity describes the tie between the cultural and biological diversity. This link has become more acknowledged over the last decade following research showing that areas with higher cultural and language diversity often overlap with areas of greater biological diversity (e.g. Loh & Harmon, 2005; Gorenflo *et al.*, 2012).

One of the presumed reasons for this link is that indigenous cultures are considered to have developed more sustainable lifestyles through their high and direct dependency on local resources. It also assumes that they act as wise trustees of biodiversity. This concept brings a massive paradigm shift in biodiversity conservation strategies. Just a few decades ago, the most common strategy was still to exclude people from nature reserves to protect its biodiversity and habitats. Today, conservation strategies are starting to consider indigenous people as potential allies in the protection of biodiversity. There are examples of successful community conservation projects around the world that aim to empower people and enable them to continue to protect the environment (e.g. https://www.naturskyddsforeningen.se/nyheter/smaskaligt-fiske-starks-i-sydafrika). These are commonplace in the Nordic countries, such as the Swedish Society for Nature Conservation, which is a charitable environmental organisation with the power to bring about change with almost a quarter of a million members.

Linguistic diversity is often used as an indicator of cultural diversity, which may in turn be linked to biodiversity. According to recent studies, the global decline of linguistic diversity (see below) is even faster than the decline of biological diversity. UNESCO and other organisations promote education in mother tongues and multilingualism. In Finland, Norway and Sweden, processes have been initiated to support and regenerate the Saami languages. Many Saami emphasize the importance of the Saami language in maintaining a close relationship with the land and its ecosystems. The organisation Terralingua supports "the investigation of the links between biological, cultural, and linguistic diversity, as well as the adoption of an integrated biocultural perspective on the perpetuation, maintenance and recovery of diversity on Earth" (http://www. http://sacredland.org/terralingua// accessed on 2018-04-12).

2.5.1 Biological diversity

Many studies suggest a close connection between biodiversity and the resilience of ecosystem function (Oliver *et al.*, 2015). It has been suggested that lost biodiversity increases the spread of infectious diseases (Keesing *et al.*, 2010) and new research points to t thathe loss of biodiversity may be related to allergies and chronic inflammatory diseases in urban environments (Hanski *et al.* 2012). Indirectly, NCP contribute to health benefits through water purification, food and medicine production, and reduce the risk of negative health consequences of extreme weather events (Coutts & Taylor, 2011). Ecosystem services do not include only biodiversity and life-sustaining systems, but also provide an excellent arena for health promotion and well-being (Maller *et al.*, 2006).

2.5.2 Cultural and linguistic diversity

The five Nordic countries and the three autonomous areas, Faroe Islands, Greenland and Åland, have a considerable shared history and substantial similarities, but also local differences in traditions and the use of biological diversity depending on geographical, climatological and ecological differences. The cultural differences may be based on nationality, but also on whether people belong to rural or urban populations or if they are farmers, fishers or other kinds of users directly dependent on biological resources. In the Nordic countries, there are main nationalities, minorities, e.g. immigrants and traditional inhabitants, and two indigenous groups, the Saami people in Sápmi in Northern Norway, Sweden, Finland and on the Kola Peninsula, and the Inuit on Greenland/Kalaallit Nunaat. To a large extent, ethnic and local culture plays an important role when it comes to the local customs, traditions and customary uses of biological resources.

In the Nordic countries, there national languages are Danish, Faroese, Icelandic, Norwegian, and Swedish (Germanic languages) and Finnish (Finno-Ugrian languages). Additional Finno-Ugrian languages are the Saami languages Inari, Lule, North, Pite, Skolt and South Saami, as well as Karelian and Olonetsian. Dalecarlian or Elfdalian, Gutnish, Low Saxon and South Jutish are minor Germanic languages. Romani (Indo-European language) and Yiddish are other minority languages. On Greenland the Inuit languages are East, West and North Greenlandic (Tunumiit oraasiat, Kalaallisut and Inuktun, respectively) (UNESCO Atlas of the World's Languages in Danger http://www.unesco.org/languages-atlas/; Tunón *et al.*, 2015).

Apart from these languages, various dialects are spoken, as well as "professional" jargon within trades, which is developed from experience-based and trade-related knowledge shared by the peers. Such jargon is essential for carrying both culture and knowledge among the practitioners, as well as playing an important social role. Consequently, farmers, fishers, hunters, etc. each share common terminology and vocabulary with their peers that needs to be transferred from generation to generation as an important part and carrier of the knowledge system. A classic example is the richness of Saami nomenclature for snow and ice. In general, the more dependent local people are of a certain biological resource or climatological and ecological factor, the more diverse the nomenclature is that describes it. Consequently, fishers have a diverse vocabulary reflecting water conditions and over-/underwater topography, a particular fish species has different names in different age categories and seal hunters in the Gulf of Bothnia used a refined language to describe the ice conditions and the seals as such, etc. The local people also carry the cultural history of an area in the local place names that mirror past uses at specific sites or the historical biodiversity of the locality.

2.6 Multiple values of biodiversity and NCP

2.6.1 Strategies for valuation

Depending on who is evaluating NCP, the result may differ quite considerably (Pascual *et al*., 2017). The valuation can vary due to changes in social or ecological conditions or perceptions, access to new information or because of worldviews or ideologies.

Policy decisions are needed to balance various options to sustain society's long-term need for functioning ecosystem services. Evaluation of the status and trends of ecosystem services helps to consider impacts of multiple decisions and the trade-offs between the different uses of the environment and NCP (Hattam *et al*., 2015). Economic valuation of NCP can help determine whether a project, a plan or a policy leads to socio-economic profitability or loss. Also, such analysis enables prioritizing between different measures, investigating conflicts of interest and facilitates balancing between various aspirations and goals. Valuation might be informative as a basis for land use or maritime spatial planning decisions, such as where and how to locate housing or coastal infrastructure and how these might affect NCP. Further, economic valuation provides a common currency to communicate the value of a threatened ecosystem service ("The cost of inaction") or the value of restoration projects that could improve the ability of ecosystems to generate benefits for the community. The valuation of NCP can also form the basis for decisions about a company's strategic focus, for example by preparing the business to consider future risks in the supply chain that could be associated with environmental impacts on the generation of natural resources for the NCP. Likewise, such information could support business operations to contribute positively to the generation of NCP for communities. Valuation of NCP can develop a basis for environmental accounts at municipal or national level. The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focused on "making nature's values visible". Its principal objective is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels. This goal aims at supporting decision-makers to recognise the wide range of benefits provided by ecosystems and biodiversity, display their values in economic terms and, where adaptable, obtain those values in decision-making.

At the same time, it needs to be recognized that all NCP cannot be valued in monetary terms. Spiritual values, such as the sacredness of a mountain, are priceless to the holders of those values, and it is important to develop language and practices in strategies and policymaking that fully incorporate these values.

2.6.2 International target-setting

Global sustainability policies aim to ensure human well-being and the sustainable use of our planet's resources, whether via sustainable development of society or via biodiversity conservation (Geijzendorffer *et al*., 2017). A new set of post-2015 development goals, the United Nations Sustainable Development Goals (SDGs), focus on poverty eradication and sustainable development. Unsustainable resource use is causing biodiversity loss and natural resource degradation, with the poor being disproportionately affected.

Such concerns are also one of the foundations of the Strategic Plan for Biodiversity of the Convention on Biological Diversity (CBD) (Lucas *et al*., 2015). The Strategic plan expresses a 2050 vision on biodiversity, accompanied by five Strategic Goals and 20 targets of the Conventional of Biological Diversity (CBD), the so-called Aichi Biodiversity Targets (https://www.cbd.int/sp/targets/ and e.g. Lucas *et al*. 2015 and the references therein). Integrating these agendas in to Nordic policy is vital because biodiversity and ecosystem services are essential for human well-being and poverty eradication.

Some of the Aichi targets, such as 1, 2, 6, 14, 15, 16, 18 and 19 (see Lucas *et al.* 2015), reflect essential aspects of the Nordic coastal environment. In the Nordic countries, many aspects of monitoring, conservation and recovery of biodiversity are linked to general agreements, such as the EU directives and regional organisations such as HELCOM and the Nordic Council. Stakeholder participation is needed, also because their needs and their knowledge are essential to this process.

2.7 Knowledge gaps

- Monitor all types of NCP or ecosystem services, i.e. provisioning, regulating, cultural and maintenance, as well as supporting services. Critical review of existing indicators is needed, specifically in tmeros of tracking the development of biodiversity and NCP (Aichi Target 19);
- Only by actively analysing data and creating syntheses, is it possible to understand changes in the ecosystem that may harm biodiversity and NCP if left unattended.

2.8 Policy Recommendations

- Develop transparent and documented political strategies regarding biodiversity and nature's contributions to people (NCP) to achieve food, energy, health and livelihood security in Nordic coastal areas (relates to Aichi Targets 6 and 14);
- Develop and improve existent indicators on biodiversity and NCP in the coastal zone for provisioning, regulating and maintenance, as well as cultural and supporting services;
- Indigenous and local knowledge may give information to managers and scientists. Thus, researchers and managers should develop a dialogue and mutual exchange of data and information (relates to Aichi Targets 18 and 17);
- The current valuation of NCP and ecosystem services represents values in a broad sense. Non-monetary valuation methods need to be included in management strategies and policy implementation;

- Stakeholders should be involved in documenting and identifying key socio-ecological areas, biodiversity hotspots and sacred sites (while applying Free and Prior Informed Consent (FPIC).

2.9 Acronyms

- CBD – UN Convention on Biological Diversity
- EFSA – European Food Safety Authority
- GDP – Gross Domestic Product
- NCP – Nature's Contributions to People
- SDGs – Sustainable Development Goals.

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3. Status and Trends of Biodiversity and Ecosystem Function

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Box 3: Summary

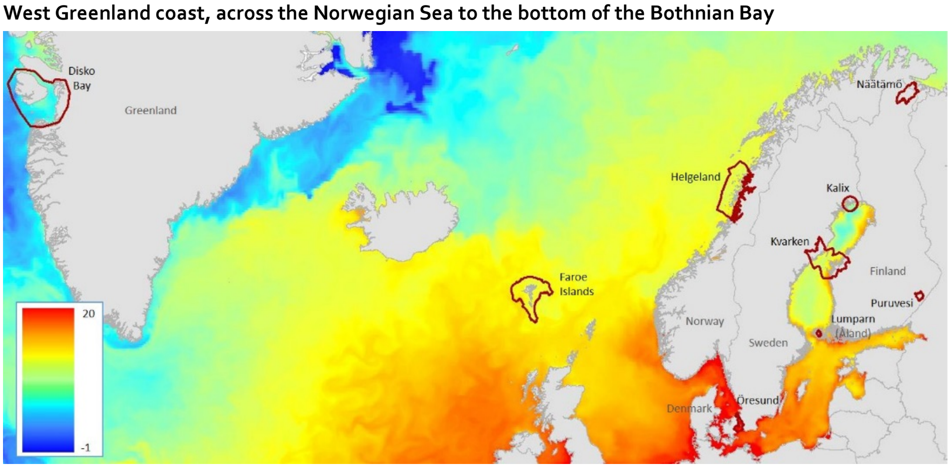
This chapter provides an overview of the status and trends in biodiversity and ecosystem function through assessment of key species and habitats, and summarizes the ecological status of selected Nordic regions. Important habitats across the Nordic coastal region include sea grass beds, kelp forests, blue mussel beds and soft sediments. Declines in sea grass have occurred since the 1970's, most likely due to eutrophication and overfishing. Norwegian kelp forests are recovering following severe losses in the 1960–1970's, most likely due to increased water temperature and changes in grazing pressure. Seabird populations have declined significantly during the last decades, reaching historical lows. Knowledge gaps are identified and a common biodiversity indicator system across the Nordic region is suggested. An indigenous local knowledge perspective is also presented.

3.1 Introduction

Changes in biodiversity and ecosystem services, or Nature's contributions to People (NCP), may result in a loss of benefits and values for present and future generations. The coastal ecosystems are among the most productive and dynamic ecosystems in the Nordic region, hosting some of the most rich and diverse habitats (McLean *et al.*, 2001). Nordic coastal ecosystems encompass a variety of habitat types essential to marine life and human wellbeing. These ecosystems are highly threatened because of the increase in human population and anthropogenic pressures (UNEP, 2006). Approximately 90 million people live in the catchment area of the Nordic marine region (85 million of these around the Baltic Sea). A part of this population however, lives in the non-Nordic neighboring countries. The chapter provides an overview of the status and trends in biodiversity and ecosystem function through assessment of key species and habitats, and summarizes the ecological status of selected Nordic regions as described in detail in (Tunón (Ed.), 2018).

The Nordic coastal region displays large variability in its geology, biology, and ecology. Geologically, it spans from the rocky coasts of North Greenland with large glacial inputs to the marine environments, across deep fjords in Norway and narrow sounds in Denmark, to the inner Bothnian Bay dominated by sandy and muddy sediments and wide-stretching shallow water areas. Water temperature spans from permanently around zero in North Greenland to temperatures above 20 °C during summer months in the Baltic Sea (Fig. 18). The marine physical environment is dominated by Arctic water masses around Greenland, Atlantic waters around Iceland and the Norwegian west coast, and temperate water masses in the south and Arctic conditions in the Northern part of the Baltic Sea, which is considered to be the largest brackish water sea in the world (HELCOM, 2009). Thus salinity (the content of salt in the sea water) ranges from full ocean water conditions (~35 PSU) on the Norwegian west coast to almost fresh water (<3 PSU) in the inner Bothnian Bay of the Baltic Sea. To a large extent, the ecology and biodiversity of the Nordic marine environment reflects these physical conditions (HELCOM, 2010) (Fig. 19).

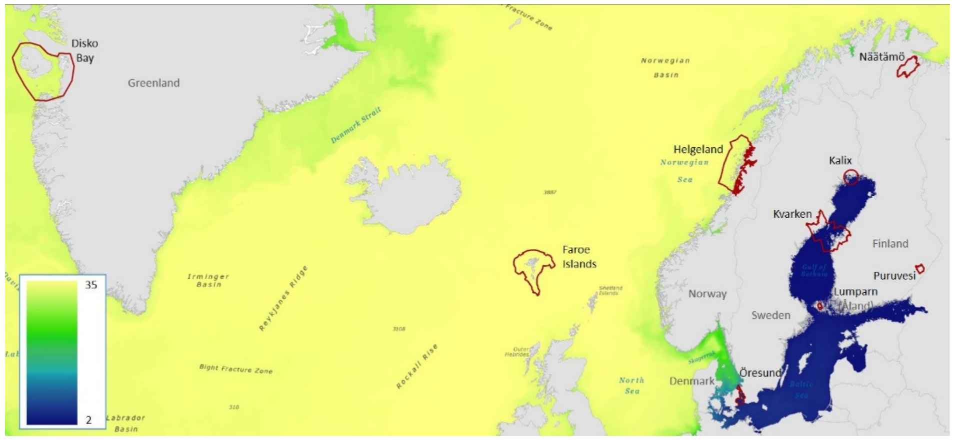
Figure 18: Map showing the gradients of sea surface temperature across the Nordic seas, from the West Greenland coast, across the Norwegian Sea to the bottom of the Bothnian Bay



Note: These physical gradients largely regulate marine biodiversity and ecosystem function in the region. Case study areas are marked with red lines.

Source: Copernicus Marine environment monitoring service (http://marine.copernicus.eu), downloaded for 16 June 2016. Maps by NIVA (Hege Gundersen).

Figure 19: Map showing the gradients of sea salinity across the Nordic seas, from the West Greenland coast, across the Norwegian Sea to the bottom of the Bothnian Bay



Note: These physical gradients largely regulate marine biodiversity and ecosystem function in the region. Case study areas are marked in red.

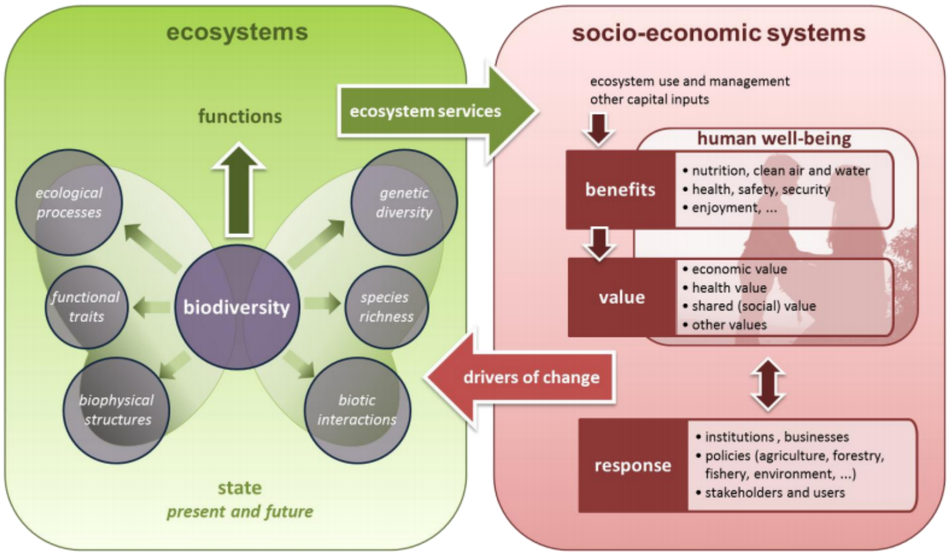
Source: Copernicus Marine environment monitoring service (http://marine.copernicus.eu), downloaded for 16 June 2016. Maps by NIVA (Hege Gundersen).

3.2 Defining biodiversity and its importance to Nordic marine life

Humankind is highly dependent on nature and NCPs. In the IPBES context, the word "nature" covers the full diversity of life: The living organisms including humans, along with their interactions with each other and their environment. Biodiversity, short for biological diversity, involves variation in life at all levels of organization and includes variability in ecosystems and their functions, in species richness and their functional properties, in genetic diversity and in biotic interactions (Fig. 20). The biodiversity of an ecosystem has implications for ecological processes, functional traits of the system and the biophysical structures. The IPBES definition of biodiversity is adopted from the UN Convention on Biological Diversity (Díaz *et al.*, 2015).

Many ecosystems are dependent on a few key species. Such key species enable the existence of many other species by modifying the environment, providing nursery areas, shelter and/or food. Such species are especially important for maintaining biodiversity due to their structural or functional abilities. Examples are tangle kelp (*Laminaria hyperborea*) and sugar kelp (*Saccharina latissima*), which are key species along the Northeast Atlantic coast line, where they form extensive underwater forests. These forests act as nursery grounds for fish and provide food for a variety of species (Christie, Norderhaug, & Fredriksen, 2009).

Figure 20: Conceptual framework for biodiversity and ecosystem functions with links to ecosystem services (see Ch. 2) and drivers of change (see Ch. 4)



Source: The EU ecosystem assessment MAES (Mapping and Assessment of Ecosystems and their Services).

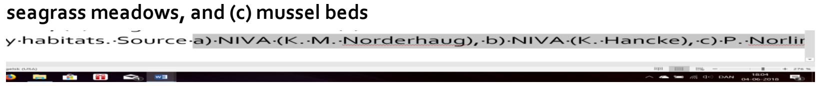
3.3 Defining Ecosystem function and value to human societies in Nordic countries

"Ecosystem function" defines the biological, geochemical and physical processes that occur within an ecosystem, including the rate at which processes occur, e.g. the cycling of nutrients and biomass production. Ecosystem function is dependent on biodiversity, so the loss of biodiversity often results in loss of ecosystem function (Bradley J. Cardinale *et al.*, 2012; Oliver *et al.*, 2015). Key habitats, such as seagrass meadows, promote multiple ecosystem functions (in this case, nursery grounds, food supply and stabilisation of the seabed) and maintain high biodiversity in marine areas. Functional diversity can be used to describe the types of species and the distribution and function they provide. For instance, deposit feeders (organisms feeding on material that have settled on the seafloor) are a functional group with importance for the turnover of nutrients and its transport between the seafloor and water column. (Gray, 1997; Strong *et al.*, 2015).

Ecosystems with "intact" levels of biodiversity hosting a high number of species use resources more efficiently (B. J. Cardinale *et al.*, 2011), whereas depauperate systems are often considered associated with lower functionality (lower resource use, lower biogeochemical fluxes and lower biomass production) (Gamfeldt *et al.*, 2015). Ecosystem function is linked to Nature's contributions to People (NCP) in terms of supporting, regulating, provisioning and cultural services (Fig. 20, Chapter 2). To maintain, or even enhance these ecosystem services, human-induced pressures on ecosystems and the drivers behind them need to be managed in a knowledgeable manner, based on sound sustainable principles. This is further elaborated on in Chapter 4.

Key habitats promote multiple ecosystem functions and maintain high biodiversity in marine areas. For example, kelp forests are key habitats along the Atlantic coast, forming dense underwater forests that provide shelter, nursery grounds and food sources for hundreds of habitat-specific species. This myriad of organisms provides essential ecosystem services such as fish biomass production, areas highly valued for recreation, along with carbon fixation and sequestration (Fig. 21) (Araujo *et al.*, 2016; Gundersen *et al.*, 2016). Other Nordic key habitats include seagrass meadows, seaweed beds, mussel beds and soft sediment habitats. Other important habitats are mudflats, shell sands, bird cliffs and coastal heaths.

Figure 21: Examples of key habitats in the Nordic coastal marine regions are (a) kelp forests, (b) seagrass meadows, and (c) mussel beds



Note: See text for additional details on Nordic key habitats.

Source: a) NIVA (K. M. Norderhaug), b) NIVA (K. Hancke), c) P. Norling.

Box 4: Glossary

- *Biodiversity*:* Biodiversity (contraction of biological diversity): The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems;
- *Biosphere*:* All the ecosystems of the world considered together. It includes the organisms living on Earth, the resources they use and the space they occupy on part of the Earth's crust (the lithosphere), in the oceans (the hydrosphere) and in the atmosphere;
- *Ecosystem*:* A dynamic complex of plants, animals and microorganism communities and their non-living environment interacting as a functional unit. Ecosystems can be defined at a variety of scales, from a single pond, a fjord, an ocean or the entire globe. Humans and their activities are part of ecosystems as well;
- *Ecosystem function*:* The flow of energy and materials through the arrangement of biotic and abiotic components of an ecosystem. It includes many processes, such as biomass production, trophic transfer through plants and animals, nutrient cycling, water dynamics and heat transfer;
- *Habitat-forming species*: Species that form structures that act as habitats for other organisms. For example, bladder wrack is a seaweed that forms dense communities in the littoral zone and offers habitat for multiple other organisms;
- *Functional diversity*: Diversity of common characteristics or functions in the ecosystem, e.g. feeding and reproductive behavior, mobility, size, productivity and capacity to conduct certain biogeochemical processes. Functional diversity can also include differences between populations' or species' response to various stress factors.

* modified from (Díaz *et al.*, 2015).

3.4 Biodiversity of the North East Atlantic coast

This section describes key species, key habitats, trends in biodiversity and the ecological status of the coastal region of the North East Atlantic coast, based on the case studies from Helgeland at the Norwegian west coast and the Faroe Islands (see Tunón (Ed.), 2018).

3.4.1 Key species

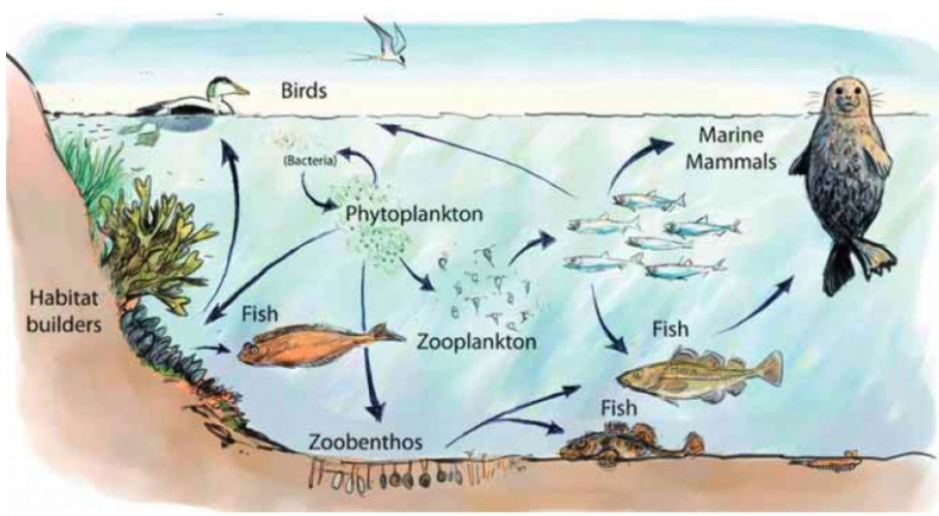
Along the rocky shores of the North East Atlantic coast, including Helgeland (NO) and the Faroe Islands, seaweeds dominate on rocks and stones in the photic zone. Seaweeds provide substrate, shelter and food for a rich associated flora and fauna, which in turn provide food for a large variety of animals including many fish species. In the tidal zone, small brown, green and red algal species dominate the flora. In the subtidal region, large kelp species such as sugar kelp (*Saccharina latissima*) and tangle kelp (*Laminaria hyperborean*) grow dense underwater forests with canopy-like structures (Christie *et al.*, 2009). In bays and inlets, eelgrass (*Zostera marina*) often dominate on sandy/muddy sediments and form extensive meadows (Bekkby *et al.*, 2008; Bostrom *et al.*, 2014). In the open water masses along the coast and in the off-shore pelagic zone, microalgal species are the dominant primary producers (e.g. *Skeletonema, Thalassiosira, Chaetoceros* spp.). These microorganisms form the base of the pelagic food web. Key zooplankton species feeding on pelagic algae are generally the same across the North East Atlantic, with copepods (e.g. *Calanus hyperboreus*, *C. glacialis*, and *C. finmarchicus*) and krill (*Euphausiacea crustaceans*) forming trophic links from phytoplankton to fish (Fig. 22) (Skjoldal, 2004). Droppings from the zooplankton provide food for a species-rich seafloor community of bivalves, echinoderms, sea anemones, crabs and fish. This way, life on the seafloor is strongly linked to and dependent on the foodweb and the production of organic matter in the open water (pelagic) community above, with implications for ecosystem function and resilience of the benthic system and key species (Renaud, Morata, Carroll, Denisenko, & Reigstad, 2008).

The commercially most important fish species in the North East Atlantic coastal waters are the demersal species cod (*Gadus morhua*), saithe (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*) and ling (*Molva molva*). In the open waters, Atlantic mackerel (*Scomber scombrus*), Atlantic herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) are caught commercially. Along the coast in shallow habitats, flat fish species of commercial value are Greenland halibut (*Reinhardtius hippoglossoides*), monkfish (*Lophius piscatorius*) and Atlantic halibut (*Hippoglossus hippoglossus*).

Sea birds play an important role as top predators in coastal marine environments and the diversity is high in this region. Key species of the coastal region includes common eider (*Somateria mollissima*), geese (*Anser* and *Branta*), guillemots (*Uria* and *Cepphus*), puffin (*Fratercula arctica*), cormorants (*Phalacrocorax*) and gulls (*Laridae*), including black-legged kittiwake (*Rissa tridactyla*). In the open ocean and Faroe Islands, key species include Northern fulmar (*Fulmarus glacialis*), storm petrel (*Hydrobates pelagicus*) and common guillemot (*Uria aalge*).

Solely aquatic marine mammals (cetaceans) in the North East Atlantic include seal and whale, whereas whale are most dominant in the North East Atlantic (Skjoldal, 2004). Most seals are fish eaters, but they also feed on crustacean, octopus and mollusk. The most commonly observed seal species of the North East Atlantic coastal region are observed close to the coast in areas with seaweeds and kelp forests, and include the harbour seal (*Phoca vitulina*), grey seal (*Halichoerus grypus*) and ringed seal (*Pusa hispida*) (Bjørge, Øien, & Fragerheim, 2007). These three species are present in the Baltic region as well (see below). More than ten species of whales are known to feed in the North East Atlantic coastal region. The most commonly observed species are members of the small tooth whales, e.g. harbour porpoise (*Phocoena phocoena*), bottlenosed dolphin (*Tursiops truncates*) and white-beaked dolphin (*Lagenorhynchus albirostris*) (Bjorge, Skern-Mauritzen, & Rossrnan, 2013). Larger tooth whales in the region include the killer whale (*Orcinus orca*), which are commonly observed along the coast. Occasionally sperm whale (*Physeter macrocephalus*) are seen off shore. Tooth whales feed mainly on fish, but are also known to feed on seal, octupus and shark. In the outer coastal region, visiting baleen whales migrate northward toward the productive Barents Sea during summer months, where they feed on the large abundance of zooplankton and smaller fish species. These species include the humpback whale (*Megaptera novaeangliae*), minke whale (*Balaenoptera acutorostrata*) and fin whale (*Balaenopters physalus*).

Figure 22: Schematics explain key ecosystem components of the food web for the Baltic Sea and NE Atlantic coastal zones



Note: See text and the case studies from the Baltic Sea, Helgeland (Norway) and Faroe Islands for details on key species and habitats.

Source: Figure is adopted from HELCOM (2010).

3.4.2 Trends in biodiversity and ecosystem function

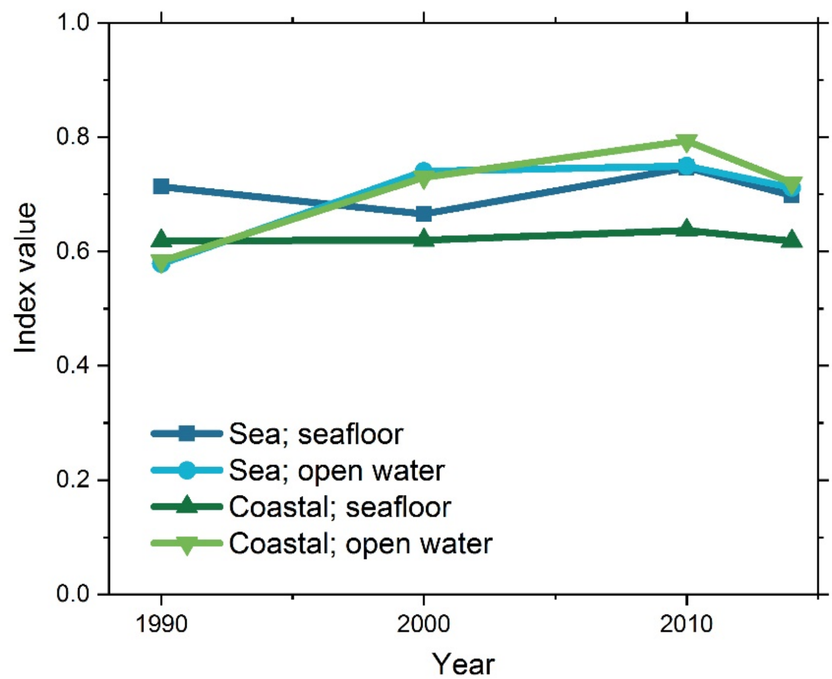
Trends in biodiversity and ecosystem function are assessed here based on a complied assessment of the Helgeland region, as a representative example of a Norwegian region with high coastal biodiversity, an intact ecosystem and a low human population density (see Hancke *et al.*, 2018). It is beyond the scope to provide a complete overview of trends in biodiversity and ecosystem function of the entire North-East Atlantic region here.

The Nature Index of Norway (Nybø, 2010) shows the state and development of biodiversity in Norway and provides an overview of the status of the environment for selected species groups and ecosystems. Indicators within the Nature Index of Norway represent populations of characteristic indigenous species, and the indicator values are based on data from monitoring, model estimates and expert assessments. The indicators in the Nature Index of Norway are particularly sensitive to the influence of climate on harvesting of marine ecosystems (Framstad, 2015). According to this index, there have been no major changes nor but a slight improvements in the biodiversity of the coastal zone of Mid-Norway during the last 25 years (Fig. 23). The slightly improved condition towards 2010 is due to improved phytoplankton biomass and numbers of harbor seal (*Phoca vitulina*), while the weak decline since 2010 is due to a small decline in the stocks of Atlantic herring, sand eel (*Ammodytes* ssp.) and some seabirds species along the coast (Gundersen *et al.*, 2015).

A recent assessment of the status of kelp forests in European waters concluded that a general decrease in abundance of native kelp is apparent in some areas (partly in areas considered as southern distribution limits), while other areas have experienced increases (Araujo *et al.*, 2016). The expanding kelp forests in Helgeland give hope for the future.

The stocks of herring, cod and crab are reported to have declined during the last decade. Estimated numbers of coastal cod show that populations are close to a critical limit; and their decline significantly linked to poor recruitment (Bakketeig, Gjøsæter, Hauge, Sunnset, & Toft, 2015).

Figure 23: Overall trend in biodiversity in the coastal region of Mid-Norway



Note: Data are from the Nature Index of Norway and show an overall slight improvement in the biodiversity of the coastal region in Mid-Norway during the last 25 years. The index includes the offshore seafloor (dark blue) and open waters (light blue), along with the coastal specific seafloor (dark green) and waters (light green). The index is compiled to represent the biodiversity of the represented habitats by compiling indicator values of relevant indigenous species on a scale between 0 and 1, where 1 describes an unaffected status with close to intact biodiversity. Both common and rare species are included in the indicators. Indicator values are based on data from monitoring, model estimates and expert assessments.

Source: www.naturindeks.no, (Gundersen *et al.*, 2015).

Kelp forests (Fig. 24) are currently recovering northwards from the south of Helgeland following large declines in Norwegian kelp forest cover in the 1960–1970s. Despite recoveries over the last decade, an area as large as 8,000 km^2 with suitable kelp habitat is still devoid of kelp and has potential for reforesting (Gundersen *et al.*, 2011). Reforestation of currently barren rocky seafloor will increase the amount of kelp biomass and enhance the biodiversity and primary production associated with kelp forests (Christie *et al.*, 2009). Drivers of the initial disappearance and the current reforestation are not completely understood, but changes in (i) water quality, (ii) grazing and predation pressure (urchins and cod) and (iii) competitive interactions (turf algae/epibionts vs. kelp) related to climate change are suggested (Araujo *et al.*, 2016).

Seagrass meadows (i.e. eelgrass *Zostera marina*) are distributed widely along the Norwegian coast and have many of the same functions as kelp forests (Bostrom *et al.*, 2014). How seagrass meadows contribute as a key habitat is described in more detail below (3.3 – the Baltic region section). The distribution and abundance of seagrass meadows has decreased in many areas throughout the North East Atlantic region.

Proposed mechanisms are reduced water transparency and increased eutrophication (see Hancke *et al.*, 2018).

Fish stocks of herring and cod are reported to have declined during the last decade. The stock of Norwegian spring-spawning herring is currently estimated to be below a critical level of 5 million tonnes, however opinions regarding the estimated stock size differ between fishers and researchers. The International Council for Marine Research (ICES) is currently renewing the stock estimation for herring (Bakketeig *et al.*, 2015). On the contrary, the stock of blue whiting has almost doubled in the North East Atlantic since 2010 and the stock is now in good condition (Bakketeig *et al.*, 2015). For populations of coastal cod the estimated numbers are considered close to a critical limit and their declines seem significantly linked to poor recruitment.

Bird cliffs and island shores provide areas for sea bird breeding, facilitating the rich biodiversity of sea birds in the Faroe Islands and along the Norwegian coast. Most of the seabird populations have declined during the last decades, except for Arctic skua (*Stercorarius parasiticus*). The populations of the northern gannet (*Morus bassanus*) and great skua (*Stercorarius skua*) are growing. See Hancke *et al.*, (2018) for details on the Helgeland case.

Marine mammals, such as populations of North Atlantic fin whale is presumed still recovering from earlier exploitation and is classified as least concern (LC) on the Norwegian red list (Kålås, Viken, Henriksen, & Skjelseth, 2010; Víkingsson *et al.*, 2009). Population sizes of killer whales are believed to have stayed relatively constant over the last three generations (Norwegian Biodiversity Information Centre, http://www.biodiversity.no/). Populations of harbor porpoise (*Phocoena phocoena*) are abundant and stable in the Helgeland area, but substantial amounts of bycatch are causing some concern (Bjorge *et al.*, 2013). Harbor seals are classified as least concern (LC, Kålås *et al.*, 2010) and are regulated through the harvesting quota. The population of otters (*Enhydra lutris*) along the coast of mid and north Norway has been decreasing over the last 25 years. They are now classified as vulnerable (VU) on the Norwegian red list (Norwegian Biodiversity Information Centre at http://www.biodiversity.no/).

Box 5: Marine carbon depositing in seagrass meadows and kelp forests

Kelp (Laminariales) species are large seaweeds that form underwater forests with canopy-like structures reaching several meters up from the seafloor. They occupy hard-bottom subtracts (rocks) and are among the most productive ecosystems on Earth, host an extremely high biodiversity (>100,000 individuals and >200 species per square meter) and provide important ecosystem services. Seagrasses meadows are marine plants that form underwater "grass fields" typically growing half a meter tall from the bottom, and thrives on soft sediments in shallow bays and estuaries. Seagrass are important food sources for animal grazers and host a high biodiversity, including large variety of fish and shellfish species. Seagrass meadows providing food, shelter and nursery grounds and thus eccential coastal ecosystem services.

Seagrass meadows and kelp forests have shown to be important in the process of sequestration, or permanent depositing, of organic carbon in the coastal zone. Seagrass meadows form thick layers of deposited and composed leaves and canopy-forming kelps constantly loose and export organic biomass to adjacent systems, a process through which both ecosystems contribute to depositing organic carbon, thus forming an "ocean sink" for atmospheric CO_2. With less than 4% total coverage of the sea surface area, they are estimated to contribute to almost 50% of all carbon deposition in the ocean (Duarte, Middelburg, & Caraco, 2005; Krause-Jensen & Duarte, 2016).

Figure 24: Kelp forest on the Norwegian west coast, which support unique ecosystems with pronounced biodiversity and ecosystem function

Source: NIVA (J. Gitmark).

3.4.3 Red listed and non-indigenous species

In Norway there are 56 red-listed marine species, which are threatened at various levels, from critical to vulnerable. Of these, nine species are considered critically endangered, including spiny dogfish (*Squalus acanthias*), European eel (*Anguilla anguilla*), common guillemot (*Uria aalge*) and bowhead whale (*Balaena mysticetus*). Another 23 species are categorized as strongly threatened, including black legged kittiwake (*Rissa tridactyla*), blue ling (*Molva dypterygia*), hooded seal (*Cystophora cristata*) and narwhal (*Monodon monoceros*) (Kålås *et al.*, 2010).

Non-indigenous species, also referred to as Alien species or Black-listed species in Norwegian management plans, are species that have spread beyond their natural limits through human activity and occupy habitats where they may displace native species. These species can potentially affect ecosystem structure and function, thus threatening pre-existing and native species. Non-indigenous species are categorized into different risk categories according to their assumed impact on habitats and native species.

Approximately 50 of these non-indigenous species (out of a total of 217 in Norway considered to impose "very high ecological risk" or "high ecological risk") are found in coastal and marine habitats of Norway. These species include Pacific oyster (*Crassostrea gigas*), Japanese wireweed (*Sargassum muticum*) and red king crab (*Paralithodes camtschaticus*) (Gederaas, Moen, Skjelseth, & Larsen, 2012).

3.4.4 Ecosystem health

According to the Water Framework Directive, the ecological status of Helgeland is generally good, as 88% of the more than 200 water bodies making up the marine region, and 99% of the total area, is classified as "Good" or "Very good" (Directorate-group, 2013). The water bodies include kelp forest and seagrass beds, as well as the pelagic environment. As mentioned above, the overall biodiversity rating is good for the coastal zone of mid Norway according the Nature Index of Norway (Gundersen *et al.*, 2015). Expansion of kelp forest and associated species has led to an increase in the index, however a decline in coastal populations of (e.g. coastal cod), mammals (e.g. grey seal, *Halichoerus grypus*) and birds (e.g. common eider), has led to an index decrease (Gundersen *et al.*, 2015).

Currently, no ecological or biodiversity status index exists for the Faroe Islands, however the overall status is evaluated as good, according to local authorities (Jan Sørensen, Natural History Museum, Faroe Islands, Pers. Comm. October 2017).

3.5 Biodiversity of the Baltic Sea region

This section assesses status and trends in biodiversity in the Baltic Sea, based on the cases studies from the Kalix, Kvarken, Lumparn and Øresund (see Tunón (Ed.), 2018).

The Baltic Sea is semi-enclosed and connected to the North-east Atlantic Ocean through three narrow straits with a maximum depth of 18 meters, which restricts water exchange with the wider ocean. The mean depth of the Baltic Sea is 55 meters and the deepest parts are approximately 400 meters. A strong salinity gradient effects both biodiversity and ecosystem function. The number of species decreases with increased distance from the North Sea. In the Baltic Sea, several essential ecosystem functions are supported by only a few species, which are of either freshwater or marine origin and live at the border of their physiological salinity tolerance (Figure 25) (HELCOM, 2010). For example, there is a decrease in diversity of benthic sediment communities with decreasing salinity, from 25 functional groups of benthic species in Skagerrak (K. Norling, Rosenberg, Hulth, Grémare, & Bonsdorff, 2007), to only 5 groups in the Baltic Sea sediments (Bonsdorff & Pearson, 1999).

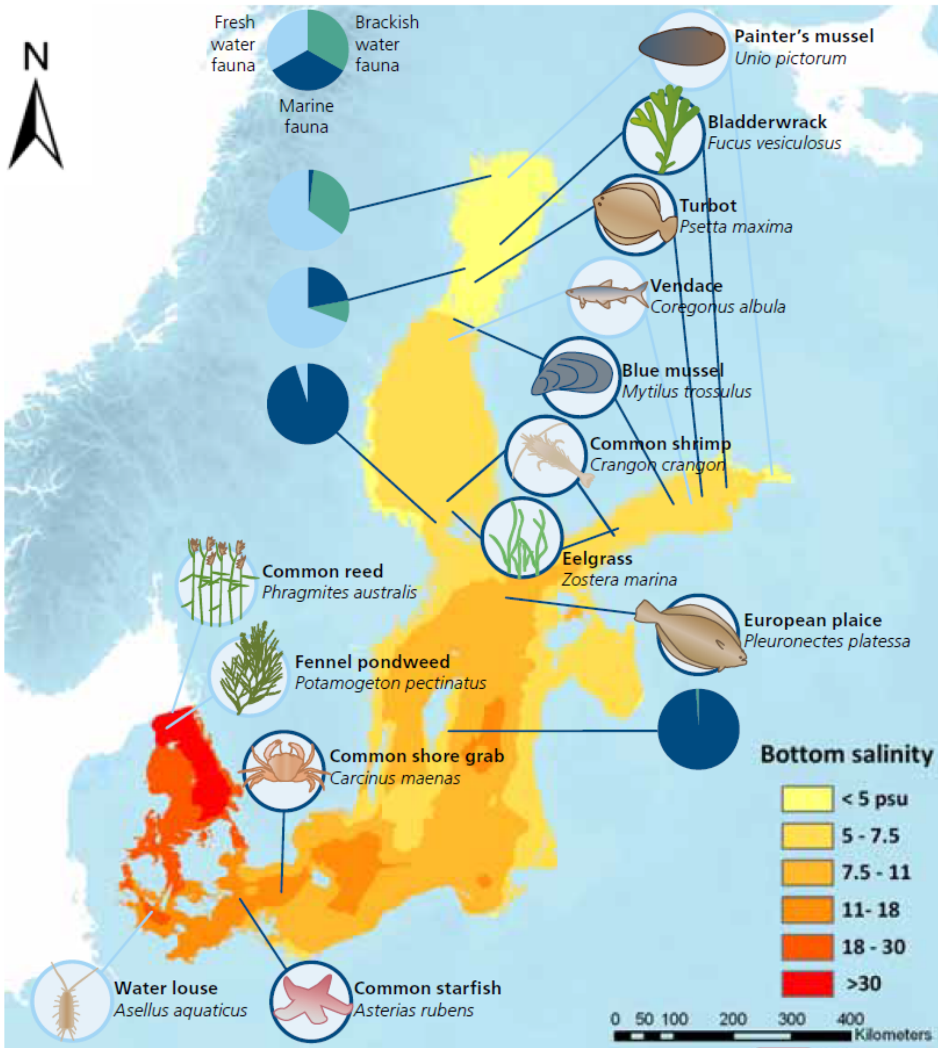
The Bothnian Bay differs from other parts of the Baltic Sea in many ways. It is characterised by low salinity, low water temperatures, a long period of ice cover, low primary productivity, low levels of nutrients (particularly phosphorus), and large amounts of riverine runoff adding organic matter and industrial-sourced nutrients (Kronholm *et al*., 2005). The Bay lacks many of the key species of the Baltic, such as bladder wrack, seagrass, blue mussels, cod and sprat. It is characterised by a combination of freshwater and salt-water species and has low biodiversity (Fig. 25).

3.5.1 Key species

Key species of the Baltic region include bladder wrack (*Fucus vesiculosus*), eelgrass (*Zostera marina*), blue mussel (*Mytilus trossulus*), Baltic macoma (*Limecola balthica*), European plaice (*Pleuronectes platessa*), turbot (*Psetta maxima*), vendace (*Coregonus albula*) and common shrimp (*Crangon crangon*) (see Figure 25). Common starfish (*Asterias rubens*) and common shore crab (*Carcinus maenas*) are only present in Kattegat and The Sound (Øresund). Other key species in the Baltic region are iconic species including salmon (*Salmo salar*), cod (*Gadus morhua*), great cormorant (*Phalacrocorax carbo sinensis*), white-tailed eagle (*Haliaeetus albicilla*), grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*) and ringed seal (*Phoca hispida*).

The Baltic Sea is one of the world's most important areas for overwintering sea ducks, not least for the globally threatened species velvet scoter (*Melanitta fusca*) and long-tailed duck (*Clangula hyemalis*). During the winter, approximately 90% of the sea ducks living in the Baltic Sea region gather in areas that constitute less than 5% of the Baltic Sea.

Figure 25: Distribution limits of key species in marine (dark blue), brackish (green) and freshwater (light blue) habitats, linked to bottom water salinity (color grade)



Source: HELCOM (2010).

3.5.2 Key habitats

Key species such as bladder wrack, seagrass and blue mussels are important habitat-forming species in the Baltic Sea.

Bladder wrack (*Fucus vesiculosus*) is the most widely distributed brown algae and a key species in the Baltic Sea, where it forms habitats and provides shelter for several crustaceans, isopods, snails, mysids and fish. Bladder wrack forms one of the most diverse Baltic Sea habitats down to 10–11 m depth. The lowest depth limit of bladder wrack (and other macroalgae) is widely used as one of the ecological quality indicators in the Water Framework Directive assessments in the Baltic Sea (Zettler *et al.*, 2017).

Blue mussel beds are key habitats in the Baltic Proper and have been shown to sustain high biodiversity in subtidal habitats (Pia Norling & Kautsky, 2008). The mussels modify the environment and support a rich diversity of associated species (P. Norling & Kautsky, 2007; Ojaveer *et al.*, 2010). Mussel beds uphold an important filter-feeding function: they regulate the availability and flow of resources such as nutrients and organic matter, thereby forming an important link between benthic and pelagic ecosystems. By doing this they counteract eutrophication and improve water quality.

Seagrass meadows are mainly found in relatively exposed and sandy areas in the Baltic Sea. They support a high diversity of associated species such as amphipods and snails and are an important nursery grounds for fish. The salinity gradient across the Baltic region creates functional differences in biodiversity and food webs in seagrass meadows, showing a decline in the number of species but an increase in the biomass of mesograzers. Meadows in the high end of the salinity gradient tend to be more productive (Bostrom *et al.*, 2014).

Soft sediment habitats are the most wide-spread habitat in the Baltic Sea. Key species of the macrozoobenthic community in the Baltic proper include *Macoma balthica, Halicryptus spinulosus, Marenzelleria arctia* and *Saduria entomon*, whereas in the Bothnian Sea, cold-water dominating species include *Monoporeia affinis*, *Pontoporeia femorata* and *Saduria entomon*.

3.6 Trends in biodiversity and changes in ecosystem function

Approximately 85 million people live in the catchment area of the Baltic Sea. Multiple pressures from agricultural landuse and maritime traffic (HELCOM, 2009) has resulted in large environmental changes during the last 100 years. Pressures include eutrophication, overfishing, pollution and changed hydrodynamic conditions. These are thought to have resulted in changes to the distribution of fish, vegetation and benthic fauna (Ojaveer *et al.*, 2010). Regime shifts from an oligotrophic to eutrophic state, with resultant changes in dominant species have also been observed (Österblom *et al.*, 2007), particularly during the last 30 to 40 years. The increased frequency and expansion of hypoxic and anoxic deep water has affected the structural and functional diversity of benthic communities. Phytoplankton productivity has increased and there has been a shift from dominance of diatoms to dominance of dinoflagellates in the phytoplankton spring bloom (HELCOM, 2009). Changes have also occurred in the zooplankton community where copepod biomass and the mean size of zooplankton have decreased, with consequences for the weight-at-age in herring stocks, Figure 26 (HELCOM, 2009). In the Bothnian Bay, eutrophication levels and phytoplankton productivity are lower than in the Baltic Sea in general.

Common eider (*Somateria mollissima*), long tailed duck (*Clangula hyemalis*), common scoter (*Melanitta nigra*) and velvet scoter (*Melanitta fusca*) are sea ducks that have similar ecological function and feed mainly on blue mussels during winter. These bird populations have severely decreased in the Baltic during the last 20 years. The number of over-wintering sea ducks decreased from approximately 7 million individuals in the beginning of the 1990s, to about 3 million birds in 2007–2009; a 30% decline in numbers (Skov *et al*. 2011).

The abundance of many fish-eating sea birds such as sandwich tern (*Thalasseus sandvicensis*), common guillemot (*Uria aalge*) and great cormorant (*Phalacrocorax carbo*) have increased during recent years. Reasons for this include protection schemes, declined concentrations of hazardous substances in prey and sea water, along with improved prey abundance due to over-fishing of large predatory fish(Herrmann *et al.*, 2015).

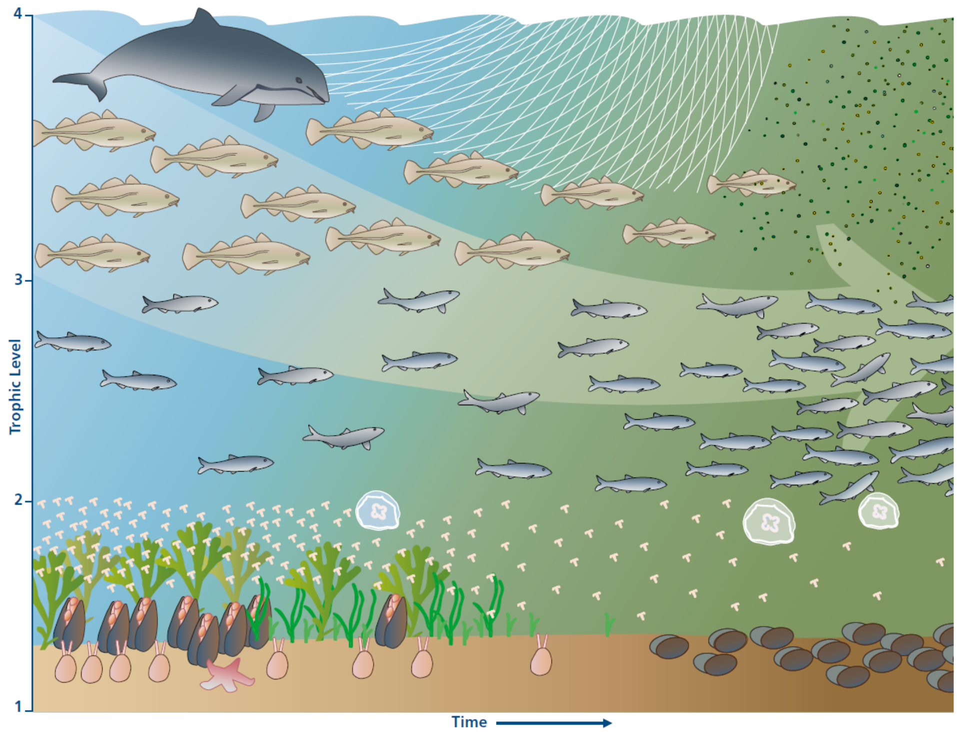
Oxygen deficiency has greatly reduced the benthic biodiversity in the Baltic Proper and decreased the abundance of benthic fauna in other regions of the Baltic as well (Karlson, Rosenberg, & Bonsdorff, 2002). As a consequence, an increase in hypoxia-tolerant species has been observed, most notably a dramatic increase in the abundance of the invasive species *Marenzelleria* spp. (Norkko *et al.*, 2012). Introduction of the invasive species *Marenzelleria* spp. has increased the functional diversity in soft sediments by increasing re-oxygenation of the surface sediments and hereby stimulating an increase in nutrient release from the seafloor to the water column.

During a regime shift in the late 1980s, the fish community underwent a change in the central Baltic Sea with a shift from dominance of demersal fish to dominance of pelagic clupeid fish, where the abundance of cod decreased and abundance of sprat increased remarkably. Reasons behind the change are thought to be climate variation and overfishing (Alheit *et al.*, 2005). Fish communities are also affected by other human pressures, for example, the abundance of perch and cyprinids have been associated with increased eutrophication in many coastal areas (Adjers *et al.*, 2006).

Seagrass meadows have suffered large declines in biomass and distribution in the Baltic regions, and in the Nordic region in general. Up to 60–100% of the vegetation has been lost over the last century in some areas, e.g. along the northern part of the Swedish west coast (Baden, Gullstrom, Lunden, Pihl, & Rosenberg, 2003; Waycott *et al.*, 2009). The biodiversity of seagrass communities are essential for ensuring high levels of ecosystem function (Duffy, Moksnes, & Hughes, 2013). Declines in seagrass abundance and distribution have negative effects on the biomass of fish and the sequestration of nutrients. Multiple stressors including eutrophication, sediment runoff, dredging and coastal development have been suggested as drivers of this negative development.

Since the 1980s, bladder wrack has decreased or even disappeared in several areas in the Baltic Sea (Torn, Krause-Jensen, & Martin, 2006). Although bladder wrack is now recovering in some areas (Kautsky, Martin, & Snoeijs-Leijonmalm, 2017; Laamanen, Korpinen, Zweifel, & Andersen, 2017), it is still declining at other locations (Vahteri & Vuorinen, 2016). During the last years, the depth distribution has increased, for instance at the Swedish coast of the northern Baltic proper and the Sea of Åland. Eutrophication is suggested to be the main driver for the historical decrease in bladder wrack (Torn *et al.*, 2006).

Figure 26: Ecological effects of eutrophication and over-fishing in the Baltic Sea, illustrated as changes in the food web structure



Note: The figure shows changes in trophic levels over time, from complex food webs to food webs with low biodiversity and simple functionally.

Source: Adopted from HELCOM (2010).

3.6.1 Non-indigenous species

About 130 non-indigenous species have entered the Baltic since the 18th century, mainly as an effect of human activities. Invasive species in the Baltic Sea include round goby (*Neogobius melanostomus*), red gilled mud worm (*Marenzelleria* spp.) and American comb jelly (*Mnemiopsis leidyi*). For a young sea like the Baltic Sea, the establishment of non-indigenous species is, to some extent, also a natural on-going process of succession and so far no non-indigenous species have resulted in the extinction of native species. Some non-indigenous species, such as *Marenzelleria* spp., may have increased functional diversity (Norkko *et al.*, 2012). However, the low number of species makes the Baltic Sea especially vulnerable, as the loss of one species may have a large effect on other parts of the ecosystem, as there may not be species to replace the niche of the lost species.

3.6.2 Ecosystem health

Ecosystem health of the Baltic Sea has been assessed by HELCOM based on biodiversity, eutrophication and hazardous substances (HELCOM, 2010). For most areas it is considered in a "non-acceptable" state, Figure 27 (HELCOM, 2010). When looking at biodiversity indices only, some areas in the northern parts of the Baltic Sea reach acceptable status (HELCOM, 2010).

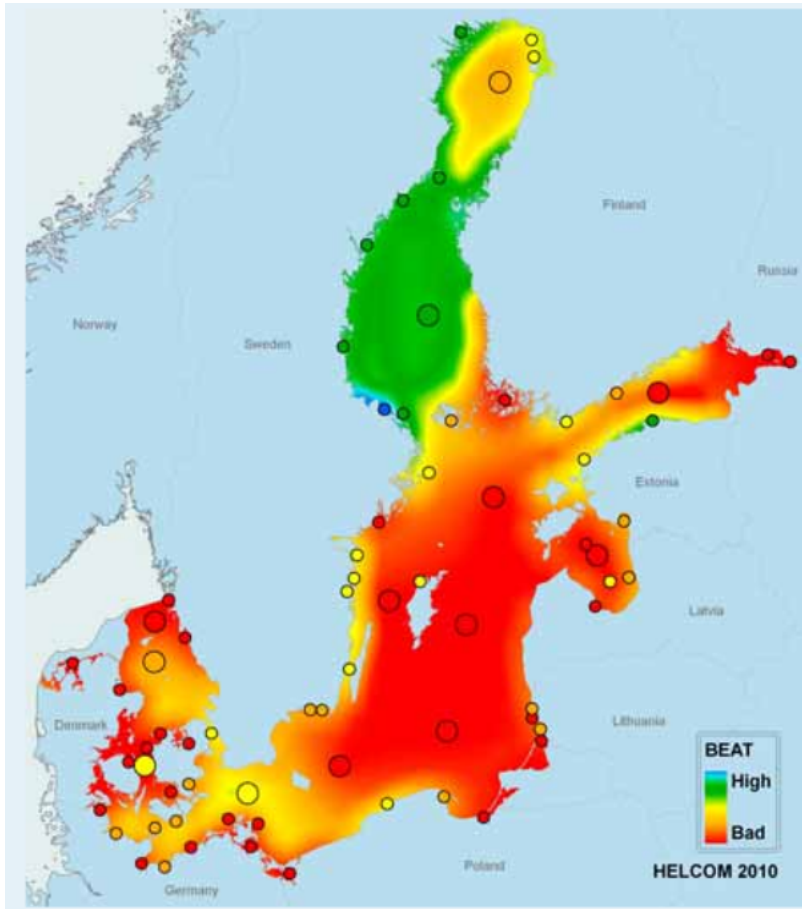
The HELCOM Red List reports have categorized at least 60 marine species and 16 marine biotopes in the Baltic Sea as threatened and/or declining, and the Swedish Environment Protection Agency lists 88% of marine biotopes as endangered. This suggests that the Baltic Sea is one of the most threatened marine ecosystems worldwide (HELCOM 2007, 2013e, SEPA 2009).

According to the 2012 International Union for Conservation of Nature (IUCN) Red list of threatened species update for birds, velvet scoter (*Melanitta fusca*) is now globally considered Endangered and long-tailed duck (*Clangula hyemalis*) is Vulnerable (http://sdg.iisd.org/news/iucn-releases-bird-update-to-red-list/).

These biodiversity losses threaten ecosystem function and resilience, as well as the provisioning of ecosystem services. It is thought that the relatively simple food webs and low biodiversity renders the Baltic vulnerable, since key functions may be supported by single species.

It is considered that the levels of sustainable use of the Baltic Sea ecosystem have been exceeded and apparent regime shifts of the Baltic Sea ecosystem have occurred as a result of overfishing and eutrophication (Alheit *et al.*, 2005; Osterblom *et al.*, 2007). However, improved efforts to reduce nutrient loading in various parts of the Baltic Sea have started to show signs of curbing eutrophication status, particularly for the pelagic indicators (J. H. Andersen *et al.*, 2017). The current preliminary HELCOM biodiversity assessment that summarize biodiversity status of several trophic levels and food webs, implies that despite the improvements in eutrophication, the effects are not visible at the level of biodiversity. Concurrently, the deterioration of many fish species and key habitats may result in welfare losses to society (HELCOM 2017).

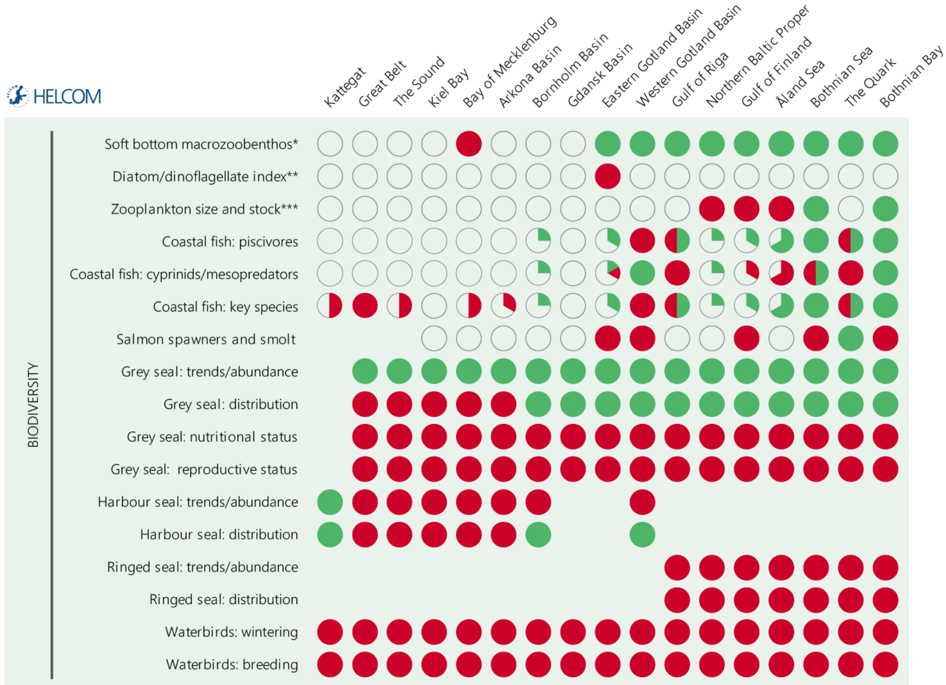
Figure 27: An integrated biodiversity status of the Baltic Sea



Note: Areas in blue and green represent areas with an "acceptable biodiversity status", while areas in yellow, orange and red represent areas with an "unacceptable biodiversity status". Large circles represent assessment sites in open basins and small circles represent coastal assessment sites.

Source: HELCOM (2009) – where general assessment principles are described. BEAT is the HELCOM Biodiversity Assessment Tool (Jesper H. Andersen *et al.*, 2014) used to produce this figure. Additionally, HELCOM (HELCOM 2017), proposed a set of biodiversity indicators to asses the biodiversity status in the sub-basins of the Baltic Sea, (see Fig. 28).

Figure 28: HELCOM Status of biodiversity Indicators in the sub-basins of the Baltic Sea



** Core indicator agreed to be tested in this assessment*
*** Pre-core indicator agreed to be tested in this assessment*
**** The indicator 'Zooplankton size and stock' is under testing for the Gdansk Basin*

3.7 Biodiversity of the Arctic

The following overview of biodiversity, status and trends for the Arctic is provided using the case study from the Disko Bay area in West Greenland (see Poulsen, 2018).

3.7.1 Key species

Calanus copepods have a key position in the food web, grazing on phytoplankton. Copepods are food for organisms at higher trophic levels, such as fish, auks and Greenland whales, while copepods' faeces are food for benthic animals. Especially three species of copepods, *Calanus hyperboreus*, *C. glacialis*, and *C. finmarchicus*, create the basis for the high marine biodiversity in Disko Bay (Boertmann, Mosbech, Schiedek, & Dünweber, 2013; Garde, 2014). Important phytoplankton species include *Thalassiosira* spp. and *Chaetoceros* spp. (Krawcyk, Witkowski, Waniek, Wroniecki, & Harff, 2014). Benthic macrofauna species consume a significant proportion of the available production and, in turn, are an important food source for fish, seabirds, seals and whales. Sand eel (*Ammodytes* ssp.) and capelin (*Mallotus villosus*) form crucial links from lower to higher trophic levels (Boertmann *et al.*, 2013; Garde, 2014) (Fig. 29).

Commercially important species include Northern shrimp (*Pandalus borealis*), Greenland halibut (*Reinhardtius hippoglossoides*), Atlantic cod (*Gadus morhua*) and snow crab (*Chionoecetes opilio*) (FAO, 2016; Garde, 2014). In the seas off East Greenland, the first Atlantic mackerel (*Scomber scombrus*) was caught in 2011. In 2013, mackerel was documented for the first time along the West Greenland coast (ICES, 2014). In 2014, 78,000 tons of mackerel were caught, providing nearly a quarter of the Greenlandic export earnings (Jansen *et al.*, 2016).

3.7.2 Key habitats

Disko Bay has a diverse seabed terrain with areas of rather shallow waters near the coast, traversed by deep troughs. Kelp forests in the tidal zone, dominated by *Fucus evanescens* and *F. vesiculosus*, provide shelter and protection for many species.

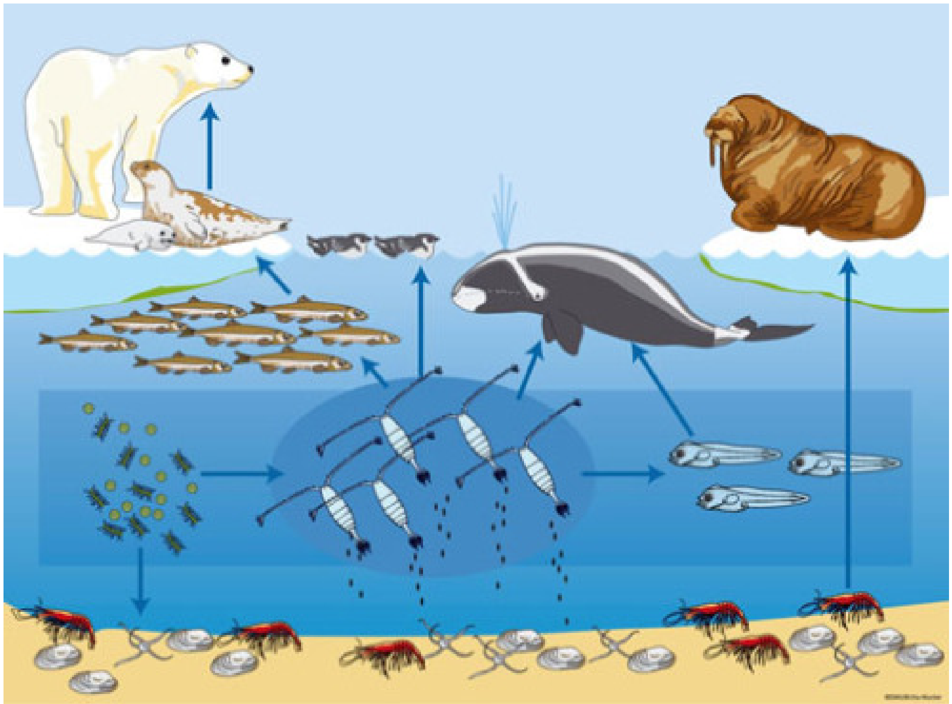
3.7.3 Trends in biodiversity and changes in ecosystem function

The anthropogenic drivers most relevant for changes in biodiversity in Disko Bay are climate change and exploitation of wild species. The number of fish species known from northwest Greenland is increasing (Boertmann *et al.*, 2013). The northern shrimp population has been declining in recent years, while there is an ongoing recovery of Atlantic cod (ICES, 2014; Jensen, 2003). Trends may be related to positive correlations between cod biomass and ocean temperature, along with strong negative correlations between shrimp and cod biomass (Worm & Myers, 2003). Among the bird species, especially common eider and thick-billed murre have suffered large population declines, which has been linked to hunting and egg collection. Eiders have responded positively as restrictions have been enforced, while murres have kept declining (Christensen, Mosbech, & Geertz-Hansen, 2015; Merkel, 2010).

3.7.4 Ecosystem health

The ecosystems of west Greenland are generally considered to be healthy. Lakes, rivers and marine waters are probably of good or very good ecological status. Habitat degradation is not regarded as a major issue in Greenland. However, climate driven changes in physical properties might alter the biological balance and regional biodiversity. For instance, northward retreatment of the sea ice edge has been linked to an increase in the distribution of kelp beds and increase in the seasonal productivity of seaweeds along the Greenland West coast (Krause-Jensen *et al.*, 2012). Wild species, and to some degree pollution and invasive species, may threaten the present good status.

Figure 29: Foodweb and biodiversity of an Arctic ecosystem



Note: Simplified view of the Disko Bay ecosystem with copepods in a central positon. *Calanus*-copepods have a key position in the food web (centered), where they graze on phytoplankton (phototrophic microalgae, middle left) and provide food for organisms at higher trophic levels such as fish, birds (auks) and whales (Greenland whale). In addition, copepod droppings constitute a food resource for bottom-living animals as they sink to the seafloor.

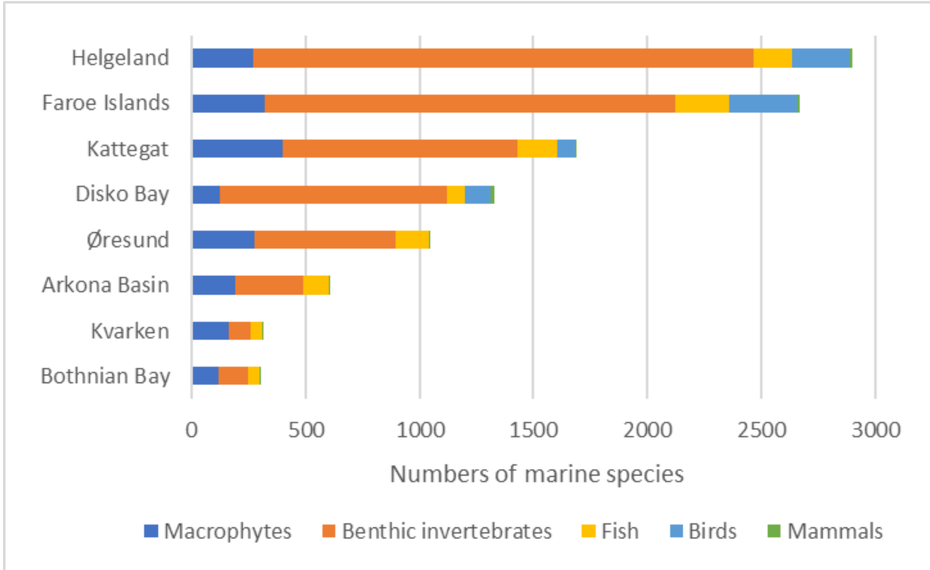
Source: B. Munter & T. G. Nielsen, 2005.

3.8 Differences and similarities between regions

3.8.1 Key species

Biodiversity gradients across the Nordic region are a reflection of the region's physical characteristics (Fig. 18 and 19). While biodiversity is relatively high in the North East Atlantic region, including the Helgeland coast and the Faroe Islands, the Baltic Sea species and functional diversity is relatively low. Consequently, even minor changes in species biomass and/or occurrence can have large effects on ecosystem function and services. The loss of a single species therefore has potentially higher impact in the Baltic Sea than in Helgeland and the Faroe Islands. Nordic coastal biodiversity is summarized in Figure 30, using the number of marine species in different functional groups and classes in each Nordic region.

Figure 30: Comparison of numbers of marine species of different groups and classes across the Nordic regions



Note: Only species associated with the coastal and/or marine waters are included. The birds and marine mammals included are those observed feeding off the marine environment.

Source: Helgeland: (Brattegard & Holthe, 2001), http://www.gbif.no/. Faroe Islands and Disko Bay: (Boertmann, 1994; Boertmann *et al.*, 2013; Hansen *et al.*, 2013). Kattegat, Øresund, Arkona Basin, Kvarken and Bothnian Bay: (HELCOM, 2012).

3.8.2 Key habitats

Key habitats of the Nordic coastal region are summarized in Table 3. Key habitats in the Atlantic region are kelp forest, smaller seaweed species, seagrass meadows, blue mussel beds and soft and sandy sediments. Entering the Baltic Sea, the large kelp species disappear (due to low salinity) leaving selected seaweed species, seagrass meadows, blue mussel beds and soft and sandy sediments as the most important habitats, with decreasing diversity along a decreasing salinity gradient (Fig. 19). Seagrass meadows are important across Scandinavia, including the Faroe Islands.

Table 3: Key marine habitats of selected Nordic regions. The selected regions represent Nordic IPBES case studies from which data has been compiled (Tunón (Ed.), 2018)

Key habitats	Helgeland	Faroe Islands	Disko Bay	Øresund	Lumparn	Kvarken	Kalix
Kelp forest	x	x	x				
Seaweeds	x	x	x	x	x	x *	x *
Seagrass meadows	x	x		x	x		
Mussel beds	x	x	x	x	x		
Maerl beds	x	x	x				
Sandy- and soft sediments	x	x	x	x	x	x	x

Note: * bladderwrack (*Fucus vesiculosus*) is not present (a key species in most of the Baltic Sea), but other small seaweed species are present.

3.8.3 Trends in ecosystem health and biodiversity

The Baltic Sea ecosystem, and to a lesser degree other parts of the Nordic region, have experienced considerable pressures from human activities over the past century, with particularly strong impacts on coastal biodiversity and ecosystem function. Pressures may affect only a few species, but due to the role of biodiversity and sometimes complex trophic interactions, the pressure may cascade through the system and have indirect effects on many other species and food web structures. An overview of the ecological status of the Nordic region is given in Table 4. In the table, color indicates the biodiversity status of each region, but note that the numbers in the table are derived from different assessment systems and thus cannot be compared between countries. While ecological status of the coastal ecosystems in the Baltic region is assessed using the WFD biological quality elements (phytoplankton, macrophytes and benthic invertebrates) and HELCOM biodiversity protocols (including pelagic invertebrates, fish, mammals, birds and key habitats), Norwegian waters are assessed using the Nature Index for Norway (NI), which includes trophic groups such as plants, fungi, algae, invertebrates, amphibians, birds, fish and mammals. The latter has a different scale, however, colors in Table 4 indicate how the status is assessed regionally or locally using regional assessment systems (Nybø, 2010).

Table 4: Biodiversity status assessment of selected Nordic coastal regions

Case region	Status *	Index
Norwegian Sea/Helgeland coast	Green	NI
NE Atlantic/Faroe Islands **	Green	**
Bothnian Bay/ Kvarken, Kalix coast	Green	HELCOM
Bothnian Sea/ Kvarken	Green	HELCOM
Gulf of Finland	Red	HELCOM
Baltic Proper	Red	HELCOM
Bornholm Basin	Yellow	HELCOM
Arkona Basin	Yellow	HELCOM
Kattegat	Yellow	HELCOM

Note: The colors green, yellow, red, indicate status classes: Good, moderate, and poor biodiversity status respectively, referring to the definitions of ecological status used in (HELCOM, 2010).

* Assessment status and number for the Norwegian Sea/Helgeland coast is from the Nature index of Norway (NI, Gundersen *et al.*, 2015). Numbers for the Baltic Sea are integrated values of biodiversity status and are means of normalized values assessed for habitats, communities, species and supporting services, based on the HELCOM (2010) classifications system and derived by (J. H. Andersen, Halpern, Korpinen, Murray, & Reker, 2015).
** No index exists for the Faroe Islands. Assessed as good quality (Jan Sørensen, Natural History Museum, Faroe Islands, Pers. Comm.).

Box 6: Nested tool for harmonized assessment of marine biodiversity

The Marine Strategy Framework Directive requires the environmental status of European marine waters to be assessed using biodiversity as one of 11 descriptors. Nested Environmental status Assessment Tool (NEAT) was applied to marine biodiversity data and indices to test the applicability and compare biodiversity assessments across the European Seas (Uusitalo *et al.*, 2016). The NEAT tool has been designed to overcome the complexity of marine biodiversity across salinity and latitudinal gradients and enable consistent methodology to integrate a broad range of indicators. The northern case studies included in the NEAT assessments were from the Baltic Sea (Gulf of Finland and Lithuanian coast), Kattegat and the Norwegian/Barents Sea and Lofoten areas in the Arctic. The outcome of the indicator based (quantitative) comparisons was very similar to the qualitative comparison in the current Nordic IPBES-like study, as the Barents Sea and Lofoten area had the highest score and the Gulf of Finland and the Kattegat, the lowest. In each of the areas, the most important ecosystem components that had the largest overall contribution to the integrated assessment were different. In the Barents Sea those were Harp seal and Kittiwake, in the Gulf of Finland benthic fauna and three species of fish (salmon, smolt and herring), at the Lithuanian coast the extent of benthic habitats affected by human impacts, and in Kattegat the winter abundance of three bird species (Fulmar, Kittiwake, and Guillemot). Although it was not possible to apply NEAT in the current study, assessments show that such tools have the potential to study comparisons of biodiversity status between areas of different scales, latitudes and salinity regimes (Uusitalo *et al.*, 2016).

Box 7: Restoration of marine ecosystems, an ongoing case

A new trend in marine ecosystem management are projects aimed to restore and reestablish harmed ecosystems, including the formal level of biodiversity and ecosystem function (Fig. 31). The MERCES (Marine Ecosystem Restoration in Changing European Seas) project is the first of its kind within the EU-framework (2016–2020, www.merces-project.eu.). The aim of MERCES is to restore different degraded marine habitats and quantify the returns in terms of ecosystems services and their socio-economic impacts.

By physically restoring harmed and/or destroyed marine habitats that are under threat due to anthropogenic activities including environmental pollution, human infrastructure and climate change, the hope is to reestablish lost biodiversity, ecosystem services and regain good environmental status of coastal ecosystems. In southern Norway, seagrass beds are being restored by planting juvenile plants in custom made physical constructions. At the Helgeland coast (a protected UNESCO World Heritage site in mid Norway) a restoration project is currently ongoing to reestablish kelp forests in areas where pronounced grazing pressure from sea urchins and eutrophication have expelled these key ecosystems (http://www.merces-project.eu/).

Figure 31: SCUBA diver working on a marine restoration project (www.merces-project.eu/) with re-establishing of a kelp forest (*Saccharina latissima*) on the Helgeland coast, Norway

Source: NIVA (J. Gitmark).

3.9 Local and indigenous knowledge

A recent trend in biodiversity assessment is to increasingly rely on citizen science, as it increases the coverage and number of observations. Another parallel methodology is community based monitoring (CBM), which places emphasis on the needs of local communities (Conrad & Hilchey, 2011; Tunón, Kvarnström, & Malmer, 2015). CBM activities are common among indigenous people and local communities in relation to IPBES-processes around the world. The *Atlas of Community-Based Monitoring & Indigenous Knowledge in a Changing Arctic* (http://www.arcticcbm.org/index.html) describes on-going community based monitoring-initiatives, reviewed in Johnson, Alessa, and Behe (2015). From a community perspective, it makes sense to keep track of the status and trends of surrounding biodiversity, especially the ones you are dependent on. The hypothesis is that local communities with an interest in a biological resource will gather reliable knowledge on, for instance, fish stocks and seabird populations. A study from Greenland shows that when the estimations from Inuit hunters and fishers were compared to researcher data on the status and trends of 24 different marine species (birds, fish and mammals) they largely agreed (Danielsen *et al.* 2014). Another example is from Swedish Saami villages where reindeer herders were accused of exaggerating the presence of bear predation on reindeer calves. However, when bear predation was measured using GPS-techniques, similar predation numbers were confirmed (Karlsson *et al.*, 2012). An increasing number of transdisciplinary collaborations between local communities and scientists could be a valuable result from the Nordic IPBES-like assessment.

3.9.1 Reflections from the ILK-process

As part of this IPBES-like report work, a Swedish and Finnish workshop to discuss ILK was held for local knowledge holders. Farmers, artisanal fishers, hunters and nature and culture tourism entrepreneurs from the coasts of Bohuslän, Östergötland, Gotland, Uppland, Stockholm archipelago, Åland and the Kalix archipelago were represented. The following is a summary of the findings related to the status and trends of biodiversity in coastal areas over the past two decades (Kvarnström & Tunón, 2018):

The white-tailed eagle (*Haliaeetus albicilla*), grey heron (*Ardea cinerea*), crane (*Grus grus*), several species of geese (*Anser anser*, *Branta canadensis* and *B. leucopsis*), otter (*Lutra lutra*) and seals (*Halichoerus grypus*, *Phoca vitulina* and *Phoca hispida bothnica*) have increased in number in the Swedish/Finnish archipelago and in the Bothnian Bay.

The populations of cormorant that increased rapidly since the 1970's seem to have stabilised. There is increasing bush encroachment on many islands in the archipelagos of Åland, Stockholm and Östergötland, and the number of pine seedlings (*Pinus silvestris*) has increased during the last few years. Nitrophilic species like stinging nettles (*Urtica dioica*) and cow parsley (*Anthriscus sylvestris*) have also increased. Sport fishing, fishing tourism and kayaking have increased, with both positive and negative impacts. Among species that have decreased are common eider (*Somateria mollissima*), gulls, pike (*Esox lucius*), blue mussels (*Mytilus* spp.) and bladder wrack (*Fucus vesiculosus*). Decreasing numbers of small-scale professional fishers and hunters have been noted. New regulations are leading to decreased quality of life in local communities in many coastal regions, e.g. Kalix, Östergötland and Gotland. Municipal services become more centralized leading to closure of local schools. In the Kalix archipelago household fishing is one of the single most important factors for a high quality of life in the local communities (see chapter 6 in this report and Kvarnström & Boström, 2018).

A few responses from Åland to a questionnaire on ILK, indicate that during the past decade, non-commercial fish species like common roach (*Rutilus rutilus*) and common bleak (*Alburnus alburnus*), as well as cod (*Gadus morhua*), have increased. Other species seem stable. This is in accordance with recent HELCOM assessments (HELCOM, 2017a). In Åland, there was agreement on observations of enormous increases in seals, particularly in the Baltic Sea – numbers reaching beyond those encountered in living memory. Furthermore, cormorant and swans (*Cygnus olor* and *C. cygnus*) have increased. The islands in the Åland archipelago are overgrown with vegetation and less people are at sea, except during the summer vacation.

The large increases in seal populations observed by participants in the workshop and responders to questionnaires, is in concert with the HELCOM assessment of seal species in the Baltic. These conclude that grey seal and harbor seal are increasing in numbers, while ringed seal populations in the Gulf of Finland are decreasing and currently only represented by around 100 animals (HELCOM, 2017b). Assessments of ringed seal populations in the Bothnian Bay show a large increase, from estimates of 2000 seals in the mid 80s (Härkönen *et al.*, 1998) to above 20,000 at present (Naturvårdsverket, 2017b). Participants were concerned about the strong negative impact of seals on fishing and fisheries. Research at the Swedish University of Agricultural Sciences highlights the different kinds of impacts seals have on fisheries, including damage to harvest and equipment, along with hidden damage through scaring off or removing fish without leaving traces. Impacts at ecosystem level include the impact of seals on fish populations and dispersal of parasites in fish (Lunneryd & Königson, 2017). Current efforts to reduce the negative impacts of seals on fishing include protective hunting and the development of new equipment (Lunneryd & Königson, 2017; Naturvårdsverket, 2017a, 2017b). Participants at the workshop commented that seal-proof equipment is expensive for small-scale household fishers and that protective hunting from a boat in open water is extremely difficult.

3.10 Case examples

Näätämö river watershed (see Mustonen, 2018a) is the home of the Skolt Saami Indigenous community and the first official collaborative management project in Finland. Näätämö is an Atlantic Salmon river with its source in Finland, flowing northward into Norway ending in the Barents Sea. Climate change, past land use and growing infrastructure plans are some of the present and future drivers of change to the basin. For the Skolt Saami, climate change is one of the most acute and relevant processes of indigenous knowledge led monitoring (Mustonen & Feodoroff, 2013; Pecl, Araújo, Bell, Blanchard, & Bonebrake, 2017). In 2010, extreme heat waves and torrential rains affected the water levels of the Näätämö river and the capacity of Atlantic Salmon to access the upstream spawning grounds. Recently, Saami have partnered with scientists to monitor the basin using ILK, which has resulted in the production of a database on salmon and water quality changes and an interesting first observation of a southern beetle species (*Potosia cuprea)* in the area (Mustonen, 2015). The community based monitoring work has also led to the identification of "lost" Atlantic salmon spawning areas, that are now subjects of a major restoration project (Mustonen, 2018a).

Puruvesi Lake (see Mustonen, 2018b) located in Savo and North Karelia provinces in eastern Finland, contains sea-like species and ecosystems. The Lake is part of the larger Saimaa Lake system. Endangered lake salmon and freshwater seal inhabit the lake. Puruvesi is also home to one of the most traditional fishing communities in northern Europe, who practice the winter seiners of Puruvesi (Mustonen, 2014). The population feed off the lake and remove approximately 400 tonnes of fish annually.

Salmon and seal are experiencing negative impacts from a range of drivers, including large-scale hydropower development and climate change. The lake it is subject to major eutrophication threats (Mustonen, 2014).

In the Faroe Islands (see Sørensen, Roto, & Tunón, 2018), seabirds have been reported to decrease during the last decade, including kittiwake (*Rissa tridactyla*), puffin (*Fratercula arctica*), guillemot (*Uria aalge*), Arctic tern (*Sterna paradisaea*) and seagulls. At the same time, species such as gannet (*Morus bassanus*), fulmar (*Fulmarus glacialis*), shag (*Phalacrocorax aristotelis*) and black guillemot (*Cepphus grylle*) have not seen the same decline. Since 1584, the local communities in the Faroe Islands have kept track of the annual harvest of pilot whales, most likely making it the longest running community based monitoring initiative in the world. There is also a more modern approach using a Facebook initiative where Faroese hunters register the number of hares hunted and researchers at the University of the Faroe Islands process the data. Small-scale professional fishing has gradually been substituted by industrial fishing and urbanisation is leading to fewer people in remote rural areas.

The PISUNA project in Disko Bay in Greenland (see case study text by Poulsen, 2018), highlights the status and trends of certain species. Local fishers and hunters monitor seals (fluctuating), Atlantic cod (increasing), common eider (increasing), humpback whale (*Megaptera novaeangliae*) (increasing), Greenland halibut (*Reinhardtius hippoglossoides*) (increasing), thick-billed murre (*Uria lomvia*) (declining), Canada goose (*Branta canadensis*) (increasing), narwhal (*Monodon monoceros*) (stable or increasing), and beluga (*Delphinapterus leucas*) (stable or increasing) (Danielsen, Frederiksen, & Mølgard, 2016).

In the Kalix archipelago of the Bothnian Bay (see Kvarnström & Boström, 2018), the local communities have mapped the abundance of fish stocks over the past three decades. Local community members and reindeer herders make regular observations of changes in abundance of fish, birds, seals and other mammals, as well as observations of changing weather patterns and changing ice cover. Special focus has been on mapping areas of presence and absence of brown trout (*Salmo trutta).* The local fishing communities hope that collaborative monitoring and co-management of fishing can support trout populations, as well as sustain and strengthen local fishing culture.

3.11 Knowledge gaps

- While HELCOM, OSPAR and other international and regional initiatives have been mapping biodiversity and ecosystem function during the last decade, no committed assessments have been made to obtain trends in biodiversity over time. However, recently some initiatives (e.g. BEAT) have been taken, aiming to quantify trends of biodiversity and improving understanding of the human impacts on NCP;
- Knowledge gaps regarding climate impacts (warming, ocean darkening, and acidification) on kelp forest and seagrass ecosystems are pronounced. Further research will help to develop an understanding of how anthropogenic and climate

driven forces impact trends in biodiversity and ecosystem function in these prestine ecosystems. A head start is the recent work on the role of kelp and seagrass in climate mitigation by the Norwegian Environment Agency and The Norwegian Blue Forest Network (www.nbfn.no). However, our quantitative understanding of these processes is limited and very coarse (Duarte *et al.*, 2005; Mazarrasa *et al.*, 2015);

- The development of common Nordic biodiversity indicators and assessment tools is recommended to aid future assessments of biodiversity and ecosystem function across the Nordic region. Some methodologies and tools are proposed locally and could be tested and modified for a common Nordic biodiversity assessment system, in line with the Norwegian Nature Index (Nybø, 2010), the Nested Environmental status Assessment tool for marine biodiversity (Uusitalo *et al.*, 2016), and the HELCOM Holistic Assessment tools for the Baltic Sea Biodiversity Assessment. HELCOM development for the Holistic assessment has developed several biodiversity indicators, agreed upon between the Baltic Sea countries. The lastest HELCOM assessment was carried out in July 2017;
- A major challenge is how to link biodiversity and ecosystem function with ecosystem services and their valuation. Currently, most qualitative assessments of ecosystem function are not operationally linked with biodiversity assessments. Also, tools that relate ecosystem function to ecosystem services should be developed for future management strategies;
- A closer link between ILK with monitoring and assessments of biodiversity is recommended. This would improve understanding of biodiversity and ecosystem function status and trends, and provide local and regional knowledge of ecosystem services and values.

3.12 Policy recommendations

- Implement multi-stressor impacts studies on coastal ecosystems. In particular, combined impacts of climate change (warming, elevated precipitation, acidification), eutrophication and human resource harvesting (e.g. fisheries) need to be better resolved and understood. Today, management programs largely focus on environmental challenges one at a time, e.g. separating climate impact studies from resource harvest monitoring;
- Identify and adjust policies that counteract incentives for conservation and the sustainable use of biodiversity in coastal areas;
- Increase political focus on the status of marine biodiversity and the influence of human activities on species and habitat diversity. This would be closely related to work with the UN Sustainable Development Goals (SDGs);
- Development of assessment tools for biodiversity and ecosystem function as part of established environmental monitoring programs (HELCOM, OSPAR, EU Habitat and Birds Directive, and the Marine Strategy Framework Directive);

- Include assessment of temporal trends in biodiversity and ecosystem assessment programs, like those recormended above, to improve future evaluations and possibilities for managers to take actions towards healthy coastal ecosystems;
- Include seagrass meadows and kelp forest contributions to carbon storage and climate mitigation in regional carbon budgets;
- Evaluate the impacts of climate pressures (sea level rise, warming, ocean darkening, and acidification) on biodiversity and ecosystem function in the coastal zone;
- Maintain a dedicated focus on scientifically sound and validated methods in applied assessment tools to secure high quality knowledge-based information for policy makers and management agencies;
- Scientific knowledge-based information should be combined with ILK in future management and policy planning, with the aim to improve quantification of NCP.

3.13 References

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4. Direct and indirect drivers of change indifferent perspectives of human well-being (quality of life)

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Box 8: Summary

The purpose of IPBES assessments is to depict how the natural world and human societies interact with each other on a conceptual level (Diaz *et al.*, 2015). Habitat degradation, eutrophication, fishing and climate change are examples of drivers of change that affect Nordic coastal habitats. Policy and governance are principal indirect drivers that both could lead to decline and deteriorations, as well as improvements and recoveries of Nordic marine environments.

Climate change will affect Nordic marine biodiversity profoundly in the future by changes in, for example, bio-chemical cycles and in the distribution of biodiversity. Such changes might lead to increased oxygen depletion in many areas, leakage of nutrients, changed trophic structures and spread of pathogens (Diaz & Rosenberg, 2008; Gregory *et al.*, 2009). It is therefore of paramount importance that effective governance is developed to mitigate impacts on nature's contributions to people (NCP) and to build sustainability and strategies for sustainability (Chapin *et al.*, 2010). Less overfishing, less eutrophication, fewer pollutants and better land-use and nature protection are measures that will improve the overall resilience of Nordic coastal environments.

4.1 Introduction

IPBES assessments aim to conceptually depict how the natural world and human societies interact with each other (UNEP, 2014). Human actions may influence natural drivers and give rise to new sorts of drivers of change that affect NCP in a multitude of ways. For instance, reforestation leading to brownification, i.e. the process of humic substances from forests and moors, which often are coloured brown due to attached iron, affects rivers and coastal habitats (Kritzberg, 2017).

Direct drivers of change, both natural and anthropogenic, effect nature directly and thereby its biodiversity and NCP. Indirect drivers of change, such as institutions and governance systems, refer to how people and societies organise themselves and their interactions with nature at different scales. Governance, along with economic, social, technological and cultural developments, are therefore indirect drivers of change. Their effects can be beneficial or detrimental to society, partly depending on the context.

4.2 Direct drivers – definition

4.2.1 Natural direct drivers

Natural direct drivers are those that are not a direct result of human activities and whose occurrence is beyond human control, hence they may have negative as well as positive impact on nature and human societies. These include natural climate and weather patterns, extreme events such as droughts, floods and volcanic eruptions, and specifically for the Nordic region, infrequent water exchange between the Baltic Sea and the North Sea, as well as occasional epizootics and plant diseases.

4.2.2 Anthropogenic direct drivers

Anthropogenic direct drivers are those that are the result of human decisions and actions. Some examples of anthropogenic direct drivers are those resulting from intensification or abandonment of land use for agriculture, forestry, transport, extraction of gravel from the seabed, mining and construction and development in coastal areas. Some drivers are linked to discharges of nutrients, hazardous substances, climate change produced by anthropogenic carbon emissions leading to pollution of soil, water or air. Other drivers lead to habitat degradation, whereas others that aim to restore terrestrial and aquatic habitats, lead to exclusions of harmful activities. Fishing and other forms of harvesting of wild populations, as well as species introductions, are example of important drivers with potential strong impacts on the marine environment. In many cases, interactions between natural and anthropogenic drivers can mitigate or reinforce their effects.

4.3 Indirect drivers – definitions

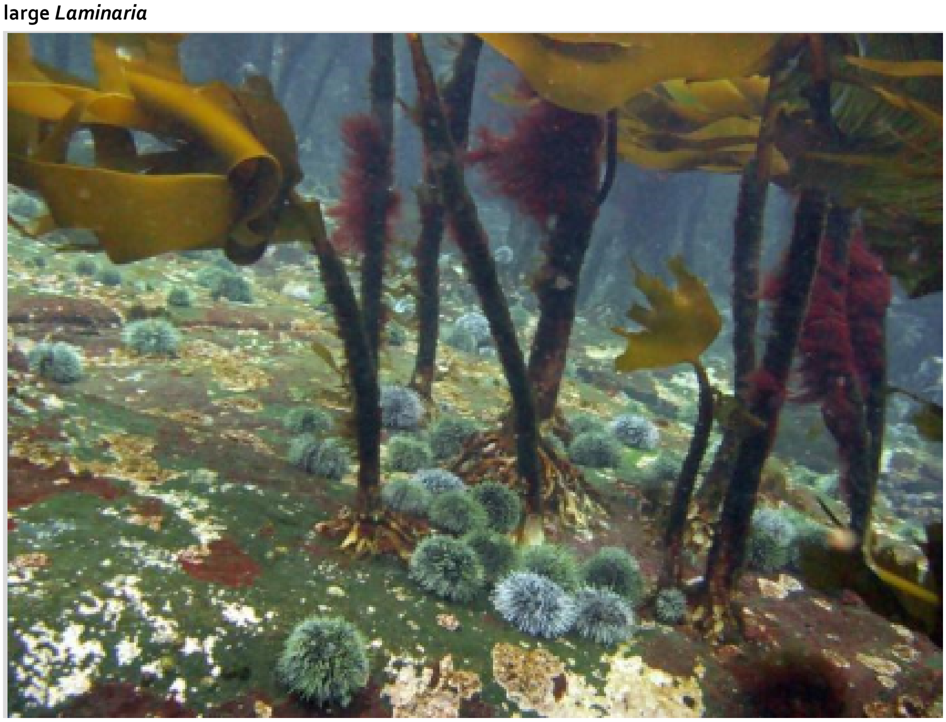
Indirect drivers are the underlying causes of change that are generated outside the ecosystem in question. They are central as they influence all aspects of relationships between people and nature. Examples include legislation, the organization of societal institutions and the demand for food. Their effects can be positive or negative, either in absolute terms or dependent on context. They are considered indirect drivers because in the vast majority of cases they do not affect nature directly, but rather through their effects on direct anthropogenic drivers.

4.4 Past and current trends of direct and indirect drivers of change – a Nordic overview

4.4.1 *Natural direct drivers*

Natural direct drivers of change, as far as they can be separated from their anthropogenic counterparts, are essential in shaping NCP. Natural variation in plant and animal populations, whether it concerns seal abundance, fish stock size variation or kelp occurrence (Fig. 32), is an intrinsic part in the development of various phenomena over time.

Figure 32: There are important natural drivers at sea, which often interact with anthropogenic drivers. Green sea urchins on the seafloor between the remaining parts of kelp forest trunks (stipes) from the large *Laminaria*



Source: Hartvig Christie/NIVA.

Natural drivers may often interact with anthropogenic drivers. As an example, it could be mentioned that since the early 1970s, more than 50% of kelp forests in the sheltered and moderately exposed areas on the Norwegian Helgeland coast between 63 and 71° N have been wiped out due to sea urchin grazing. This grazing has reduced previously rich kelp forest areas into biological deserts, or so-called barren grounds (Sivertsen, 1997). The ultimate reason for this development is not entirely understood but might relate to both stochastic (random) and cyclic events due to natural drivers. However, over the last decade, a northward gradual recovery of the kelp vegetation has been observed (Norderhaug & Christie 2009; Rinde *et al.*, 2014). This positive change is partly explained by the adverse effects of higher sea temperatures on sea urchin recruitment, which is related to climate change – an anthropogenic driver (Fagerli *et al.*, 2013) – and partly from increased predation on urchins from northward expanding edible crab (*Cancer pagurus*) and shore crabs (*Carcinus maenas*), i.e. a natural driver (Fagerli *et al.*, 2014).

The importance of each driver varies across the case studies, as can be seen in Table 5. All drivers and their impacts in different parts of the Nordic region are presented below.

Table 5: Comparative table of direct and indirect drivers of change in the case study areas

Nature's Contribution to People	The Quark	Kalix	Nätäämö	Lumparen	Puruvesi lake	The Sound	Helge-land	Faroe Islands	Disko Bay
Provisioning									
Fishing and other sea products	x	x	x	x	x	x	x	x	x
Herding		x	x			x		x	
Agriculture	x	x	x	x		x	x		
Energy	x					x	x		x
Livelihood	x	x	x		x	x	x	x	x
Regulatory & supporting									
Climate & biochemical cycles	x	x		x		x	x		x
Resilience	x	x				x	x	x	x
Biological functions	x	x	x	x	x	x	x		x
Cultural									
Recreational & aesthetical	x	x		x		x	x		x
Tourism	x	x		x		x	x	x	x
Social life, wellness	x	x	x	x	x	x	x	x	x
Existential	x	x	x		x		x	x	x

Source: Tunón (Ed.), 2018.

Trophic interactions are influenced by numerous processes and factors. Good knowledge and insights into ecological relationships are therefore often vital in order to develop applicable and efficient strategies for their management. Many management issues concern predator-prey relationships in nature, such as between the commercially important vendace (*Coregonus albula*) in the Bothnian Bay and the recovery of seals. The seal stocks have partly improved from previous reproductive failure induced by hazardous substances, giving rise to new conflicts between local users and protection needs (Hårding & Härkönen, 1999). The most recent study tentatively suggests that seals in the Bothnian Bay consume around 6,000 tons of vendace per year (Hansson *et al.*, 2017), which is around four times more than the 1,400 tons caught by the fishers. The vendace population is believed to be decreasing and calls are made for a culling of seals. In order to reduce conflicts of interest, for instance, between local communities and conservation interests, local participation is vital.

Other kinds of imbalances in trophic relationships may result in increased frequencies of algal blooms and faster growth of filamentous algae due to overfishing of predatory fish (Moksnes *et al.*, 2008). Meadows of submerged eelgrass (*Zostera* sp.) are declining in many parts of the world, not in the least on the Swedish west coast (see also Chapter 3). The reasons for this decline are construction of e.g. marinas (Moksnes *et al.*, 2016) and eutrophication, which leads to shading by epiphytes and poor oxygen condition in the sediment (Connell *et al.*, 2017), along with lower abundance of predatory fish. Some efforts are now being made to restore eelgrass meadows.

Management actions may interact with natural processes, which could add to a deteriorating situation. For example, the protection of juvenile fish has resulted in stunted growth in Baltic cod due to increased food competition in certain size classes (e.g. Svedäng & Hornborg, 2014; 2017).

Climate change may also impact trophic relationships. In Disko Bay on the west coast of Greenland (see Poulsen, 2018), natural direct drivers with an impact on biodiversity and ecosystems include natural changes in climate and weather patterns. Interviews with fishers in Greenland indicate that the population of Atlantic cod has followed changes in sea temperature for centuries (Petersen, 2002). Cod biomass is positively related to ocean temperature while shrimp biomass is strongly negatively related to cod biomass (Worm & Myers, 2003).

Catastrophic events may be more important than usually recognised. The spread of pathogens, such as the eelgrass virus in the 1930s, devastated most of the eelgrass vegetation in the Kattegat, which at the time covereded up to 25% of the sea area (Rasmussen, 1977). Today, eelgrass only covers a minor part of that area (around 10%). Another example is the seal epizootics that caused large-scale kills in the North Sea region in 1988 and 2002, when more than 50% of the seals died in the eastern North Sea including in the Skagerrak and Kattegat (Härkönen *et al*., 2006).

4.4.2 Anthropogenic direct drivers

Habitat degradation may be linked to eutrophication, bottom trawling, oil spills or coastal development, which are regularly associated with reductions in biodiversity. Habitat degradation affects NCP such as provisioning, regulating and cultural services.

Changed land use, such as the construction of hydro-power stations, affects flows of material such as nutrients, hinders animal migrations, degrades cultural and existential values and reduces the potential for local economic activities such as agriculture and forestry. Bridge construction may affect water exchange and give rise to silting effects during the construction phase. However, the hard substrates also provide colonisation opportunities for species, which can have a positive impact on biodiversity by facilitating settlement of algae and other habitat-forming species, such as blue mussels. Competition for space is an increasingly important factor, affecting coastal habitats at sea as well as on land (Box 9).

In the Faroe Islands, it is common practice to extract material from the seabed in inshore areas. There is no legal restriction on sand extraction and sand is usually taken within fjords and close to the coastline. Sandeel (*Ammodytes* sp. – a commercial fish species) have preferences for a specific grain size and quality of sand, and the demands on near-shore areas may thus constitute a negative driver for sandeel populations. As puffins (*Fratercula arctica*) feed on sandeels, this practice of excavating sand from inshore areas may also lead to a decline in the puffin stock. Furthermore, sandeel are also targeted by industrial fishing fleets (see Sørensen, Roto, & Tunón, 2018).

Leisure boating affects many Nordic coastal regions. At Lumparn in the Åland archipelago, habitat degradation has been linked to intensive boating, which is thought to have adverse impacts on macrophytes (submerged plants), as well as on other benthic organisms (Vävare & Häggblom, 2018).

Acidification is a significant driver in the Bothnian Bay (Swedish Water Authority, 2017), in the Quark area and in the estuaries in Ostrobothnia (western Finland around the Quark archipelago). Because of discharges from acidified rivers, fish kills and metal loading occasionally occur in the coastal environment (HELCOM, Kronholm *et al*., 2005). Acidification of water bodies is a result of acidic sulphate soils and is a process that is accelerated by the draining of land for agriculture and forestry. Acidification is also a mounting threat on a global scale, due to the increased atmospheric content of CO_2, which leads to a higher content of carbonic acid in seawater.

Box 9: Competition for space in the most densely populated Nordic area

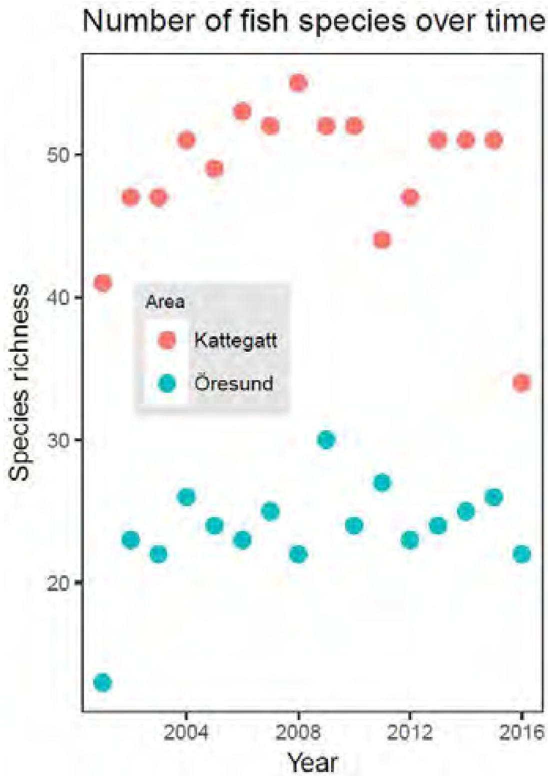
Competition for space both on land and at sea is a critical issue in densely populated areas. The Sound region is the most densely populated area in Scandinavia with about two million inhabitants, who with their modern lifestyles and high demand for various resources, have the potential to effect ecosystems and biodiversity in a multitude of ways (Fig. 33). There is an urgent need for regulating the use of marine and coastal space in the region due to shipping, fishing, recreation and tourism, housing and infrastructure development projects such as a bridge and tunnel across the Sound, new harbours and offshore wind turbine parks. The extraction of sand and other materials also put strains on the bottom habitats in the Sound (c.f. https://www.theguardian.com/cities/2017/feb/27/sand-mining-global-environmental-crisis-never-heard, viewed April 17, 2018). Policy instruments that aim to deal with spatial planning and clarify which interests take priority in various areas at the coast and in the sea include Marine Spatial Planning using an ecosystem – approach, the introduction of exclusive economic zones and Integrated Coastal Zone Management.

Figure 33: Competition for space and demand of NCP: The Sound is the most densely populated area in Scandinavia, still there are numerous bathing places to visit and the quality of bathing water is mostly good to excellent

Note: High bathing water quality also means clearer water and improved conditions for higher biodiversity.

Source: Data from the European Environment Agency for 2016: see Petersen *et al.* 2018.

Figure 34: Cod abundance in the Kattegat and Öresund over time: Catch per unit effort (kg cod per trawling hour)



Source: Data have been retrieved from www.ices.dk, viewed in March 2, 2018.

Box 10: Competition for space in the most densely populated Nordic area: trawling ban regulation

The Sound region is one of the most densely sea-trafficked places in the world oceans. This condition affects the environment both directly through emissions of various hazardous substances and underwater noise. These demands for space have led to responses by governance systems, with unintentional benevolent consequences: because the Sound has been heavily trafficked for a long time, towing of fishing gears was already forbidden in 1932 (Anon., 1932).

It is hence interesting to note that there are indications of a somewhat healthier status of the Sound cod stock relative to the nearby stocks in Kattegat (Fig. 34). Fishery management of the Sound is co-managed with the rest of the western Baltic (e.g. ICES, 2016), which as a consequence, means that fishing quotas seldom are limiting in the Sound. Instead, it is the ban on trawling that is regulating; fishing is carried out with less efficient and less size-selective artisanal fishing methods, which in the end has preserved the stock in a much more productive state compared to other adjacent cod stocks in the Baltic (Svedäng & Hornborg, 2017).

Eutrophication is a key anthropogenic driver of change and involves complex processes of nutrient discharges from e.g. municipalities, agriculture, fish farms, shipping and transport. This enrichment may lead to increased production of organic material such as filamentous algae, or phytoplankton blooms that can cause changes in trophic structures. The outcome of the enrichment depends both on the flow of nutrients and the trophic structure.

In the Sound, discharges of nutrients from municipalities and surrounding intensively cultivated land have enriched the environment and resulted in higher primary production. This higher production of organic matter sometimes results in seasonal hypoxia, especially during the late summer. Improved sewage treatment and changed land management practices have counteracted the degree of eutrophication. Musselbeds and eelgrass meadows also help to mediate the inflow of nutrients, hence increasing ecosystem resilience. Because of the filtering of the water masses by the mussel beds, phytoplankton biomasses are lowered, counteracting water turbidity (e.g. Lindahl *et al*., 2005). This improved water transparency favours eelgrass growth at greater depths. Eelgrass meadows are beneficial for mediating nutrient flows (Oshima *et al*., 1999).

The more natural, or less truncated, fish population size structures found in the Sound in comparison to adjacent sea areas (Box 10) also ensure that more regular trophic relationships prevail, which in turn, support macroalgae and macrophytes at the expense of filamentous algae (Moksnes *et al*. 2008). When predatory fish such as Atlantic cod disappear, grazing pressure on filamentous algae is reduced, leading to shadowing and suffocation of eelgrass meadows, decreased biodiversity and less suitable nursery habitats for many fish, including Atlantic cod.

In the Helgeland area on the northwest coast of Norway, transportation of nutrients by sea currents from western Europe may be causing eutrophication (Andersen *et al*., 2016, Gundersen *et al*., 2016). The response of seagrass ecosystems to coastal nutrient enrichment has shown to follow a "threshold pattern". When nutrient enrichment exceeded moderate levels, a switch from positive to negative net leaf production was observed. Epiphyte load also increased with nutrient enrichment, potentially driving this shift (Connell *et al*., 2017). Eventually, it may cause eelgrass meadows to decrease. As a consequence, biodiversity and fish nursery areas will disappear as well.

The inshore area at Lumparn in the Åland archipelago is highly sensitive to local enrichment, leading to eutrophication due to its limited water circulation. Nutrients are discharged from agriculture, settlements and private sewers, leading to severe problems with algae blooms in some years. When water quality declines, it affects recreational values and quality of life.

Fishing is an essential direct driver in all Nordic coastal waters. For instance, the rich herring fishery in the Sound may have been the main reason and motivation for its first settlements (Fig. 35). Fishing in the Nordic countries often includes intense professional, subsistence and leisure fishing.

Fishing may lead to erosion of size and genetic structure, lower productivity, changed trophic relationships, trophic cascades or starvation of seabirds. The effects of fishing are more or less related to the amount of fishing (effort) and the selectivity of fishing, which is a result of gear constructions, mesh sizes, and temporal and spatial allocations of fishing. Fishing may extract higher proportions of some subgroups (e.g. subpopulations, age and size groups, sex) than others, potentially leading to lower productivity (Svedäng & Hornborg, 2014; 2017) and evolutionary changes in life history parameters such as age and size at maturity (Hutchings, 2009).

Figure 35: Woodcut, illustrating the herring fishery in the Sound in the Middle Ages

Note: Please note the axe standing upright in a herring shoal, indicating an exceedingly high density of fish.

Source: Olaus Magnus (1555)

Other kinds of imbalances in trophic relationships may result in growth stunting in fish. For example, the protection of juvenile fish species has led to food competition in specific size classes and stunted growth in Baltic cod. Here, management actions interact with population dynamic processes with unforeseen implications (e.g. Svedäng & Hornborg, 2014; 2017).

Fishing also results in emissions of greenhouse gases, abrasion of the seabed and by-catches of mammals and birds. These problems are aggravated by tax exemptions on fuel for the fishing industry.

Pollution from hazardous substances including the loading of heavy metals, organic substances place serious pressures on NCP and on quality of life. Seals and other mammals in the Baltic Sea declined in numbers during the latter part of the 20th century, due to reproductive failure caused mainly by PCBs and other organochlorides (Hårding *et al.*, 2007). The decline in sea mammals has had an impact on existential and recreational values.

Due to stricter regulations and measurements, some of these problems have been curtailed. However, cadmium and organochlorides in Baltic herring (*Clupea harengus*) still pose serious risks for human health (Kiljunen *et al*., 2007). Dioxin is still released in to the marine environment from the paper and pulp industry. Higher levels of dioxin in Baltic herring has resulted in recommendations of restricted intake, especially by children and women in the fertile age.

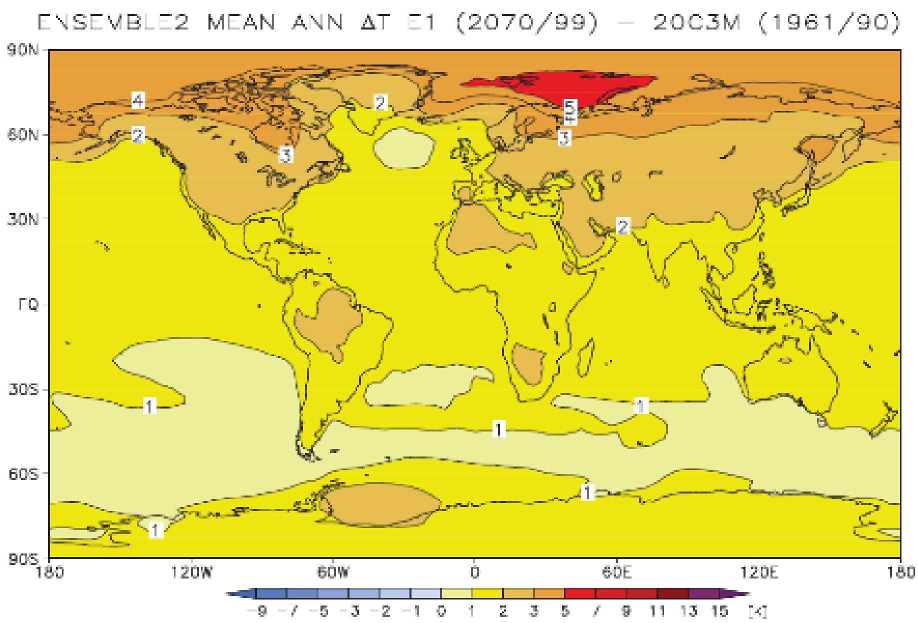
Albeit far from the industrial or urban areas of Europe, the level of mercury in sea mammals in the Faroese and Greenlandic waters may be at high levels (AMAP, 2011; Weihe & Joensen, 2012). Effects of a mixture of chemicals, the "cocktail effect", must also be considered. Whilst the concentration of each substance is below safe toxicological limits, the total effect may be substantial (e.g. Backhaus & Faust, 2012).

Invasive species may lead to significant impacts on biodiversity, which in turn lead to changes in ecosystem function and productivity. For instance, the alien species round goby (*Neogobius melanostomus*) is spreading quickly in the southern Baltic Sea, as well as in other parts of Europe and the US. In test fishing in the Muskö area of the Stockholm archipelago, the number of round goby individuals caught increased from nine in 2013 to 1835 in 2017 (SLU, 2017). Originally first observed in the Bay of Gdańsk in the southern Baltic, it now completely dominates the coastal fish fauna. It is expected to spread throughout the Baltic Sea, including the Bothnian Bay, and may result in significant impacts on ecosystems in the future.

Invertebrates such as the polychaete *Marenzelleria sp.*, sea walnut (*Mnemiopsis leidyi*) and the Arctic comb jelly (*Mertensia ovum*) have accidentally spread from ballast water, but the consequences remain unclear (Ojaveer & Kotta, 2015). Mink (*Mustela vison*) and racoon dog (*Nyctereutes procyonoides*) have escaped from fur farms and cause severe problems among seabirds locally. Some plants such as *Rosa rugosa* (https://www.nobanis.org/globalassets/speciesinfo/r/rosa-rugosa/rosa_rugosa.pdf) spreads along the shores, changing the local plant communities.

Climate change, which is related to greenhouse gas emissions, can profoundly affect Nordic marine biodiversity. Climate-related pressures include melting sea ice, decreased snow cover and permafrost thawing and increased discharges of organic matter, which may lead to altered trophic relationships (e.g. Andersson *et al.* 2015). Even in a scenario wherere CO_2 levels have been stabilised at 450 PPM, dramatic consequences can still be expected in the Nordic region (Fig. 36). Higher seawater temperatures lead to increased ecosystem respiration rates (Hoegh-Guldberg & Bruno, 2010). For instance, due to the higher respiration rates oxygen deficits return faster in deeper water layers and seabed than previously after inflows of fresh, well-oxygenated water masses into the Baltic Sea. In the northern parts of the Nordic countries and seas, fish stock productivity can be expected to increase as an effect of rising water temperature (e.g. Stenevik & Sundby, 2007).

Figure 36: Projection of the departure (anomaly) in annual mean temperature for the years 2077–2099 relative to the estimated temperature during the period 1960–1999



Note: This scenario of changes in temperature on a global scale is modelled according to the optimistic assumption at which atmospheric CO2 stabilises at 450 PPM by 2140.

Source: van der Linden & Mitchell, 2009

Increased fishing opportunities in Greenland waters may already be observed. Local fishers and hunters in Disko Bay point to climate change as the likely reason for the ever-changing status of fish and wildlife populations (Danielsen *et al.*, 2016). Sea ice loss affects the entire food web and human communities that rely on sea ice for travel (Eamer *et al.*, 2013). Many marine species, as well as some marine invasive species, have the potential for northward expansion as sea-surface temperatures increase (Fernandez *et al.*, 2014).

There are indications of changes in food webs in the waters around the Faroe Islands (Beaugrand *et al.*, 2010). A northward shift in the distribution of plankton has been observed, which negatively affects gadoid recruitment, with implications on the local cod stock. Some pelagic fish species like Atlantic mackerel and Atlantic herring are at present more abundant in Faroese waters (Sørensen, Roto, & Tunón, 2018) than around a decade ago.

Changes in hydrography due to global warming has resulted in significantly decreased populations of seabirds in the Faroes. In particular, populations of kittiwake (*Rissa tridactyla*), puffin, guillemot (*Uria aalge*), Arctic tern (*Sterna paradisaea*) and seagulls have been affected. On the contrary, species like gannet (*Morus bassanus*), fulmar (*Fulmarus glacialis*), shag (*Phalacrocorax aristotelis*) and black guillemot (*Cepphus grylle*) are less affected (Sørensen, Roto, & Tunón, 2018).

In the ocean-connected and sea-like ecosystems such as those in Näätämö river and Lake Puruvesi, which are crucial ecosystems for both Skolt Saami and Atlantic salmon (*Salmo salar*), climate change will most likely increase water temperatures and cause changes in ice cover thickness and duration. Extreme heat waves and changes in precipitation can also be expected to lead to population declines of species such as Atlantic salmon, vendace (*Coregonus albula*), trout (*Salmo trutta*), grayling (*Thymallus thymallus*), Saimaa ringed seal (*Pusa hispida saimensis*) and other cold-dependant species (Mustonen, 2018a & b).

In the Bothnian Bay, climate change is expected to result in intensified acidification, with potentially significant negative impacts on marine life. Cold water species like burbot (*Lota lota*), salmon, trout, vendace, whitefish (*Coregonus lavaretus*) and herring may be directly negatively affected, while warm water species like perch, pike and roach may increase in abundance. New research (Jonsson *et al*., 2017) predicts that methyl-mercury may increase three to six-fold in zooplankton in the Bothnian Sea through expected biogeochemical and ecological changes, with continued bio-accumulations further up in the food chains.

4.4.3 Indirect drivers

The legislation is the juridical manifest of policies, established by parliament and governmental agencies on a national level. On an international level, intergovernmental bodies such as IMO (International Maritime Organization) or HELCOM may be empowered as lawmakers. Legislation regulates the interaction between people and their activities and between people and nature. The EU is a unique intergovernmental body that operates on different levels of sovereignty, depending on the policy area. For instance, regarding fisheries, the EU member states have transferred all their legislative power to the EU, although the EU has by delegation, returned some of its legislative power to the member states. The Common Fisheries Policy (CFP) concerns four policy areas: conservation policy, structural policy and market policy, and an external dimension. The CFP aims to achieve sustainable fishery. However, a second objective of the CFP is to support and promote the fishing industry and economic development, which may lead to a conflict of interests (Sterner & Svedäng, 2005).

Legislation and protective measures are important indirect drivers for the local economy and regulate how NCP are utilized by local communities. Protective measures taken to enhance sea trout stocks in the Kalix archipelago is an example of how different interests need to be balanced. Local participation is essential to achieve positive results, since many of the actions that need to be taken will affect local culture and use of biological resources. In this case, legislation severely restricts local fishing of other species and is a threat to the survival of fishing communities (Kvarnström & Boström, 2018). Instead, the fishers recommend local co-management based on monitored fishing and regular follow up of population trends.

In most Nordic countries, constructions and other physical changes close to the shoreline are firmly regulated, albeit political and commercial interests often challenge these protection policies. There are exceptions to this approach. On Åland for instance, exploitation is governed by legislation, municipal planning and the homestead right (hembygdsrätt). As Åland has no formal protection of the shoreline, it is the homestead right that regulates who may purchase houses along beaches and shorelines and thereby .

Policies on the other hand, are usually underpinned by legislation, information and economic incentives. Subsidies and taxation are often of crucial importance for the management of fisheries as economic incentives. However, lowering the costs of fishing causes problems with over-utilisation of fishery resources.

Environmental awareness in Nordic countries underpins public demand on environmentally friendly methods and well-functioning NCP. The right of public access to most of the countryside in Nordic countries (exceptions are cultivated grounds or private areas in the vicinity of houses) is an important convention that codifies people's often close relationships to nature. The possibility to bathe publicly in, for instance, the harbour areas of Copenhagen and Malmö or in Stockholm and Helsinki, is also an expression of the high expectations of well-functioning governance systems that respect and maintain NCP. The Sound bridge construction is another example where public environmental awareness has spurned the governance systems to adopt more environmentally friendly approaches (Petersen *et al*., 2018).

Economic development is a key driver in all aspects of human activities exerting influence on nature. All Nordic countries are economically advanced welfare societies, meaning among other things that their "ecological footprint" is considerable in spite of environmental awareness and measures taken to protect nature.

There is a general understanding that a more sustainable economy requires a global reduction in resource use and energy conversion (e.g. Fiksel, 2006). The concept of "decoupling" has been applied to this challenge, meaning "using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken" (UNEP, 2011). Technological development is also of paramount importance for all aspects of human activities exerting influence on nature. There are however numerous trade-offs between prosperity, technological advancements and their ecological impact (e.g. Chertow, 2001).

Demographic changes in population numbers and age structure are important factors that may alter the use of and relationship to nature. All Nordic countries show population ageing due to increasing life expectancy and low fertility rates. As a consequence, the increases in population numbers are rather modest. Population number is factor of great importance on the impact on NCP, however also depending on economic performance and life-style.

A critical indirect driver is the ongoing urbanization. As a part of demographic and economic development, people are moving from rural areas towards bigger municipalities and towns. As a consequence, competition for space is declining in rural areas, whereas competition for space in the urban areas is increasing. However, rural areas that struggle to keep up their population numbers may have benefitted from immigration from other parts of the world, although the bigger cities tend to grow more.[19] As urbanisation proceeds, traditional cultural landscapes are changing. In coastal areas, the urban lifestyle manifests through the conversion of many farmhouses into summerhouses, local communities turn to seasonal living and local inhabitants commute instead of engaging in the local economy. Local fishermen and local farmers disappear, as do domestic animals grazing coastal semi-natural grasslands with implications for biodiversity.

Due to ongoing urbanisation on for instance the Faroe Islands, customary use of biological resources like hunting, fishing and sheep farming – the backbone of the settlement structure – is declining. Over the last decades, Faroese economy has been orienting towards service and knowledge sectors. Furthermore, globalisation has changed traditional preferences and challenged the traditional settlement structure. Today some 40% of the Faroese population live in the growing capital region, whereas just 1% of the population live on small islands without road connection (Hagstova, 2017). This depopulation may change the general attitude towards traditional activities such as the egg-harvest, hunting of some bird species, as well as pilot whale hunting (Sørensen, Roto, & Tunón, 2018).

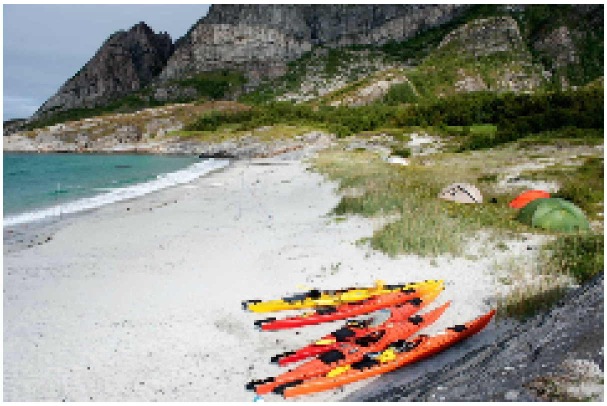
Cultural development has a profound influence on our view of nature. Aesthetic and ethical perspectives on nature and the use of different NCP are usually very important for how governance is developed. The precautionary approach adopted during the construction of a bridge between Denmark and Sweden, as to avoid any large-scale effects on the ecosystem in the short- and long-term, is an expression of caring for nature.

Tourism is an increasingly important cultural and economic indirect driver in Nordic coastal areas. Biodiversity and other NCP are increasingly exploited and capitalised upon in event-related "health" and "wellness" industries. Nature-based wellness tourism is a growing industry that capitalises on the findings that water and water-based nature have a rejuvenating effect on people (e.g. https://www.luke.fi/en/wellness-from-water, viewed on April 17, 2018).

The expansion of tourism may indeed generate new challenges, with higher demands on the development of infrastructure causing negative impacts on ecologically sensitive regions (Thostrup & Rasmussen, 2009). Development can cause disturbances to migrating birds, marinas potentially destruct sheltered bays, wetlands and shorelines.

[19] http://www.scb.se/sv_/Hitta-statistik/Artiklar/Urbanisering--fran-land-till-stad/

Figure 37: Popular recreational activities in the Helgeland area are kayaking, bicycling, riding, hiking, fishing and hunting



Note: These NCP are in principle indirect anthropogenic drivers but attempted arranged to impose minimal impact on nature and its benefits to people through organized tours with a Sustainable Destinations trademark.

Source: www.innovasjonnorge.no

Ecoturism and cultural tourism involve visiting fragile, pristine and relatively undisturbed natural areas. These low-impact activities have become popular in many parts of the Nordic region. Examples include "Blue care" in the Quark area (https://www.luke.fi/en/wellness-from-water/) and recreational activities in the Helgeland area on the Norwegian coast (Fig. 37). Many tourists are interested in familiarising with local traditions and e.g. Saami villages have always been popular for tourists. Ecologically and culturally sustainable tourism is dependent on NCP, as well as the ILK on their sustainable use.

4.5 Knowledge gaps and future monitoring

- We need better knowledge and understanding of the interactions and coupling between different drivers, especially with regard to the dynamics of marine and coastal ecosystems and how such drivers may ultimately influence the provision of various NCP;
- Due to the fact that our knowledge concerning ecosystem function and connectivity always will be limited, it is of paramount importance that management issues are handled according to the precautionary principle;
- As to avoid irreversible losses of biodiversity in coastal areas, both on land and at sea, we need improved monitoring of natural and semi-natural environments and their biodiversity for planning purposes. We also need to impose an overriding legal perspective that ensures commitment for implementation of effective management processes;
- Integrated approaches should be sought for and "good practice" examples should be explored and utilised in practical management;
- The impact of tourism on fragile environments needs to be evaluated and monitored;
- In some cases, we lack knowledge regarding how different decisions and regulations may affect biodiversity, NCP and people's opportunity to use them.

4.6 Policy Recommendation

- It is recommended to safeguard the right to public access and to protect the coastal environments from further exploitation, since seashores and natural environments close to cities are increasingly under threat due to privatisation and exploitation. New constructions in unexploited areas should be avoided as far as possible;
- Better management and conservation of the "naturalness" of landscapes in order to preserve and/or improve NCP;
- The knowledge from cultural traditions and closeness with nature in many ILK communities needs to be included in stakeholder processes towards an environmentally, socially, economically balanced and sustainable society;
- Nordic societies, together with other partners, should draw benefits from technological development. This enables change towards a less-energy dependent society and thus promotes "decoupling" of economic development from expanding resource utilisation;
- A target of zero emissions of greenhouse gases should be set for the whole Nordic community by endorsing carbon capturing tecniques;

- In this study, the successful, albeit unintentional protection of the fish stocks in the Öresund by the trawling ban is highlighted as an interesting aspect of fisheries management. Experiences such as this kind of *partial* protection of an entire watershed should be used in future development of Marine protected areas (MPAs);
- Nordic countries should be in the forefront for advocating and developing best practices in coastal areas for ecologically and culturally sustainable economic development, using ILK and tradition.

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5. Analysis of interactions between Biodiversity (B), Ecosystem Services (ES), and Nature's Contributions to People (NCP)

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Box 11: Summary

The conceptual IPBES framework has been used in the Nordic countries for developing an integrated approach for assessing the relationship between nature and humans. The challenge is to establish the link between Biodiversity (B), Ecosystem Services (ES) and NCP at and across different scales. To synthesize this relationship between (B), (ES), and (NCP), this chapter provides a qualitative expert-based analysis of the information provided in chapters 1, 2, 3, 4 and 6; and from 5 case studies located in different Nordic countries. The perspectives from the Indigenous and Local Knowledge (ILK) communities indicate tensions between general management goals and local vested interests. Knowledge gaps and future perspectives provide guidance for further work and management actions. The policy recommendation suggests the urgency for mainstreaming biodiversity and ecosystem services in all policies.

5.1 Introduction

5.1.1 An integrated approach to assessing the relationship between nature and humans at and across different scales

Biodiversity, in a broad perspective, is closely connected to the functioning and structure of ecosystems and to the services they provide in terms of social, economic and cultural values (Millennium Ecosystem Assessment (MA), 2005). The relationships between Biodiversity (B), Ecosystem Services (ES), Nature's Contributions to People (NCP) and Governance needs further attention to untangle the complexities underlying these processes interacting across spatial scales and changing over time as part of a global Complex Adaptive System (CAS) (Levin, 1998). There is the urgency to develop strategies that promote the conservation of Biodiversity (B) and the attached ES for the sustainable use of ecosystems (Naeem *et al*., 2012; Perrings *et al*., 2010; Mace *et al*., 2015).

Recent studies suggest the need for a more integrative operational networks approach (Dee *et al.*, 2017). A network specifying how people benefit from nature and how human activities influence ecosystems. Both societies and nature change over time. Management therefore has to mirror these changes to provide a sustainable management framework that will form the basis for a better understanding of the interactions between ecosystem processes and societal needs, and how ecosystem services may change in both time and space. There is also the need to provide an assessment of ES in terms of risks and threats related to each ES. The assessment needs to underpin human well-being and how this is related (Maron *et al.*, 2017) to both changes in ecosystem function, societal dynamics and economic growth. In particular, there is also a need to re-visit the concept of valuation of ES (Gunton *et al.*, 2017; Bateman *et al.*, 2013) to embrace the perception of different stakeholders, especially including the ILK perspective, thus adequately representing the different sectors of society.

The conceptual IPBES framework (Díaz *et al.*, 2015 (see Ch. 1) has been used in the Nordic countries for developing an integrated approach for assessing the relationship between nature and humans and in particular, the link between Biodiversity (B) and Ecosystem Services (ES) at and across different scales. In this chapter, we synthesize the information provided in chapters 1, 2, 3, 4 and 6 with reference to specific case studies from different Nordic countries, including perspectives from ILK communities.

5.2 Qualitative comparative analysis based on expert judgements

We have provided a qualitative comparative analysis including the ILK perspective, based on expert's judgements using a Delphi analysis approach. The experts who have carried out the analysis are those who have contributed to this report. The set of concepts and criteria for the Delphi qualitative analysis were selected by common agreement from the experts and applied to a selected set of case study areas (Tunón, H. (Ed.). (2018). The analysis included the following case studies:

- Helgeland;
- Disko Bay;
- Öresund;
- Kvarken;
- Lumparn.

5.2.1 Methods: Delphi Analysis

The Delphi method approach using expert knowledge (Norman & Olaf, 1963) was used for ranking Ecosystem Services (ES) according to different criteria. A selected set of specific questions were developed, adapting our approach to the information and methodology in ICES (2014) and Tam *et al.* (2017). The high-level criteria used for assessing ES in relation to Biodiversity in the case studies are based on the following concepts:

1. *Availability of underlying data (Measurable ES). Existing and ongoing data*: Information on the relevant ES was selected dependent on availability and monitoring practices – *Relevant spatial coverage*: evaluate whether the spatial coverage of the ES considered in the individual case studies is sufficient – *Relevant temporal coverage*: evaluate whether the temporal coverage of the ES considered in the individual case studies is sufficient;
2. *Reflect changes in ecosystem component and biodiversity.* Take in to consideration how the ES are linked and de facto reflect changes in ecosystem components and biodiversity;
3. *Conceptual (Theoretical Basis) linking ES to Biodiversity.* Take in to consideration existing scientific literature linking ES to biodiversity processes;
4. *Communication and Public Awareness.* Evaluate if the concept describing the link between ES and biodiversity is understandable to the general public;
5. *Management. Relevant to management*: consider if the monitored ES is relevant for management – *Management thresholds (targets) estimable*: consider if the ES has actual management thresholds (targets) relating to the maintenance of ES in relation to biodiversity processes – *Cost-effectiveness*: consider if the acquisition of information for each of the ES considered is cost-effective to maintain.

We also developed an *Ecosystem Services – post criteria evaluation* to report information through cross-referencing between the different chapters: *Ecosystem services correlation with a societal attribute*; *Current Economic Value*: information of the current economic values linked to the ES considered in the cases studies – *Ecosystem services association with ecosystem component:* this information will provide a list of the ecosystem component linked to biodiversity processes that are relevant for the ES considered in the case studies – *Impact of drivers on ES*: provide a list of the main drivers linked to the ES for each case study.

The set of questions for the following criteria categories were selected:

- Criteria 1. Availability of underlying data (Measurable ES):
  - Existing and ongoing data;
  - Relevant spatial coverage;
  - Relevant temporal coverage.
- Criteria 3. Conceptual (Theoretical Basis) linking ES to Biodiversity:
  - Scientific credibility;
  - Associated with key biodiversity processes;
  - Unambiguous.
- Criteria 5. Management:

– Relevant to management;
– Management threshold (targets) estimable;
– Cost-effectiveness.

In order to review the Ecosystem Services (ES) against the different criteria above, we proposed to use a modified Delphi method approach (ICES, 2014). The ranking applied was 0= not met, 1= partly met, 2= fully met. The score was expressed as percentage of the total available score (i.e. max score x number of categories, 2 x 11 = 22), as suggested from other studies (ICES, 2014 and Tam *et al.*, 2017). In our particular case the list of provisioning, regulating and maintenance, and cultural ecosystem services has been modified from the CICES Group and Class and TEEB, as relevant for coastal marine ecosystems (Fig. 38).

Figure 38: Modified CICES Group and Class and TEEB as relevant for coastal and marine ecosystems

CICES Service Section	CICES division		Modified CICES Group and Class (as relevant for coastal and marine ecosystems), items from TEEB	examples/explantations
Provisioning services	Nutrition	P1	Fisheries (commercial)	Fish, shellfish, crustaceans, mammals, birds, algae (etc.) and their outputs used for food (such as collecting bird eggs for food, etc.)
		P2	Aquaculture (commercial)	
		P3	(Artisanal) Fishing	
		P4	(Artisanal) Hunting	
		P5	Algae and other plants	
		P6	other/ additional	
	Water	P7	Sea water	Seawater used for industrial purposes, such as cooling (possibly also desalination)
	Materials	P8	Raw materials	Fibres and other material from plants, algae, and animals for direct use or processing (including agricultural use and genetic materials from biota), as well as medicinal and ornamental use
		P9	Genetic resources (DNA)	
		P10	Medicinal resources	
		P11	Ornamental resources	
		P12	other/ additional	
	Energy	P13	Biomass based energy sources	e.g. algae for energy, burning seal or whale oil for light
		P14	other/ additional	
		P15	other/ additional	
Regulating and maintenance	Meditation of waste, toxics and other nuisances	R1	Waste treatment	mediation of waste by biota and ecosystems (their ability to remove or store pollutants, e.g. bioremediation by organisms, filtration, storage and accumulation)
		R2	Air purification	
		R3	other/ additional	
	Mediation of flows	R4	Coastal erosion prevention	Mass stabilization and control of erosion rates, flood protection (etc.)
		R5	Regulation of water flows	
		R6	other/ additional	
	Maintenance of physical, chemical and biological conditions	R7	Climate regulation	Lifecycle maintenance, habitat and gene pool protection (dispersal and maintenance of nursery population and habitats, gene pool protection); pest and disease control; decomposition and fixing processes; chemical condition of water; climate regulation (by reduction of greenhouse gas concentration)
		R8	Nutrient regulation	
		R9	Biological control	
		R10	Disturbance prevention or regulation	
		R11	other/ additional	
		R12	other/ additional	
Cultural sevices	Physical and intellectual interactions with biota and ecosystems, and seascapes	C1	Recreation, swimming, diving	Experimental and physical use (e.g. many activities of recreation, swimming, diving, leisure fishing, etc.), scientific, educational, heritage, entertainment, technology (such as robotics) and aesthetic interactions
		C2	Leisure fishing and hunting	
		C3	Aesthetic information/ interactions, sea/ landcape	
		C4	Information for scientific and education, cognitive development	
		C5	Cultural heritage and identity	
		C6	Inspiration for Art, Media, and Design, and Technology	
		C7	other/ additional	
		C8	other/ additional	
	Spiritual, symbolic and other interactions with biota, ecosystems, and seascapes	C9	Symbolic values	Symbolic, sacred and/ or religious, as well as existence and bequest values;
		C10	Spiritual, sacred, and/ or religious experience	
		C11	Existence and bequest values	
		C12	other/ additional	
		C13	other/ additional	

The results of the Delphi analysis for the respective case studies are presented in Annex A.

5.2.2 Methods: MAES land-sea cover based ecosystem service assessment across Nordic coastal seas

Case study experts were asked to evaluate different MAES and EMODnet Seabed ecosystem type's capacity to deliver ecosystem services using a three-step evaluation criteria (values 0, 1 or 3). The lists of evaluated ecosystems is based on the case study GIS frames, so every expert answered only to those ecosystem types that were adjacent to their area of expertise. The selected ecosystem services were the same as for the Delphi analysis and followed the CICES categories for all case studies. All the case study specific matrices used for the evaluation are presented in Annex B. The major ecosystem types including the seabed habitats from Emodnet and the MAES ecosystem typologies are listed in Figure 39. The MAES and Emodnet Seabed habitat (land or sea cover) classes were listed based on the case study and each class role in the delivery of ecosystem services was coded with 0–3 to selected CICES ES classes. In this Nordic IPBES-like coastal ecosystem assessment, an expert-based evaluation of the major ecosystem types determining their capacity to deliver ecosystem services was carried out. The approach was tested using MAES ecosystem types and EMODnet Seabed types, along with GlobCover land-cover types for Greenland, as a basic biotope categorization. The evaluation was carried out by a limited number of case study experts who know their region well.

Expert views were gathered for five out of nine case studies: Disko Bay (Greenland), Helgeland (Norway), Öresund (Denmark-Sweden), Kvarken (Finland-Sweden) and Lumparn (Åland). The method was not considered applicable to the following case studies: Puruvesi and Näätämö (Finland), Kalix (Sweden), Faroe Islands and Iceland. Condition of available Seabed data classes was assessed only at Helgeland and Kvarken. Condition was evaluated with three classes (green, yellow, red, which indicated good, slightly degraded and stongly degraded conditions of the ecosystem) in relation to four attributes: structure of, function by, trophic levels of biota in, and pressures to each habitat type. The principles of this methodology and further background information related to the MAES land-sea cover based ecosystem service assessment across Nordic coastal seas are explained in Chapter 1.

Figure 39: Major ecosystem types including the seabed habitats from EMODnet and the MAES ecosystem typologies

Major ecosysten types	MAES ecosystem typologies
Coastal dunes, rocks	B1 - Coastal dunes and sandy shores
	B2 - Coastal shingle
	B3 - Rock cliffs, ledges and shores, including the supralittoral
Surface waters	C1 - Surface standing waters
	C2 - Surface running waters
	C3 - Littoral zone of inland surface waterbodies
Wetlands	D1 - Raised and blanket bogs
	D2 - Valley mires, poor fens and transition mires
	D3 - Aapa, palsa and polygon mires
	D4 - Base-rich fens and calcareous spring mires
	D5 - Sedge and reedbeds, normally without free-standing water
	D6 - Inland saline and brackish marshes and reedbeds
Grasslands	E1 - Dry grasslands
	E2 - Mesic grasslands
	E3 - Seasonally wet and wet grasslands
	E4 - Alpine and subalpine grasslands
	E6 - Inland salt steppes
	E7 - Sparsely wooded grasslands
Shrublands	F1 - Tundra
	F2 - Arctic, alpine and subalpine scrub
	F3 - Temperate and mediterranean-montane scrub
	F4 - Temperate shrub heathland
	F5 - Maquis, arborescent matorral and thermo-Mediterranean brushes
	F6 - Garrigue
	F7 - Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff vegetation)
	F8 - Thermo-Atlantic xerophytic scrub
	F9 - Riverine and fen scrubs
	FB - Shrub plantations
Woodlands	G1 - Broadleaved deciduous woodland
	G2 - Broadleaved evergreen woodland
	G3 - Coniferous woodland
	G4 - Mixed deciduous and coniferous woodland
	G5 - Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice
Land habitats with sparse vegetation (including permanent ice and snow)	H2 - Screes
	H3 - Inland cliffs, rock pavements and outcrops
	H4 - Snow or ice-dominated habitats
	H5 - Miscellaneous inland habitats with very sparse or no vegeation
Arable and cultivated land	I1 - Arable land and market gardens
	I2 - Cultivated areas of gardens and parks
Urban, industrial and contructed land	J1 - Buildings of cities, towns and villages
	J2 - Low density buildings
	J3 - Extractive industrial sites
	J4 - Transport networks and other constructed hard-surfaced areas
	J5 - Highly artificial man-made waters and associated structures
	J6 - Waste deposits
Coastal and marine littoral and benthic habitats	A1 - Littoral rock and other hard substrata
	A2 - Littoral sediment
	A3 - Infralittoral rock and other hard substrata
	A4 - Circalittoral rock and other hard substrata
	A5 - Sublittoral sediment
	A6 - Deep-sea bed
Estuaries and lagoons	X1 - Estuaries
	X2_3 - Coastal lagoons
	A12 - Littoral rock or sediment
	A128 - Littoral rock or sediment and sea ice
	A34 - Infralittoral and circalittoral rock and other hard substrata
	A348 - Infralittoral and circalittoral rock and other hard substrata and sea ice
	A18 - Littoral rock and other hard substrata and sea ice
	A28 - Littoral sediment and sea ice
	A58 - Sublittoral sediment and sea ice
	A68 - Deep-sea bed and sea ice
	0 - Unclassified
Seabed habitats EMODNET	A3.4: Baltic exposed infralittoral rock
	A3.5: Baltic moderately exposed infralittoral rock
	A3.6: Baltic sheltered infralittoral rock
	A4.4: Baltic exposed circalittoral rock
	A4.5: Baltic moderately exposed circalittoral rock
	A4.6: Baltic sheltered circalittoral rock
	A5.13: Infralittoral coarse sediment
	A5.14: Circalittoral coarse sediment
	A5.23 or A5.24: Infralittoral sand or infralittoral muddy sand
	A5.25 or A5.26: Circalittoral fine sand or circalittoral muddy sand
	A5.33 or A5.34: Infralittoral sandy mud or infralittoral fine mud
	A5.34: Infralittoral fine mud
	A5.35 or A5.36: Circalittoral sandy mud or circalittoral fine mud
	A5.35: Circalittoral sandy mud
	A5.36: Circalittoral fine mud
	A5.43: Infralittoral mixed sediment
	A5.44: Circalittoral mixed sediment
	Na

5.3 Results and Discussion

5.3.1 MAES land-sea cover based ecosystem service assessment across Nordic coastal seas

Cultural and regulating ecosystem services got higher values compared to the provisioning services. *Inspiration for Art, Media, and Design, and Technology* (C4) has the highest average points (26.2). Other ecosystem services found to be among the most important ones were *Nutrient regulation* (R8, 25.5*), Information for scientific and education, cognitive development* (C4, 24.3), *Biological control* (R9, 23.5), *Genetic resources (DNA)* (P9, 22.8), *Existence and bequest values* (C11, 20.8), *Disturbance prevention or regulation* (R10, 20.3), *Climate regulation* (R7, 19.0), *Waste treatment* (R1, 18.2), *Aesthetic information/ interactions, sea/landscape* (C3, 18.2), *Recreation, swimming, diving* (C1, 17.0), and *Cultural heritage and identity* (C5, 17.0).

In Greenland the highest importance values were given for *Existence and bequest values* (C11, 3.0) and *Inspiration for Art, Media, and Design, and Technology* (C6, 3.0). In Helgeland the highest value was given to *Leisure fishing and hunting* (C2, 2.3), but provisioning services such as *(Artisanal) Fishing* (P3, 1.5) and *(Artisanal) Hunting* (P4, 1.9) also got significant points. In Öresund *Recreation, swimming, diving* (C1, 1.3*), Aesthetic information/ interactions, sea/landscape* (C3, 1.0), and *Information for scientific and education, cognitive development* (C4, 1.0) were appreciated, but also several others were noted to have importance, for example *Fisheries (commercial)* (P1, 0.7), *Waste treatment* (R1, 0.7), and *Nutrient regulation* (R8, 0.7). In Kvarken *Inspiration for Art, Media, and Design, and Technology* (C6, 1.8), *Information for scientific and education, cognitive development* (C4, 1.6), *Nutrient regulation* (C8, 1.6), *Waste treatment* (R1, 1.6), and *Genetic resources (DNA)* (P9, 1.5) were among the most important ecosystem services. In Lumparn *Recreation, swimming, diving* (C1, 0.9), *Nutrient regulation* (R8, 0.9), *Regulation of water flows* (R5, 0.9), and *Genetic resources (DNA)* (P9, 0.9) got the highest importance values.

The used methodology has its limitations. For instance, areas are different in size, population, ecosystem service bundle profiles and ecosystem condition. The differences in socio-ecological context of the areas and historical events also provide major dissonance. Therefore, straightforward summing and statistical analysis is not the best way to interpret results. The stochastic variability between different expert knowledge and opinions would decrease by increasing the number of respondents and experts to fill in the matrix. However, the purpose of this exercise was to provide an equal conceptual framework and a synthesis for evaluating the importance of different ecosystem services and ecosystem types providing these services. This information is in addition to local experts' very detailed case study information (see Case Study report, MAES-EMODnet evaluation Annex B) and the Delphi survey (Annex A). Thus, this synthesis aims to serve as additional material for the synthesizing of the outcomes of the Nordic IPBES-like coastal ecosystem assessment

5.3.2 *Condition assessment for key MAES ecosystem types*

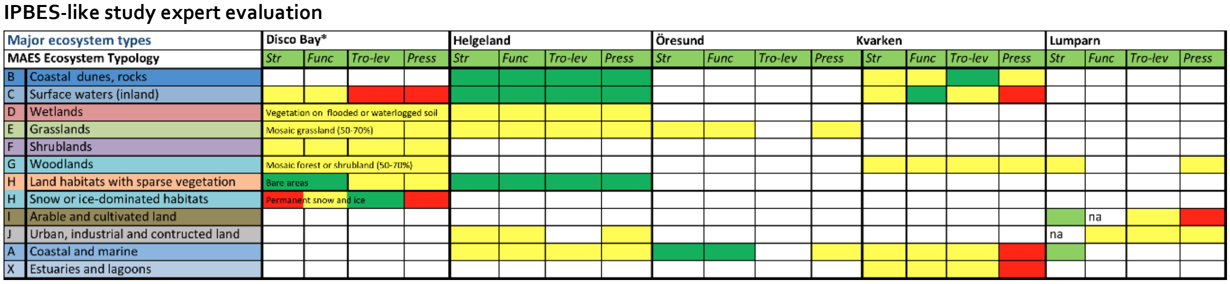
Assessment of the capacity of ecosystems to deliver NCP is a part of the European Union's Biodiversity Strategy 2020 coordinated by the MAES expert group, while the assessment of the benefits of the improvements and costs of degradation are part of the integrated natural capital accounting (INCA) process. Improving our understanding of the condition of ecosystems will help to assess their capacity to deliver ecosystem services. Practically, this means that if we could get improved knowledge on the condition of various coastal land cover types, for instance based on the Corine Land Cover database and coastal & marine ecosystem types using EMODnet and Marine-WISE, a better spatially-explicit quantification of ecosystem services would be possible. Further, such information would be useful also for management and spatial planning practices.

Following the MAES ecosystem typology (see Ch.1) the ES were evaluated for each coastal ecosystem types. The qualitative assessment considered the aspects reported in Figure 40. Please note that the Sound case study was omitted from this evaluation since the assessment was only partially completed.

If the structure was assigned as *degraded*, this meant that some key species of the ecosystem type are endangered or not present. Accordingly, *degraded function* meant that some of the critical functions delivering ecosystem services are degraded, while *degraded trophic levels* meant that food webs are not functioning and particularly top-down control in the ecosystem is hampered.

In general, most of the ecosystem types were assessed to be in good condition or slightly degraded (Fig. 40).

Figure 40: Summary of the ecosystem condition assessment of the different ecosystem types in the case study areas based on Nordic-IPBES-like study expert evaluation



Note: The various MAES ecosystem subtypes within each Typology group are pooled and only one evaluation is presented for each group. In case of several assessed habitats under each group, the worst assessment class is presented. Str= Structure of the ecosystem, Func= Function of ecosystem, Tro lev= trophic levels, and Press= Pressures. The color coding is: green= good condition, yellow= slightly degraded; red = strongly degraded. *Converted from GlobCover classes.

Only in some case study areas were the attributes strongly degraded. The overall comparison of the different coastal ecosystem assessments in the five case studies showed that the terrestrial coastal ecosystem types, including wetlands, grasslands and woodlands, along with inland surface waters, were considered slightly degraded (Fig. 40) in all case studies except Helgeland. The marine coastal ecosystem types were mostly considered to be slightly degraded and strongly degraded in all case studies. This indicated that in general, the perception was that the coastal ecosystem types were not delivering their full potential to sustain ecosystem services. More detailed results are provided in Annex B and some specific features of each case study are mentioned below.

In Greenland, *Bare areas* or "sparse areas" with a vegetation cover|<15% were assessed to be in good condition (green) for *structure* and *function*. Areas covered by *permanent snow and ice* (such as glaciers) were considered to be in good condition for *trophic levels*, but serious degradation (red) in *structure* and *pressures*. *Water bodies* scored high for degradation of trophic levels and pressures such as climate driven changes. Other land-cover classes showed some degradation and were coded yellow. Despite low human population and the remote location of Disko Bay, the perception of the ecosystem condition was lowest in the Greenland case, which indicates that localized pressures in the Arctic region are considered to be major drawbacks in ecosystem services delivery.

In Helgeland and Kvarken, coastal seabed habitats were included in the assessment. In Helgeland, the *Infralittoral seabed* (photic zone, soft bottom, dominated by sea grass habitats) was assessed to have some degradation in all four attributes, and noted pressures were eutrophication, light availability in coastal ocean "ocean darkening", and infrastructure. *Rock and other hard substrata* (both *Infralittoral* and *Circalittoral depth zones)* and the soft bottom seabed down to 200m (*Circalittoral seabed*) were all assessed to be in good condition. The main pressures, such as warming of the sea surface temperature, were expected to have a positive impact on more shallow (*Infralittoral)* rock and other hard substrata. In Kvarken all coastal underwater habitat types (*Littoral rock and other hard substrata*, *sediments*, *rock and other hard substrata* (*Infralittoraland Circalittoral*)), all types of soft bottoms below the littoral zone, as well as the *estuaries* and *Coastal lagoons* showed some degradation, while *soft sediments and estuaries* in general were considered to be strongly degraded. The pelagic coastal waters were assessed to be in good condition. In Kvarken the trophic levels of the terrestrial habitats *Rock cliffs, ledges and shores,* including *the supralittoral* coastal type, were assessed to be in good condition. Other attributes were evaluated as having some degradation. Pressures were assessed as seriously degraded to *Surface running waters* (lower parts of coastal rivers).

In Helgeland, the terrestrial ecosystem types *Low density buildings*, *Mesic grasslands*, and *Raised and blanket bogs* were evaluated to have some degradation in relation to all four parameters. Pressures such as depopulation and reduced grazing were identified. The remaining assessed habitat types and parameters were categorized to have some degradation.

In Öresund, the coastal underwater habitat *sublittoral sediments* were evaluated to be in good condition for structure and function, but some degradation was observed with pressures including x, y and z. *Mesic grasslands* were noted to have some degradation and coastal and marine areas are under increased pressure.

In Lumparn, *arable land and market gardens* were marked to be under serious pressure, however changes in the ecosystem structure were not detected. Trophic levels were also estimated to have some degradation. *Cultivated areas of gardens and parks* were assessed to be in good condition. The structure of *circalittoral rock and other hard substrata* and all other assessed classes were categorized as having some degradation.

5.3.3 Applicability and limitations of the ecosystem assessment method

The challenge was to develop a consistent assessment approach across all case studies and their different ecosystem types. The purpose of the assessment was to judge how ecosystem condition is linked to the provision of ecosystem services in each case study. There is a growing need to develop unified approaches and methods to evaluate ecosystem condition.

The current approach provides useful trends, but is based on expert knowledge that may, to a certain extent, be biased and subjective. For example, baselines may differ from case to case. A larger number of experts would reduce potential bias and quantification degradation levels could help to reduce subjective baselines. Expert knowledge on terminology applied, including specific habitat typologies of MAES or EMODnet Seabed categories, is required. Overlaps between habitat typologies could be avoided by improved understanding of methodologies. Further emphasis on coastal terrestrial habitats would be beneficial, but the exercise was somewhat too ambitious in relation to the resources available.

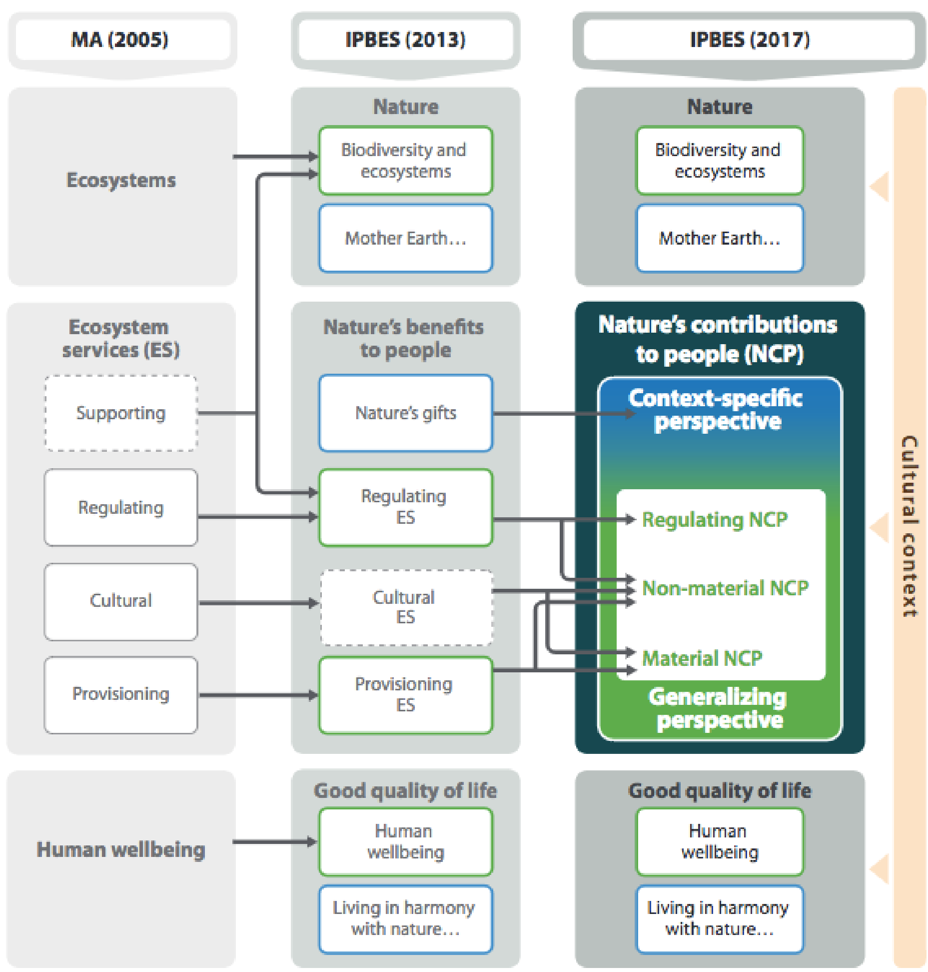
More of these simple and robust assessment approaches are increasingly needed, not only for regional IPBES assessments, but also for implementation of national environmental policies and strategies for sustainable development and reporting for international environmental agreements, such as the CBD and the European Commission. Harmonized data sources, use of GIS data sets in a synchronized manner and the application of Earth Observation data form the future basis of monitoring of biodiversity and ecosystem services (Vihervaara *et al*., 2017; Cord *et al*., 2017).

5.3.4 Indigenous and Local Knowledge (ILK) case studies

After thorough consideration, the Delphi method was considered to be inapplicable to the general perceptions of ILK communities and hence a separate discussion regarding the connection between nature and people is presented here. In the global context, the concept of ecosystem services has been challenged from indigenous peoples and local communities, but also from conservation biologists, since the evaluation and quantification of the different services are objectively non-comparable. In theory, estimates can be made of the monetary value of provisioning and some regulating ecosystem services, but cultural, social, spiritual and intrinsic values are more difficult to measure or even non-measurable.

Defining and classifying categories of ecosystem services, representing unidirectional flows from ecosystems to people and connecting feedback mechanisms as drivers of change, has often proven to be a challenge. However, knowledge systems of many indigenous peoples and local communities, as well as relational approaches in environmental-social sciences and humanities, conceive the linkages between nature and people without strict boundaries between them and in relations based on reciprocity, with human obligations towards the non-human parts of the world. Theoretically, the development in concepts and terminology has been very rapid. The term ecosystem services was formally established with the Millenium Assessment 2005 (Millennium Ecosystem Assessment., 2005. Washington, DC, Island Press.). IPBES has developed the conceptual framework (Fig. 41) and terminology to further more explicitly include "other knowledge systems", specifically ILK. The overarching term changed from "Nature's Benefit to People" (NBP) to "Nature's Contribution to People" (NCP): *The element "nature's benefit to people" was adopted by IPBES Second Plenary, and further developed into NCP by IPBES Fifth Plenary in order to fully capture the fact that the concept includes all contributions to people, both positive (benefits) and negative (detriments)* from Diaz *et al.*, 2018 Supplementary Material (http://science.sciencemag.org/content/sci/suppl/2018/01/18/359.6373.270.DC1/aap8826-Diaz-SM.pdf))

Figure 41: Aesthetic and ethical perspectives on nature and the use of NCP are important for how governance is developed



Note: Where cultural ecosystem services were part of the classification of MA 2005, IPBES has established culture as a mediator in the relationship between people and all NCP.

Source: Diaz *et al.*, 2018 Supplementary Material for Assessing nature's contribution to people.

The Multidisciplinary Expert Panel of IPBES also proposes that the term Nature's Contributions to People can be used when referring to "Ecosystem Services" (ES). Discussions of the implication of this change in terminology underline that we need to use the terminologies side by side, as we cannot differentiate directly between them. The notion of "ES" is also problematic in a Nordic context, particularly when it comes to the perception of indigenous peoples and local communities. It is generally disputed by the ILK communities, that the concept of ES reduces the value of nature to merely a supplier for goods for mankind. However, most ILK communities consider people as a part of nature, with responsibilities for maintaining its values. Nature's value is intrinsic. One of the limitations of ES is that the strong actors in the market are the ones that can most easily present financial arguments in favour of their own sector. Efforts to estimate the value of ecosystems may thus serve to preserve already existing power imbalances and therefore seldom takes the multiple parallel uses of resources in to account (Tunón *et al*. 2015). However, in the present Nordic IPBES-like study, we do not make any attempt to estimate the gross value of ecosystems services, but instead assess the importance of biodiversity for the available ecosystem services (or NCP), including available monetary statements. For instance, the monetary valuation of forestry or fishery is readily available, likewise there are a number of studies that make an effort to value non-market benefits, such as subsistence/household berry picking, hunting, herding etc.

Secondly, indigenous peoples such as the Inuit, Saami and other local communities with traditional lifestyles, typically view themselves as part of nature – a system that is structured by a web of mutual relationships and obligations, not one defined by a one-way flow with humans as the ultimate beneficiaries (Mustonen, 2009, Mustonen & Mustonen, 2016). Nature is generally not seen as a system with the sole purpose to provide for the human society, but a system of intrinsic values where man and her use are subordinated. The expression that "the local community belongs to the land" is often used and in that worldview, it is an immoral act to abuse natural resources or to jeopardize the future delivery of gifts from ecosystems. Based on such conceptions, we should not impose a quantitative (monetary) comparison, implying that trade-offs in terms of potential land uses have no moral content. Decisions on land use should not be based mainly on measurement-based information (Arctic Council, 2013).

Recent scientific discussions regarding Saami indigenous knowledge (e.g. Lehtinen & Mustonen, 2013; Pecl *et al*., 2017) suggest that ILK is a knowledge paradigm with its own merits. Knowledge on lands and ecosystems from these communities has been called "earth views" (Tunón, 2009). This indigenous and local-traditional epistemological context looks at the places and ecosystems as holistic wholes, i.e. for example songs, poems and oral expressions of traditional knowledge are closely related to nature-based activities such as fishing or hunting. Earthviews (Lehtinen & Mustonen, 2013) are one way of analyzing these place-based readings of socio-ecological systems. Change and event emerge as key intellectual apparatus in this process. If an ILK observation of a change is positioned into a dialogue with a scientific view of the same issue, interesting and important new discoveries may emerge, as has been the case of southern insect species spreading to the Näätämö basin, to name one example (Pecl *et al*., 2017).

Linking indigenous knowledge with scientific knowledge in different assessments globally, is developing both within and outside IPBES, for example regarding climate change (Alexander *et al*., 2011). However, the difficulties of conveying the millennia-old relationships that the indigenous and local-traditional peoples have with their homelands should be recognized (Mustonen, 2009; Arctic Council, 2013). Most of the case studies in this assessment contain various proportions of contributions of ILK. However, for some of the case studies the ILK perspective is dominant and hence a methodology with a stronger focus on qualitative indicators is used. The ILK case study areas have been chosen based on their illustration of important aspects of human – ecosystem relationships. The importance of NCP has not been ranked in these case studies, as all NCP have inherent values for local communities with long-term engagements and "earth views" of their localities.

The value and importance of joint fact-finding, co-production of knowledge and co-governance, where scientists, indigenous and local communities and policy-makers create more policy-relevant and scientifically robust, knowledge basis for future management and policy decisions should be stressed (e.g. Saarikoski & Raitio, 2013).

ILK views on provisioning systems are provided in this study, but it is important to stress that these systems are concurrently perceived as cultural and spiritual services to the local people. For instance, artisanal fishing is a provisioning service as the actual activity in itself is part of a lifestyle and constitutes an important contributor to the local quality of life. The removal of the possibility to continue with a customary fishing practice is often a serious threat or harm to the cultural and social structures of the local community and may lead to economic and social tragedies. To describe the ILK perspective is therefore an important measure to visualise cultural and spiritual ecosystem services entangled with provisioning services. Understanding the ILK perspective highlights the intrinsic values of nature and their importance for quality of life.

Quantitative assessments are often, from an ILK point of view, a misguided way to evaluate the local dependence on different ecosystem services. Most often, local communities are dependent on several different provisioning services and feel that these cannot be weighed against each other. In some rural areas, diversification is both a survival strategy and a choice of lifestyle, and the subsistence lifestyle has become a quality of life in itself. Very often, the ILK systems have been built on communal systems of harvests, suffering from the trend towards more individualistic processes of production. Small-scale customary use is often performed for subsistence purposes, but for instance, at irregular intervals a surplus of the catch from fishing is sold. This visualises the conflict between large-scale commercial uses of biodiversity and traditional small-scale customary use. Changes in customary use of ecosystem services are often inflicted by external drivers, like regulations regarding resource management or competing resource use. Within ILK systems there are processes of, for example, limiting self-harvest of Atlantic salmon (Mustonen & Mustonen, 2016) in years of low stocks, along with ongoing ILK discussions regarding local governance of subsistence fishing in the Northern Gulf of Bothnia (Nilsson & Tivell, 2009; Nilsson *et al*. 2012). This implies systems of endemic or place-based resource management, which is closely linked with customary uses.

In the case studies we provide examples of specific elements of ILK in the Nordic space in the context of nature, ecosystems and governance, including co-management (Tunón *et al*., 2018). ILK is in a strong place to assess the cultural services. Excellent and credible community-based monitoring examples exist across the Nordic space. These are highlighted to provide on the ground examples of the detection of change, arriving species, amounts and quality of species. Additionally, a number of key examples where place names, oral histories and ILK can position long-term ecological change to a positive dialogue with sciences to offer nuanced and deep readings of these places and change are presented in the report.

5.3.5 Results from the Delphi analysis across the case studies

The Delphi analysis was carried out for the following Case Studies:

- Helgeland;
- Disko Bay;
- Öresund – the Sound;
- Kvarken;
- Lumparn.

The ILK provided the information using a narrative format based on knowledge in section 5.3.1 of this Chapter.

The ES that scored highest are reported for each Case Study in Figure 42. The ES categories are reported in quotation marks below to reflect Figure 42 and 43.

For the Provisioning ES, "Fisheries (Commercial)" was a common feature across the five case studies; ("Artisanal Fishing"), was represented in three of the case studies: Disko Bay, Öresund-the Sound and Kvarken. "Algae and Other Plants", scored higher in Helgeland but not in the other case studies. "Aquaculture (Commercial)" has the highest score for Helgeland and Kvarken. "Artisanal (Hunting)" was present as an ES in Disko Bay and Lumparn. "Raw Materials" in Öresund-the Sound; and "Sea Water" in Lumparn. For the Regulating and Maintenance ES, "Waste Treatment", was present in four of the case studies except for Kvarken. "Nutrient Regulation", scored highest in Öresund-the Sound, Kvarken and Lumparn. "Air Purification", in Helgeland and Disko Bay, while "Climate Regulation", was surprisingly found only in Helgeland. "Disturbance Prevention or Regulation" only for Kvarken and "Biological Control" only for Lumparn. When it comes to Cultural ES, "Leisure Fishing and Hunting" was found across all case studies, while "Cultural Identity and Heritage" was found for four case studies, except for Öresund-the Sound. "Aesthetic Information/Interactions/Sea/ Landscape" was found for Helgeland and Öresund-the Sound, while "Recreation Activities" and "Existence and Bequest Values" was only found for Disko Bay and

Lumparn respectively. "Information For Scientific And Education, Cognitive Development" was present for the Sound and Kvarken.

In Figure 43, the ES that scored lowest provided an indication that these ES need more attention in order to have sufficient information for providing a qualitative assessment. In particular the Cultural Service: "Cultural Heritage and Identity" was only present for Öresund-the Sound. For the Provisioning ES, "Ornamental Resources" was present only for Helgeland, while "Genetic Resources (DNA)" was found for Helgeland and Disko Bay. "Medicinal Resources" was present for Helgeland, Disko Bay and Kvarken. "(Artisanal) Fishing" was in common for Helgeland and Lumparn and "Sea Water" for Helgeland, Disko Bay and Kvarken. "Biomass Energy Based Resources", "Algae and Other Plants" and "Raw Materials" was found for Disko Bay, Kvarken, and Lumparn respectively. For the Regulating and Maintenance ES, "Coastal Erosion Prevention" scored lowest for Helgeland, Disko Bay and Kvarken. "Biological Control" and "Nutrient Regulation" scored lowest for Helgeland. "Air Purification", "Waste Treatment" and "Climate Regulation" were found at Kvarken, while "Regulation Of Water Flows" for Kvarken and Lumparn and "Disturbance Prevention Or Regulation" only for Lumparn. For the Cultural Services, "Symbolic Values" and "Spiritual, Sacred, And/Or Religious Experience" scored lowest for Helgeland, Disko Bay and Kvarken. "Information For Scientific And Education, Cognitive Development" scored lowest for Helgeland and Lumparn, while "Aesthetic Information/Interactions/Sea/Landscape" was present for Öresund-the Sound, Disko Bay and Kvarken. "Existence And Bequest Values" only for Disko Bay, while "Inspiration For Art, Media, and Design, and Technology", was reflected in the case studies for Kvarken and Lumparn.

The ES that the scored highest in the Delphi analysis point to that sufficient information is available to qualitatively assess the relationship between Biodiversity, ES and Human well-being for these high-scoring services. However, for those that scored lowest, more information is needed.

The *Ecosystem Services post-criteria evaluation* was carried for Öresund-the Sound case study. For the Provisioning services, "Fisheries (Commercial)" showed that there was a correlation between societal values and the trawl ban regulation, despite the service not having a large economic value. Fish and indirectly benthic fauna and vegetation, were correlated with this ES, which showed that the major impacts on this ES were trawling and eutrophication. For the Regulating and Maintenance services, "Waste Treatment" and "Nutrient Regulation", were correlated with societal values related to dilution, transport and uptake/storage of nutrients from land, agriculture and urban development. The economic values was presumably large and were associated with the following ecosystem components: Vegetation nutrient uptake, benthic fauna/mussels filtering water and fishing (potential destruction of trophic relationships that stabilise the system). Nutrient discharges that overloads the system were the major drivers of change (For more detailed information, see Annex A Delphi Analysis Tables). The results of the Delphi analysis also pointed out the need to integrate ILK in these kinds of qualitative assessments in the future.

Figure 42: Delphi analysis results for 5 Case Studies highlighting the Ecosystem Services (ES) that had the highest score

ECOSYSTEM SERVICES (ES)	HELGELAND - NORWAY	DISKO BAY - GREENLAND	ÖRESUND the SOUND	KVARKEN	LUMPARN
PROVISIONING	• FISHERIES (COMMERCIAL) • AQUACULTURE (COMMERCIAL) • ALGAE AND OTHER PLANTS	• FISHERIES (COMMERCIAL) • (ARTISANAL) FISHING • (ARTISANAL) HUNTING	• FISHERIES (COMMERCIAL) • (ARTISANAL) FISHING • RAW MATERIALS	• FISHERIES COMMERCIAL • (ARTISANAL) FISHING • AQUACULTURE (COMMERCIAL)	• FISHERIES (COMMERCIAL) • SEA WATER • ARTISANAL HUNTING
REGULATING AND MAINTENANCE	• WASTE TREATMENT • AIR PURIFICATION • CLIMATE REGULATION	• WASTE TREATMENT • AIR PURIFICATION	• WASTE TREATMENT • NUTRIENT REGULATION	• NUTRIENT REGULATION • BIOLOGICAL CONTROL • DISTURBANCE PREVENTION OR REGULATION	• NUTRIENT REGULATION • WASTE TREATMENT • BIOLOGICAL CONTROL
CULTURAL SERVICES	• AESTHETIC INFORMATION /INTERACTIONS/SEA/LANDSCAPE • CULTURAL HERITAGE AND IDENTITY • LEISURE FISHING AND HUNTING	• LEISURE FISHING AND HUNTING • RECREATION ACTIVITIES • CULTURAL HERITAGE AND IDENTITY	• RECREATION • LESIURE FISHING AND HUNTING • AESTHETIC INFORMATION/INTERACTIONS/, SEA/LANDSCAPE • INFORMATION FOR SCIENTIFIC AND EDUCATION, COGNITIVE DEVELOPMENT	• LEISURE FISHING AND HUNTING • INFORMATION FOR SCIENTIFIC AND EDUCATION, COGNITIVE DEVELOPMENT • CULTURAL HERITAGE AND IDENTITY	• LEISURE FISHING AND HUNTING • EXISTENCE AND BEQUEST VALUES • CULTURAL HERITAGE AND IDENTITY

Figure 43: Delphi analysis results for 5 Case Studies highlighting the Ecosystem Services (ES) that had the lowest score

ECOSYSTEM SERVICES (ES)	HELGELAND - NORWAY	DISKO BAY - GREENLAND	ÖRESUND the SOUND	KVARKEN	LUMPARN
PROVISIONING	• ORNAMENTAL RESOURCES • GENETIC RESOURCES (DNA) • SEA WATER • MEDICINAL RESOURCES • (ARTISANAL) FISHING	• BIOMASS BASED ENERGY SOURCES • GENETIC RESOURCES (DNA) • SEA WATER • MEDICINAL RESOURCES	• NOT APPLICABLE (NB)	• ALGAE AND OTHER PLANTS • SEA WATER • MEDICENAL RESOURCES	• RAW MATERIALS • (ARTISANAL) FISHING
REGULATING AND MAINTENANCE	• COASTAL EROSION PREVENTION • BIOLOGICAL CONTROL • NUTRIENT REGULATION	• COASTAL EROSION PREVENTION • CLIMATE REGULATION	• NOT APPLICABLE (NB)	• AIR PURIFICATION • WASTE TREATMENT • COASTAL EROSION PREVENTION • REGULATION OF WATER FLOWS • CLIMATE REGULATION	• REGULATION OF WATER FLOWS • DISTURBANCE PREVENTION OR REGULATION
CULTURAL SERVICES	• SYMBOLIC VALUES • SPIRITUAL, SACRED, AND/OR RELIGIOUS EXPERIENCE • INFORMATION FOR SCIENTIFIC AND EDUCATION, COGNITIVE DEVELOPMENT	• EXISTENCE AND BEQUEST VALUES • SYMBOLIC VALUES • SPIRITUAL, SACRED, AND/OR RELIGIOUS EXPERIENCE • AESTHETIC INFORMATION/INTERACTIONS, SEA/LANDSCAPE	• CULTURAL HERITAGE AND IDENTITY	• SYMBOLIC VALUES • SPIRITUAL, SACRED, AND/OR RELIGIOUS EXPERIENCE • AESTHETIC INFORMATION/INTERACTIONS, SEA/LANDSCAPE • INSPIRATION FOR ART, MEDIA, AND DESIGN, AND TECHNOLOGY	• INSPIRATION FOR ART, MEDIA, AND DESIGN, AND TECHNOLOGY • AESTHETIC INFORMATION/INTERACTIONS, SEA/LANDSCAPE • INFORMATION FOR SCIENTIFIC AND EDUCATION, COGNITIVE DEVELOPMENT

The results from the Delphi analysis (see Annex A) are also summarized for comparison in Figure 44.

Figure 44: Ecosystem Services (ES): Provisioning, Regulating and Maintenance, as well as Cultural Services scored across case studies. The dots indicate: green: well represented, yellow: partially represented, orange: not represented

ECOSYSTEM SERVICES (ES) PROVISIONING	KVARKEN	HELGOLAND – NORWAY	LUMPARN	DISKO BAY - GREENLAND	ÖRESUND THE SOUND
FISHERIES (COMMERCIAL)	🟢	🟢	🟢	🟢	🟢
(ARTISANAL) FISHING	🟢	🟡	🟠	🟢	🟢
AQUACULTURE (COMMERCIAL)	🟢	🟢	🟡	🟡	
(ARTISANAL) HUNTING	🟡	🟡	🟢	🟢	
ALGAE AND OTHER PLANTS	🟠	🟢	🟡	🟡	
RAW MATERIAL	🟡	🟡	🟠	🟡	🟢
ORNAMENTAL RESOURCES	🟡	🟠	🟡	🟡	
BIOMASS BASED ENERGY SOURCES	🟡	🟡	🟡	🟠	
GENETIC RESOURCES (DNA)	🟡	🟠	🟢	🟠	
SEA WATER	🟠	🟠	🟢	🟠	
MEDICINAL RESOURCES	🟠	🟠	🟡	🟠	

ECOSYSTEM SERVICES (ES) REGULATING AND MAINTENANCE	HELGOLAND - NORWAY	LUMPARN	ÖRESUND THE SOUND	DISKO BAY - GREENLAND	KWARKEN
WASTE TREATMENT	🟢	🟢	🟢	🟢	🟢
NUTRIENT REGULATION	🟠	🟢	🟢	🟡	🟢
AIR PURIFICATION	🟢	🟡		🟢	🟠
BIOLOGICAL CONTROL	🟠	🟢		🟡	🟢
DISTURBANCE PREVENTION OR REGULATION	🟡	🟠		🟡	🟢
CLIMATE REGULATION	🟢	🟡		🟠	🟠
REGULATION OF WATERFLOW	🟡	🟠		🟡	🟠
COASTAL EROSION PREVENTION	🟠	🟡		🟠	🟠

ECOSYSTEM SERVICES (ES) CULTURAL SERVICES	ÖRESUND THE SOUND	LUMPARN	HELGOLAND - NORWAY	DISKO BAY - GREENLAND	KVARKEN
LEISURE FISHING AND HUNTING	🟢	🟢	🟢	🟢	🟢
CULTURAL HERITAGE AND IDENTITY	🟠	🟢	🟢	🟢	🟢
INFORMATION FOR SCIENTIFIC AND EDUCATION	🟢	🟠	🟠	🟡	🟢
RECREATION ACTIVITIES	🟢	🟡	🟡	🟢	🟡
EXISTENCE AND BEEQUEST VALUES	🟡	🟡	🟡	🟠	🟡
INSPIRATION FOR ART, MEDIA, AND DESIGN AND TECHNOLOGY	🟡	🟠	🟡	🟡	🟠
AESTHETIC INFORMATIONS, ITERACTIONS, SEA/LANDSCAPE	🟢	🟠	🟢	🟠	🟠
SYMBOLIC VALUES	🟡	🟡	🟠	🟠	🟠
SPIRITUAL, SACRED, AND/OR RELIGIOUS	🟡	🟡	🟠	🟠	🟠

The main patterns that emerged from these analyses were that the following ES were well represented across case studies: for the provisioning ES: fisheries (Commercial), for the regulating and maintenance ES: water Treatment, and for the cultural ES: Leisure Fishing and Hunting. The Cultural Heritage and Identity ES was also well represented across case studies, apart from the Sound. Many of the ES that were qualitatively scored by expert in this analysis were not well represented (orange dots). This indicates that there is a need to provide more information to the public to enhance understanding of the links between biodiversity (B), ecosystem services (ES), and nature's contributions to people (NCP), and thus enhance their awareness of the importance of these links for sustainable futures.

5.4 Integrated assessment

The qualitative Delphi analysis, along with ILK perspectives from case studies, provided a first qualitative analysis of the interactions between the functional aspects of biodiversity processes, ecosystem services and governance. The analysis also pointed out current knowledge gaps. In our analysis, we have pointed out the importance of considering ecosystem services in relation to human well-being and culture (Chapter 2), to the functional aspects of biodiversity processes (Chapter 3), to the direct and indirect drivers of change (Chapter 4), to governance, institutional arrangements and private/public decision-making across scales and sectors (Chapter 6) and included reflections from ILK communities. However, the restraints in time and finance in this assessment have made it impossible to ensure full and effective participation of ILK representatives. There is an urgency to move toward an IPBES framework assessment for the Nordic countries that connects different perceptions of nature and knowledge systems for promoting a more holistic and sustainable ecosystem governance (Tengö *et al*., 2014). Our analysis pointed out that there is a need for more integration and understanding of the links between the functional aspects of biodiversity, the drivers of change, ecosystem services and governance. This aspect is fundamental for proposing a multidimensional approach that includes different values of NCP (Pascual *et al*., 2017). Our capacity to understand biodiversity processes from a variety of perspectives, including ILK perceptions of the nature-human well-being relationship as described by Pascual *et al*. (2017), needs to be considered. A closer look at the link that food webs provide in characterizing both trophic predator-prey interactions and non-trophic interactions such as habitat modification (Kéfi *et al*., 2015), along with linking these changes to ecosystem services, would help to improve our understanding of the functional aspects linking biodiversity processes to ecosystem services.

Habitat modification and species removal caused by drivers of change and human pressures such as fishing are reflected in food web dynamics. Improved understanding of the different levels of complexity in ecological systems provides a way to quantify both trophic and non-trophic interactions such as habitat modification, as shown through ecological network visualization (Kéfi *et al*., 2015; Pocock *et al*., 2012; Thompson *et al*., 2012). A fundamental step forward will be to link biodiversity structure and functioning to a broader network theory approach that will enable connecting ecosystem services with different socio-economic and valuations perspectives (Dee, *et al*., 2017). Cultural Ecosystem Services (CES) play an important role in providing "non-material" values for human well-being. The inclusion of ILK perspectives can help to address knowledge gaps and highlight research priorities for CES (Rodrigues *et al*.,2017) and set a new agenda for the assessment of ES and CES in the Nordic countries.

5.4.1 Scale at which management actions are required

As pointed out in the IPBES framework (Díaz *et al*., 2015) there is a need for a better understanding of the role and impact of institutions and governance on biodiversity and ecosystem services across scales. Defining assessments scales will provide information to management and policy to guide the valuation of ecosystem services, including the different value dimensions of NCP; as well as the interactions between public and private actors (Ostrom, 2005; Ostrom & Cox, 2010). As a general approach, the first important step is to assess the ecological and socio-economic scales, both in time and space, of the kind of process or processes that need management actions and discuss the objectives of the required management actions using multi-stakeholder dialogues that include an ILK perspective. In order to do so, there is also a need to include different scientific perspectives. This approach will provide information on the boundaries of the assessment and provide a framework for management and information for policy instruments and participatory measures that includes a multiplicity of users (Morf *et al*., 2017).

An important aspect that has emerged throughout this report is the importance of assessing threats to ecosystem services and to determine their vulnerability, especially in relation to changes in supply and demand as suggested by Maron *et al*. (2017). The categorization of threats linked to ecosystem services will provide information on the thresholds associated with each service in relation to drivers (Maron *et al*., 2017), and provide information on the scales that management action from global to regional and local. The concept of scales both in terms of ecological interaction processes and socio-economic dynamics need to be evaluated in the context of ecosystem services supply and demand. In this respect, innovative governance in the Nordic countries showed that the collaborative management initiatives in Laponia and Näätämö for the aquatic ecosystems and coastal basins, provide excellent examples of the model (Ostrom & Cox, 2010) of knowledge "flow" and co-management linked to a co-governance approaches that promote biodiversity sustainability and human well-being at the required scales. ILK materials may also provide long-term historical data through traditional practices, languages, toponymic place names and uses of the lands and waters where no monitoring data or field monitoring exists. This is especially true in the areas of Saami land use and occupancy.

A multi-scales approach (Maron, *et al.*, 2017) is necessary to incorporate a "landscape" vision that goes beyond the current coastal environment definition but includes, as we have shown in this report, the enture watershed and eco-regional boundaries that connect the sea/coast/land interface. In this respect, a network theory approach (Dee *at al*., 2017) is able to address the assessment of trade-offs and the uncertainty in relation to the coupling between biodiversity, ecosystem services and governance.

5.4.2 Knowledge gaps

There is a need to consider how governance and ecological outcomes can be sustainably implemented at multiple scales, merging different actors' perspectives and promoting a broader dialogue between different stakeholders (Morf *et al*., 2017). In order to understand the links between functional biodiversity, ecosystem function and ecosystems services, including long-term visions (Belgrano, Woodward & Jacob, 2015), tools for developing ecological indicators that can quantify ecological status (Petchey & Belgrano, 2010) and include consideration of species traits such as body-size distribution are needed. The development of operational ecological indicators within, for example, the EU MSFD next cycle beyond 2018, can provide useful tools to support the socio-economic valuation of ecosystem services.

At present, the ILK perspective in not well integrated or "recognized" as an integral part of any assessment linking biodiversity, ecosystem services and governance. More knowledge is required to understand the multiple dimensions of interactions between the functional aspects of biodiversity from the natural sciences perspective. Furthermore, institutional governance, co-management of ecosystems and good quality of life aspects can be learned from from societal and ILK perspectives. Participatory processes require a disproportionate amount of time and effort and that is partly why they are seldom performed in practice (Tunón *et al.*, 2015). Knowledge-based coupling of socio-ecological systems would promote both ecological and socio-economic resilience. Methods of ILK inclusion into assessments have been discussed for decades in the Arctic context, which partially overlaps the Nordic region. In June 2017, the International Arctic Social Sciences Association (IASSA) issued a declaration on indigenous knowledge that may be helpful for future assessments:

Indigenous knowledge provides a foundation for individual and collective well-being of past, present, and future generations of Arctic Indigenous Peoples. This knowledge system holds inherent value and methodologies, functions and validation processes. Indigenous knowledge empowers communities throughout the circumpolar north to significantly advance our understanding, intellectual performance and management of the Arctic.

IASSA has demonstrated their willingness to expand the ways in which indigenous scholars and indigenous knowledge holders are engaged. By providing a platform that brings together a holistic and meaningful conversation, this progress will continue within IASSA and beyond.

Moving forward we suggest the following actions that can be supported by IASSA, individual IASSA members and the broader research community:

- Revise IASSA research principles to explicitly include indigenous knowledge;
- Clearly declare and ensure permanent support for indigenous knowledge within IASSA as defined by indigenous peoples, e.g. the development and supporting an indigenous knowledge working group or task force;
- Produce a white paper synthesizing existing national and international ethical protocols for the engagement of indigenous knowledge and indigenous communities;
- Work with indigenous knowledge holders to develop best practices for the engagement and utilization of indigenous knowledge and indigenous knowledge holders within Arctic research;
- Sponsor and facilitate indigenous knowledge workshop(s), early career training opportunities or other engagement formats within IASSA;
- Advocate for indigenous knowledge engagement by other Arctic research organizations, at the international and national levels (Arctic Council, IASC, national funding agencies, those that define research needs and other appropriate organizations);
- Investigate methods that position indigenous communal oral histories as being of equal value to peer-reviewed science in Arctic studies.

In order to capture the spiritual-cosmological interactions and values of ILK case studies, especially the Saami and the Inuit, as well as other coastal local-traditional communities, certain and particular views are required. This view, in line with the global IPBES indicators, of a holistic approach of human-ecosystem engagement in places where they still exist, need to be included in future assessments.

At present, there is a need for a novel approach that considers all the different perspectives of the socio-ecological system, including ILK views and perceptions. Such approaches, combined with tools to explore future management scenarios that consider threats and thresholds of ecosystem services, including novel indicators for policy actions, would be desirable. Currently, there is a lack of public awareness on the importance of the link between biodiversity, ecosystem function and ecosystem services providing NCP and human well-being. There is a need for further explorations of transformative changes that unfold from natural systems and diffuse to cultural and geopolitical transformations (Latour, 2014; Latour, 2013) across boundaries (Steffen *et al*., 2015) from individuals to global scales. This includes a vision that embraces an understanding of the dynamics of public assembly (Butler 2015) and provides new narratives for a novel governance perspective.

5.5 Future Perspectives

5.5.1 Perspectives

Many aspects related to the coupling of biodiversity and ecosystem services are currently being addressed (Schultz *et al*., 2016; Garpe, 2008; Gundersen *et al*., 2016). There is the urgency to quantify the ecological and socio-economic resilience across scales (Folke, 2006; Hein *et al*., 2006) and in relation to biodiversity loss (Chapter 3 in this report; Worm *et al.* 2006) with reference to Socio-Economic-Systems (SES). In particular, there is a need to investigate how changes in biodiversity at multiple trophic levels are related to ecosystem function (Soliveres *et al*., 2016), and how function is linked to ES flow. For example, how fisheries governance and regulations can be related to changes in SES, as recently discussed by Ojea *et al*. (2016). One other question to address Is how the added values of the inclusion of an ILK perspective will contribute best to increase our understanding of the ecological and socio-economic resilience of a system? Modelling platform such as the ARIES (Artificial Intelligence for Ecosystem Services) methodology (Villa *et al.* 2014) can be used to quantify the multidimensional aspects across scales of the links between, biodiversity, ecosystem services and SES. One of the many challenges that we face is our capacity to communicate and consider different perspectives and evaluation criteria when assessing ecosystem services and NCP. One question that we may ask is:

How will combinations of indirect and direct drivers change in the future and how will these changes affect biodiversity, ecosystem services and human well-being?

To try to answer this, we need novel approaches and tools that will help us to explore and untangle the multifaceted complexity of this challenge. A way forward could be to use operational network theory for assessing the relationship between the natural and non-natural processes linked to ecosystem service dynamics, as shown by Dee *et al*. (2017). The combination of network theory and an evaluation of ecosystem services under threat, will provide more coherence in the way ecosystem services are currently defined. This should include a broad assessment perspective for valuing ecosystem services, considering the multidimensionality and the ILK perspectives of this aspect (Gunton *et al*., 2017, and Pascual *et al*., 2017). As pointed out by Pascual *et al.* (2017), the economic valuation of ecosystem services is a combination of different unidimensional valuation considerations such as cultural, ILK, socio-economic and ecological perspectives, as well as a more pluralistic views. This points out the need to bridge these views in a more integrated perspective that will be beneficial for promoting a sustainable/holistic approach for the different value dimensions of NCP. This is of particular interest (as pointed out in Chapter 6 this report) when assessing ecosystem services in terms of the institutions and governance perspective, as well as in terms of human well-being. There is also the need to consider and address how to couple the coastal zone ecosystem services, including cultural ecosystem services, with the adjacent terrestrial ecosystem and connected landscape. This in turn will provide solutions on how to merge different value perspectives and promote public awareness and public infrastructure projects (Zandersen *et al*., 2017) that will help to sustain ecosystem services for future generations. This will also provide a platform for stakeholder engagement that will facilitate communication across societal sectors and promote good governance. Another of the current challenges is the consideration of mainstreaming ecosystem-based adaptation (EbA) and its inclusion in policy evaluations and recommendations (Ojea, 2015). Therefore, the concepts of NCP, including consistent evaluation and assessments of them, should be mainstreamed and incorporated in all policies (health, education, transport, land-use, environment, climate change, etc.). Biodiversity and ecosystems services are fundamental for the long-term survival and development of human society, and thus should be linked to various policies that aim to promote human well-being and improve resilience and sustainability of the society (FAO 2016; Maes *et al*., 2013). Further points to be considered in relation to the above rationale are presented in Box 12.

Box 12: Human well-being and resilience

- Provisioning ecosystem services such as fishery and household/artisanal fishery are highly scored as the criteria's for the Delphi analysis are fulfilled and basically met. Waste treatment and nutrient regulations are also well developed in all case study areas. Cultural activities have been less focused on, even though tourism, leisure activities such as outdoor sports and recreation is growing. As the demand for land for development increases, the pressure on biodiversity increases and the local population experiences change.
- Research establishing the link between biodiversity and ecosystem services is underdeveloped. Further research into the functional causal relationship would be beneficial.

- In the context of the Nordic IPBES-like study, the importance of joint fact-finding is stressed. As is the co-production of knowledge and co-governance practices, where scientists, policy-makers and indigenous and local communities create a more policy-relevant and more scientifically robust, knowledge basis for future management and policy decisions (e.g. Saarikoski & Raitio, 2013).
- Promote management actions at the jurisdictional scale that will be beneficial for human well-being.

5.6 Policy recommendation

5.6.1 Policy

- Evaluate the costs and benefits of existing environmental policies, prioritise and streamline them to help overcome the high density of policies;
- Where possible, coordinate the implementation of policies across the Nordic region to reduce policy conflicts;
- Identify pathways to achieve the 2050 vision of the Strategic Plan for Biodiversity and implement the Sustainable Development Goals and their targets;
- Stakeholders, including the public, need to have a major influence and fully contribute in decisions concerning the use of land and coastal water areas;
- Promote a multidimensional scale approach to NCP to bridge different valuing dimensions of ecosystem services with the inclusion of the ILK perspective. Include ILK to facilitate assessing cultural services in the Nordic countries;
- Provide policies that promote the inclusion of trade-offs and uncertainty in relation to the biodiversity/ecosystem services/governance interface.

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6. Options for governance, institutional arrangements and private and public decision-making across scales and sectors

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Box 13: Summary

This chapter examines the conceptual framework boxes and fluxes on "Institutions and governance and other indirect drivers" (Ch. 1, Fig. 1). International and EU governance of relevance for ecosystem services, biodiversity and water is presented. Policy integration, policy coherence, management regimes and stakeholder involvement is reflected upon. The chapter contributes to further understanding of the current and future challenges for sustainable use and conservation of biodiversity and ecosystem services. It provides insights in options for integrating biodiversity and ecosystem services into sustainable development strategies and provides examples of current policy conflicts, along with trade-offs and innovative governance strategies for management of natural resources. Policy-makers need to find ways to handle policy conflicts, improve integration of different stakeholders' perspectives and value dimensions including ILK in policymaking, develop new data collection methods for linking biodiversity and ecosystem services, and develop governance systems that enhance transparency, sustainability and human well-being.

6.1 Introduction

The main role of this chapter is to reflect the conceptual framework boxes and fluxes on "Institutions and governance and other indirect drivers" (Chapter 1, Figure 1). Our aim is to provide insight into the relationship between international, EU and Nordic governance structures and give examples of how they affect important aspects of democracy and socio-ecological trade-offs in the Nordic coastal regions. In order to do so, we have chosen to focus mainly on the formal systems for water governance in the different countries. The implementation of the EU Water Framework Directive (WFD) (where relevant) or formal systems for water governance (where the WFD is not relevant) is presented to obtain a comparative overview of the formal institutional frameworks for the governance of natural resources. This chapter examines how biodiversity and ecosystem services are mainstreamed in practical policy in the Nordic coastal regions and presents the different international and national policies of relevance when working towards the goal of achieving good water quality. Water quality is defined by both ecological and chemical parameters, which in turn is affected by a range of actions both on land and on water in coastal regions, and thus depends on decisions in many different policy areas. Therefore, water governance is a policy area signified by the need to handle goal-conflicts (Söderberg, 2016) and our focus on water governance provides highly relevant insights into institutions for biodiversity and ecosystem services governance, how different policies interact and how trade-offs between different ecosystem services are handled in the Nordic region.

International and EU governance of relevance for ecosystem services, biodiversity and water governance is briefly presented. Institutions for water governance in the different countries are mapped out and compared and examples from case studies are provided. Policy integration, policy coherence, management regimes and stakeholder involvement is reflected upon. Through this approach, the chapter will contribute to further understanding of the current and future challenges for sustainable use and conservation of biodiversity and ecosystem services, provide insights in options for integrating biodiversity and ecosystem services into sustainable development strategies, and provide examples of current policy conflicts and innovative governance strategies for the management of natural resources. Based on the overview in this chapter and our case studies, this chapter presents opportunities and challenges for policy- and decision-making in the Nordic region, identifies knowledge gaps and provides recommendations for the future.

6.2 Framing institutions and policy options for biodiversity and ecosystems governance

Environmental issues have been on the international agenda since the conservation movement arose in the early 20th century and were first discussed within the UN in the early 1970s. The 1972 United Nations Conference on the Human Environment (UNCHE) in Stockholm recognised the human responsibility to take the environment into consideration and the need to conserve natural resources for present and future generations. Fifteen years later, the Brundtland Commission's Our common future (WCED, 1987) defined *sustainable development* as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43) and emphasised that we must change policies and institutions if we wish to address the challenges of interlocked economic and ecological systems. As a result, the principle of *environmental policy integration* (EPI) was included under Article 8 in Agenda 21, which was the outcome of the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro. Persson (2004, p. 1) defines EPI as "the integration of environmental aspects and policy objectives into sector policies". The concept of sustainable development is the basis and the target of environmental policy integration, which after the Rio Declaration, has become increasingly explicit in international and European policy. The principle of environmental policy integration also has a long history within the EU and Article 11 of the Treaty of the European Union prescribes that environmental concerns are to be integrated into other policy areas (European Union 2016, Article 11). EU environmental policy also prescribes the precautionary principle, to prevent pollution and rectifying pollution at the source, as well as maintaining a high level of environmental protection and the principle that the polluter pays (European Union, 2016, Article 191–193). Water and biodiversity protection is governed at international and EU-level by a number of treaties, agreements and directives. Efforts to limit and reduce emissions into air and water have a long history. Several international agreements have been adopted in recent decades with the aim of limiting emissions of pollutants. The Nordic EU countries Denmark, Sweden and Finland are known as "Green Member States" within the EU – recognized as environmental forerunners (Liefferink and Skou Andersen, 2010). There is also a common Nordic culture of well-developed information-systems, equity, trust in the State and obedience to regulations, as well as a long-standing corporate governance tradition where participatory governance structures and extensive cross-border cooperation has a long history (OECD, 2003; Lekvall, 2014; Moos Nihlfors, Merok Paulsen, 2016). All of the above make the Nordic countries relevant to study and compare from an environmental policy implementation perspective. What are the trends, the lessons and the obstacles for integrating biodiversity in the Nordic?

In order to improve the sustainability of biodiversity and ecosystem services, the impact of institutions and governance needs to be understood, as is emphasised in the IPBES framework (Diaz *et al*., 2015; Pascual *et al*., 2017). The interaction between public and private actors is determined by the *formal societal institutions* or "rules on paper" (e.g. policies and laws) and *informal institutions in society* or rules in use (e.g. social norms and traditions) (Ostrom, 1990; North, 1990). This chapter maninly focuses on the formal institutions for environmental governance in the Nordic. It is important to consider that the general trend within environmental governance in the Nordic countries, is the move towards *polycentric governance* (Ostrom, 2010; Biggs, 2015) and *participatory governance* (Driessen, 2014; Sandström & Söderberg, forthcoming; Duit & Löf, 2009; Primmer, 2015), which means that many different actors are involved in the policy making process in more or less formal ways. Stakeholder participation in water governance and how the integration of ILK has been organized within the Nordic countries is presented in this report. A move towards *multi-level governance* (Bache & Flinders, 2003; Joas & Eckerberg, 2004) can also be observed, where power previously held by the nation state shifts both upwards (to the supranational level), downwards (to the local level) and sideways (to involvement of both private and public actors in policymaking). These trends have implications for *policy coherence*: since policy density is high, there are many different political goals to be achieved simultaneously, which increases the risk for policy conflicts. Such policy conflicts are often related to the difficulty in balancing ecological, economic and social sustainability, as well as to the difficult weighting of different ecological goals (Söderberg, 2016; Söderberg & Eckerberg, 2013). Policy conflicts detected in our case studies in the Nordic region are also presented here.

6.3 International and EU governance

A number of international conventions protecting ecosystem services and biodiversity have been integrated into different regulations and directives within the EU. An overview of the Multilateral Environmental Agreements relevant for the coastal regions in the Nordic countries can be found in Table 6. Important to mention are the Ramsar Convention on the conservation of wetlands (1971), the World Heritage Convention (1972), the CITES Convention on International Trade in Endangered Species (1973), the Bonn Convention on the protection of Migratory Species of Wild Fauna (1979), the Bern Convention of the protection of European Wildlife and natural Habitats (1982) and the UN Convention on Biological Diversity (CBD) (1992) requiring a more integrated ecosystem approach to environmental governance. The ecosystem approach in the CBD is defined as "a strategy for integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". It also emphasizes the economic and social aspects of the human system and its principle two states that "management should be decentralized to the lowest appropriate level" (CBD, 2004a). The objectives of the CBD are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Several different instruments have been developed within CBD, one of which has focused on ILK and issues regarding full and effective participation in decision-making and sustainable customary use. The CBD has also agreed on a Strategic Plan for Biodiversity, including the Aichi Biodiversity Targets for the 2011–2020 period. The plan provides an overarching framework on biodiversity, not only for biodiversity-related conventions, but for the entire UN system and all other partners engaged in biodiversity management and policy development. Aichi Target 2 aims to, by 2020, achieve that "biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems". Furthermore, Aichi target 18 states that ILK and "customary use of biological resources" should by 2020 be fully integrated and reflected in the implementation of CBD with "the full and effective participation of indigenous and local communities, at all relevant levels." Public participation in environmental decision-making and access to environmental information is also required under the Aarhus Convention (2005). Furthermore, the Paris Agreement (2015) aims to enhance the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) through ambitious climate change mitigation and adaptation efforts, with the aim to keep a global temperature rise below 2 degrees Celsius. The Agreement can be expected to have implications for biodiversity and ecosystem management work in the Nordic region.

Two EU directives are of particular importance for biodiversity governance within the EU and thus important to mention here: the *Birds Directive* (Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds) and the *Habitats Directive* (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). These two directives oblige member states to define Natura 2000 areas to protect biodiversity and conserve habitats and species. Biodiversity protection and ecosystem restoration is currently emphasised in the 2020 Biodiversity Strategy (European Commission, 2011) and the 7th Environment Action Programme (European Union, 2013). Biodiversity protection should thus be integrated into policymaking in all EU member states.

The ecosystem approach concept as used by CBD has been taken up by e.g. the Regional Seas Conventions OSPAR, for the North East Atlantic and HELCOM for the Baltic Sea (CBD, 2004a, Hammer, 2015). The EU Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy) uses the term "ecosystem based approach" and under the EU Common Fisheries Policy (CFP) both the terms "ecosystem approach" and "ecosystem-based approach" are used and seemingly in the same context (European Commission, 2009, 2011). These terms are thus used as synonyms in this chapter.

The two most important pieces of EU legislation on water governance are the WFD, (inland and coastal waters) adopted in 2000 (European Parliament, 2000) and the *Marine Strategy Framework Directive* (European Parliament, 2008). Both of these directives require member states to set and implement action plans in order to achieve the directives' objectives. The implementation of the WFD and water governance in the Nordic is discussed in more depth later in this chapter.

Water governance is closely related to spatial planning in landscapes and seascapes. The EU Commission has proposed a Framework for Marine Spatial Planning (MSP) and Integrated Coastal Zone Management (ICZM). The ultimate goal for marine planning is to identify the use of space at sea for various sea-based activities. The MSP aims to identify the different uses of marine space and facilitate a coherent and sustainable implementation of various initiatives for the marine environment. ICZM is a tool for all the political processes that affect the coastal zone with the goal of achieving sustainable development in the interaction between land and sea. MSP and ICZM complement each other, such as the Marine Directive, the Renewable Energy Directive, Oceans Highways Initiative, and the Habitats Directive, but also the reformed Common Fisheries Policy and the new Structural Funds. Under the proposed framework, each Member State is to establish and implement a development plan for the sea areas, along with an integrated strategy for the coastal zone, for which there are a number of minimum requirements. These plans and strategies should be revised every six years.

Several EU Directives also impact water management. Among the most important are the Floods Directive (2007/60 / EC), the Habitats Directive (1992/43 / EC), the Birds Directive (1979/409 / EEC), the Drinking Water Directive and the Nitrates Directive (91/676 / EEC), which contains minimum requirements for reducing nitrogen losses (nitrate losses) from agriculture to surface water, groundwater, and coastal and marine waters. The Nitrate Directive requires each member state to identify areas that are vulnerable to nitrate pollution and establish a program of measures aimed at reducing nutrient leaching from agriculture. The Common Fisheries Policy (CFP) and the Common Agricultural Policy (CAP) also have great influence on the environment in the coastal zone. In addition, the Emission Ceilings Directive for air emissions (2001/81 / EC) and the REACH chemicals legislation are important for water management. As directives, laws and actions in many different policy areas affect water quality, water management can be viewed as an illustrative case in order to illuminate the applied management of biodiversity and ecosystem services in the Nordic region.

Table 6: Selection of Multilateral Environmental Agreements (MEA) relevant for the coastal regions in the Nordic

MEA	Purpose	Date adopted	Entry into force	Parties in total/Nordic
Ramsar Convention – Convention on Wetlands of International Importance especially as Waterfowl Habitat	To conserve and promote the wise use of wetlands	1971	1975	169 /all
World Heritage Convention – Convention concerning the protection of the world cultural and natural heritage	To establish an effective system of identification, protection and preservation of cultural and natural heritage, and to provide emergency and long-term protection of sites of value	1972	1975	193 /all
EU Birds Directive	Oldest EU legislation on environment. Emphasis on the protection of habitats for endangered and migratory bird species. It establishes a network of Special Protection Areas (SPAs) including all the most suitable territories for these species. Since 1994, all SPAs are included in the Natura 2000[20] ecological network. Overarching strategy: EU Biodiversity Strategy 2020	1979	Amended in 2009	28 EU Member states
CMS – Convention on the Conservation of Migratory Species of Wild Animals	To conserve wild animal species that migrate across or outside national boundaries by developing species-specific agreements, providing protection for endangered species, conserving habitat, and undertaking cooperative research	1979	1983	124 /Sweden, Finland, Denmark, Norway
CBD – Convention on Biological Diversity	To conserve biological diversity and promote its sustainable use, and to encourage the equitable sharing of the benefits arising out of the utilization of genetic resources. Ecosystem approach. Strategic Plan for Biodiversity 2010–2020, including Aichi Biodiversity Targets	1992	1993	196 /all Nordic

[20] http://ec.europa.eu/environment/nature/natura2000/index_en.htm

MEA	Purpose	Date adopted	Entry into force	Parties in total/Nordic
Aarhus Convention – Convention on Access to Information, Public Participation in Decision-Making Access to Justice in Environmental Matters	To guarantee the rights of access to information, public participation in decision-making, and legal redress in environmental matters	1998	2001	47 /Sweden, Norway, Finland, Iceland, Denmark
EU Water Framework Directive	To achieve good ecological status in all inland and coastal waters	2000	2000	28 EU Member States/Nor-way & Iceland
EU Habitat Directive	Conservation of natural habitats and wild fauna and flora to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements, including Natura 2000 ecological network. Overarching strategy: EU Biodiversity Strategy 2020	1992	1992	28 EU Member states
EU Flood Risk Directive	Aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. Requires Member States to assess if all water courses and coastlines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk	2007	2007	28 Member States
Paris Agreement	To enhance the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) through ambitious climate change mitigation and -adaptation efforts with the aim to keep a global temperature rise below 2 degrees Celsius	2015	2016	170 /all

6.4 Formal institutional framework for Nordic governance – comparing WFD implementation in the Nordic region

The EU Water Framework Directive was adopted in 2000, replacing a fragmented set of water related EU policy frameworks (European Parliament, Council 2000). The WFD was developed in an open consultation process involving interested parties, such as local and regional authorities, water users and non-governmental organizations (NGOs). This common water policy framework has two main aims: to protect all inland, freshwater, groundwater and coastal waters in EU and achieve good ecological water status, and to get citizens and stakeholder organizations actively involved in the water management process (European Commission, 2003). The WFD implementation process is formed as an integrated, iterative 6-year water management cycle. Information and consultation is mandatory in specific phases of the WFD water management cycle, while active participation is encouraged. The focus on mandated stakeholder participation in the WFD provides a novel mode of EU policy, combining participatory and multi-level governance (Newig and Koontz, 2013). The implementation of the WFD has been supported with guidance documents, policy papers and an arena for exchange of experiences by the Common Implementation Strategy (CIS[21]) established in 2001, led by Water Directors of the Member States and the Commission and with participation of relevant stakeholders.

The WFD follows an ecosystem approach in the sense that waters should be managed according to hydrological boundaries in larger River Basin Districts (RBDs), redrawing the administrative map of water institutions in Europe (CBD, 2004a). This reorganization implies new demands on institutional arrangements at local, national and international levels (Hammer et al, 2011). Transnational cooperation is important for implementing the WFD. In the Nordic region, all countries except for Iceland share one or more RBD with another country, and Finland shares one with Russia, who is not an EU member. Norway and Iceland are connected to the European Union through the Agreement on the European Economic Area (the EEA agreement).

However, the WFD requires only a subset of ecosystem components to be assessed (Borja *et al.* 2010). For instance, it cannot provide ecosystem-based management in coastal areas, as it does not include assessment of fish populations as a quality element.

The implementation of the Directive is the responsibility of the individual Member States, including setting up the competent river basin authority for each RBD and the necessary national legal and regulatory adjustments. Two general governance models can be distinguished: national and regional approaches to governance (Hedin *et al.*, 2007). In the Nordic countries, Denmark and Iceland have the main authority located at the national level, while Finland, Norway and Sweden have a regional governance approach.

Denmark has 4 River Basin Districts,[22] divided into 23 main catchment areas. The Danish Nature Agency under the Ministry of Environment[23] is the competent authority. A River Basin Management Plan (RBMP) is produced and reported for each of the 23 sub-districts. The RBMP plans are legally binding for national, regional and local authorities and there is a general obligation for individual decisions to take the RBMPs into account. International collaboration takes place in the cross-border international district between Denmark and Germany, as well as in the Sound region between Denmark and Sweden (see further, the Sound case study). The cooperation involves the bordering municipalities. The Danish part of the Sound is managed under both the WFD and the Marine Strategy Directive, while the Swedish part is managed only under the WFD.

[21] http://www.ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm
[22] http://www.mst.dk/natur-vand/vandmiljoe/vandomraadeplaner/om-vandplanlaegning/organisering/
[23] http://www.en.mfvm.dk/

Greenland is not an EU member[24] and does not have a formal system for WFD implementation. The Department of Environment and Contingency Management under the Greenlandic Ministry of Nature and Environment govern water issues on Greenland and three nautical miles from land (and the area between 3–200 nautical miles from land is under Danish jurisdiction). Pollution of the marine environment resulting from Greenlandic wastewater does not at present rank among the more important environmental issues. Wastewater from houses and factories is usually discharged into the sea, mostly after filtration. However, the prospects of future oil and mineral exploitation projects, as well as international attention on water pollution, have recently drawn increased attention to water management in Greenland.

Sweden has 5 River Basin Districts,[25] of which three are shared with Norway and/or Finland. One County Administrative Board (CAB) in each district is assigned to govern the water district as the Water District Authority (WDA,[26] Vattenmyndighet). Five Water Delegations (Vattendelegation) comprised of eleven experts appointed by the Swedish government, make the formal decisions on Environmental Quality Standards (EQS), Program of Measures (PoM) and Management Plans for each WDA. At the national level, the Swedish Agency for Marine and Water Management (SwAM[27]) has the overarching responsibility for implementing the WFD and the Marine Strategy Framework Directive. SwAM coordinates the WDAs in implementing the Water Quality Management Ordinance (VFF 2004:660; SFS 2011:619). SwAM also cooperates with other state level agencies, i.e. the Swedish Environmental Protection Agency (SEPA) and the Swedish Board of Agriculture,[28] and with CABs and municipalities (SFS 2011:619; SwAM 2014). The Water Quality Management Ordinance (Vattenförvaltningsförordningen, VFF 2004:660) prescribes that the WDA is responsible for governance of water quality in their district. This task is completed by determining EQS, constructing a Management Plan and a Program of Measures, constructing a register over protected areas and through constructing and implementing Environmental Surveillance Programmes. All of Sweden's CABs must assist the WDA in the preparations of programs and in coordinating regional water management, as well as in instigating and supporting local Water Boards.

Finland with 8 RBDs,[29] of which two are shared with Sweden and Norway, has integrated the WFD into their existing environmental administration There are 13 governmental regional administration centres (The Centre for Economic Development, Transport and the Environment, ELY-centre[30]) that manage the RMBP and Programme of Measures in their areas of operation. Five of the ELY-centres are named as

[24] http://www.nalakkersuisut.gl/
[25] http://www.vattenmyndigheterna.se/SiteCollectionDocuments/gemensamt/publikationer/broschyrer-foldrar/faktablad-engelska.pdf
[26] http://www.vattenmyndigheterna.se/
[27] http://www.havochvatten.se/en/swam/eu--international/international-cooperation/watercog/swedens-water-management.html
[28] http://www.jordbruksverket.se/
[29] http://www.ymparisto.fi/en-US/Waters/Protection_of_waters/Planning_and_cooperation_in_river_basin_districts/River_basin_districts
[30] http://www.ely-keskus.fi/en/web/ely-en/

coordinators of each RBD. Each RBD has a steering group with directors of each ELY-centre in the district. This steering group makes the decisions regarding RBMP. The Ministry of Environment is responsible for cooperation related to the Marine Strategy Development and implementation with the other states in the catchment area of the Baltic Sea. At the national level, national governmental research institutes (such as the Finnish Environment Institute SYKE[31] and Natural Resources Institute LUKE,[32] among others) have a supporting role (e.g. development of monitoring and EQS assessment system, data management system, EU reporting, national coordination, tools and models) in the planning and implementation process.

Åland constitutes one basin (RBD 8). The Åland Government is responsible for developing a management plan and an action program for the Åland waters and Åland adjacent coastal waters to RBD 3 in southwestern Finland. Water Framework Directive reporting to the EU is carried out nationally by Finland. The Government of Åland[33] and its Environment Agency (Miljöbyrån) at the Department of Social Affairs, Health and Environment, prepares the processes involved in the WFD (Water Framework Directive) management cycle, including cooperation with the public and other interested parties. The Water Framework Directive is implemented in the Åland legislation, mainly through the Water Act (1996: 61) and Water Regulation (2010: 93).

Norway, together with Iceland, is connected to the European Union as an EFTA country, through the Agreement on the European Economic Area (EEA). The WFD was formally taken into the EEA-agreement in 2009, granting the EFTA countries extended deadlines for implementation. EFTA-counties reporting obligations are to the EFTA Surveillance Authority (ESA). Norway has taken full part in the Common Implementation Strategy (CIS) for the WFD. Norway performed a voluntary "pilot phase" implementation of the WFD in selected sub-districts 2007–2009. The WFD was transposed into the Norwegian Regulation on a Framework for Water Management, Vannforskriften (The Water Regulation), entering into force in 2007. RBMPs for the entire country were prepared from 2010 until 2015, synchronized with the time schedule of the second cycle of implementation in the EU (vannportalen.no; Hanssen *et al.* 2016).

The close to 30,000 water bodies in Norway have been grouped into 105 sub-districts and 11 River Basin Districts (RBDs).[34] Of these, several share watercourses with Sweden, Finland and Russia (vannportalen.no, 2017). Selected County Councils are appointed as Competent Authorities for their respective River Basin Districts. They chair a District Water Board, ensuring the participation and sector integration of all municipal and district authorities.

The WRA is responsible for determining EQS, constructing a Management Plan, Program of Measures, a registry of protected areas and implementing Environmental Surveillance Programmes. All of Norway's local water areas must assist the WRA in the

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[31] http://www.syke.fi/en-US

[32] https://www.luke.fi/en/

[33] http://www.regeringen.ax/

[34] http://www.vannportalen.no/globalassets/nasjonalt/engelsk/river-basin-management-planning-at-district-level/the-water-regulation-divides-norway-into.pdf

preparations of programs, coordinating the regional water management and instigating and supporting local Water Boards. The national authority for the implementation of the WFD is the Norwegian Ministry of Climate and Environment that also chairs a committee of eight ministers to ensure sufficient sector integration. The Norwegian Environment Agency[35] is responsible for administrative coordination and the day-to-day administration of the RBDs, including leading a Committee of Directorates consisting of central government agencies, as well as regional and local level representatives, with the task to prepare national guidance for the RBDs. A National Reference Group is connected to the Committee of Directorates also allowing for the participation of national industry associations, NGOs and civil society representatives (vannportalen.no, 2017).

Iceland has one single river basin district,[36] divided into four sub-districts. Iceland is connected to the European Union through the Agreement on the European Economic Area (the EEA agreement). The WFD was formally taken into the EEA agreement in 2009 and fully transposed into Icelandic legislation in 2011 (Halleraker *et al.*, 2013). Iceland reports its obligations to the European Surveillance Authority (ESA). The Environment Agency implements the WFD and works with five state institutes/agencies (Icelandic Met Office, Institute of Freshwater Fisheries, National Energy Authority, Icelandic Institute of Natural History and Marine Research Institute), local authorities, water district committees and consultation groups to analyse and classify the water bodies of the RBD.

6.5 Mainstreaming biodiversity and ecosystem services across sectors in the Nordic region: Examples from water governance and the case studies

Case studies and examples from water governance in the Nordic region aim to provide an overview of how environmental aspects are integrated across policy areas and of the policy conflicts that arise in this process. Furthermore, water governance and our case studies provide important insights into what policy instruments are in place and how participatory governance is organized in the Nordic region.

6.5.1 Policy integration across sectors, ecosystem services and scales

The Sound between Denmark and Sweden provides a relevant example of how successful work for cross-border cooperation and environmental policy integration can be organized. The Sound is the most densely populated area in Scandinavia and one of the most trafficked places in the world's oceans. Since the Sound is a hotspot of almost all kinds of human activities, associated environmental pressures have the potential to affect

[35] http://www.miljodirektoratet.no/english/

[36] http://www.government.is/

biodiversity and ecosystem function and services. However, our case study shows that the area is a well-functioning ecosystem with a relatively high biodiversity, which may be explained by appropriate standards for environmental protection and a general precautionary approach to the environment that have helped to preserve ecosystems. EU and national spatial planning regulations protect both terrestrial and marine areas and have helped to halt the impacts of urban and agricultural development. In the Sound area, there is a long tradition of municipal and regional cooperation across borders in order to act for a healthy marine environment. Since 1995, this cooperative work has been conducted within "The Sound Water Cooperation". The almost 18 km long bridge across the Sound exemplifies how highly marine environments and ecosystems are placed on political agenas, particularly in terms of investments in water quality that have made bathing possible in the harbours of Copenhagen and Malmö.

The WFD is implemented in all Nordic countries and therefore provides another relevant point of departure for comparing formal processes for environmental policy integration in the Nordic region. Generally, water governance work is ecosystem based, organized in 6-year water cycles and the process is carried out in cooperation with stakeholders. However, the formal process is organized differently in different countries (see section 6.4). Denmark, Iceland, Finland and Åland have implemented the WFD in line with their existing environmental administration, resulting in consistency in power structures and responsibilities regarding the WFD process in these countries. In Denmark, the RBMP is not binding to individual persons i.e. operators and water users. Therefore, the obligation of compatibility of the RBMP with other decisions and plans applies to the RBMP in its entirety. In Finland, one of the main challenges in the water area is the vague nature of the RBMP and Management Strategies. Plans are not considered legally binding for the authorities, but something they should take into account in their decision-making (e.g. plans, permits, municipal environmental regulations) (Kauppila 2016). Furthermore, implementing additional measures is mainly voluntary for both public and private actors. Sweden and Norway have created new institutional arrangements for water management, which has given rise to confusions regarding the power structures within the systems. In Finland, Sweden and Norway, Management Plans and Programmes of Measures are established for each river basin based on the EQS and after discussion within stakeholder groups. However, although the Swedish WDAs/Norwegian WRAs set the goals for water governance, the responsibility to implement the Management Plans and Programmes of Measures rests heavily on municipalities and national authorities. The Programmes of Measures thus forms a meta-regional level authority that provides guidelines both downwards to municipalities and upwards to state agencies, which report back on their undertaken measures to the meta-regional river basin district authorities. As a result, Swedish SwAM/Norwegian NEA first receive directives from the WDAs/WRAs, then report their undertaken measures back to the WDAs/WRAs and finally receive compiled reports from the WDAs/WRAs following their reporting to the EU. Sweden's new and untraditional power directions within the country's system for water governance have been pointed out as one reason for difficulties in reaching the goal of good water quality (Söderberg, 2016).

6.5.2 Policy coherence

One obstacle for successful integration of biodiversity goals and other environmental goals is policy conflicts. In practice, biodiversity and water quality goals can be in conflict with other targets influencing the water environment, such as flood risk management, climate change, tourism, infrastructure development and agriculture. Examples of detected policy conflicts in case studies and management of water in the Nordic are presented below.

The Sound: Although the Sound provides a good example of cross-border cooperation and environmental policy integration in practice, there are also some examples of policy incoherence that need to be addressed. It is relevant to note that the Swedish Sound part is managed under the WFD (with stricter demands for management plans), while the Danish part of the Sound is managed by a combination of the WFD and the Marine Strategy Framework Directive (MSFD), a process which is less finalised and currently negotiated in HELCOM. Furthermore, areas protected by Natura 2000 must fit under a specific designation basis – the habitat type has to be listed in the Habitats Directive Annex I. The Danish national Nature Protection Act protects coastal areas, while the Marine Environment Act protects marine areas. Given that different Directives and different regulations are in place, protection of the Sound as a whole would require cooperation from both sides of the Sound – Denmark and Sweden – causing the need, although much integration is done already, for more work streamlining or developing special protection legislations in the area (see Petersen *et al*., 2018). Furthermore, Swedish sector authorities and County Administrative Boards have signalled that water issues are one of the areas of their work that often conflicts with goals and priorities in other policy areas (SEPA, 2011). Similarly, Söderberg (2016) concludes that Swedish water bureaucrats experience the goals in the Programme of Measures as vague and difficult to understand and point out a number of other regulations that limit the practical space for implementing measures according to the Programmes of Measures. In addition, different authorities handle the different regulations that affect water quality work, and they all have different perceptions of how efforts should be balanced between water quality and other issues such as agricultural competitiveness, forestry, societal planning, renewable energy production, employment policy and economic development (Söderberg, 2016).

Kalix: One area often forwarded as a successful Swedish participatory governance/co-management example is the professional bleak roe fishing in the waters around Kalix (see e.g Rova, 2004). At the same time, the ILK case study of the Kalix area (see Kvarnström & Boström, 2018) in Sweden shows that the possibility to continue traditional small-scale artisanal fishing for household needs has been negatively influenced by extensive changes in regulations. The Kalix case study shows how multi-level governance structures and many different policies clash with resulting negative impacts on local people's way and quality of life. At present, there is an extensive network of authorities that create, implement and oversee compliance of regulations relating to fishing in the coastal waters of the Bothnian Bay. The new fishing regulations regarding fishing and the selling of fish have meant that local community members in the Kalix area no longer can catch their own fish or sell any surplus as previous generations did. At the same time, the number of seals in the Baltic Sea and the Gulf of Bothnia have increased significantly, as has seal-related damage to fish and fish equipment, while protective hunting of seals is regulated on several levels. The most complicated example of the fishing regulations is the professional salmon fishing and salmon fishing with fixed fishing gear on private waters. These activities are surrounded with a very complicated regulatory framework where virtually all agencies have a part, ranging from EU quotas on salmon to national catch allocations, to regional and local rules that regulate dates and quotas and the distribution of catches between river and coastal waters. There is no co-management at present, but a local organisation, *Kustringen*, has carried out eco-mapping and mapping of fish and fishing for several years. Proposals have been made for the introduction of local fishing regulations involving the local population in monitoring and governance (see Kvarnström & Boström, 2018). However, so far this ambition has not led to anything in practice in terms of co-governance.

Åland: A number of policy conflicts are reported on in relation to water and biodiversity management in Åland. One conflict between Åland and Finland concerns the total allowable catch (TAC): a catch limit (in tonnes or number) that is determined for the fish stocks that have the highest commercial value. Countries must use clear and objective criteria when allocating national quotas for its fishermen. They are required to ensure that quotas are not exceeded. Another policy conflict relates to fish farms in the Baltic Sea, which have negative environmental impacts on aquatic ecosystems. However, they also constitute an important source of income in the Åland archipelago (ÅSUB 2015). A sharp cut of fish farming operations would have major social and economic consequences, but a reduced nutrient load is good for the aquatic environment and its ecosystem services: a reduction of excessive nutrients is needed to prevent eutrophication and improve the Ålandic water status (including wild fish stocks). The possible development of the aquaculture industry must comply with the requirements for the improvement of water quality in accordance with the WFD), HELCOM's Baltic Sea Actions Plan and recommendations and the Åland marine strategy (Directive 2008/56/EG) (see Vävare & Häggblom, 2018): Two recent EU Commission judgments, the Weser Judgement and Schwarze Sulm, clarify the application of Article 4 of the WFD. Member States are required to not grant permission for a project if the project can cause deterioration of a surface water body or if the project compromises the achievement of good status of a body of surface water. The strict conditions make it difficult to allow the establishment of new fish farms in coastal waters with moderate or poor water status, such as in the Baltic Sea. This was made very clear in a Swedish judgment in March 2017 concerning fish farms in waters around the High Coast in Sweden.

Helgeland: Helgeland in Norway, like many areas in Nordic water management, is subject to many conflicting interests of both economic and ecological development. In an attempt to find a way forward and balance the different goals and needs in the area, a regional coastal plan has been developed between 13 local authorities (see Hancke *et al.*, 2018).

The Quark: In the case study of the Quark between Sweden and Finland, insights into how cross-border cooperation can be organized according to an ecosystem-based approach in order to achieve a coherent management program are presented. The intergovernmental governance of the Quark strait has been developed through official cooperation programs between regional authorities. The Kvarken Council is a political cross-border dialogue platform formed by the cities of Vaasa, Kokkola, Seinäjoki and Jakobstad, the three Regional Councils of Ostrobothnia in Finland, as well as the Regional Council of Västerbotten and the city of Örnsköldsvik in Sweden. It was founded in 1972 and the board has six members from Finland and six from Sweden. The Council is one of eleven official cross-border operators funded by the Nordic Council of Ministers. The Council is registered in Finland and Finnish law is applied. The chairmanship is circulated between the cities of Vaasa and Umeå (two years each) (see Ilvessalo-Lax *et al.*, 2018).

Disko Bay: Obtaining coherent biological knowledge in the Arctic is generally difficult, expensive and dependent on long-term monitoring activities, since many species are distributed over vast areas. In addition, extreme weather conditions, remote locations and expensive logistics and transportation may limit the biological knowledge about particular populations. Thus, lack of data leads to biological advice that often creates controversy between the scientific community and the fishers and hunters. Fishers and hunters have accumulated traditional ecological knowledge for decades and therefore often find it difficult to understand and accept the notion of lack of data (Ministry of Environment and Nature 2014). This case study also demonstrates that local people are expected to contribute to monitoring initiatives without any economic compensation (see Poulsen, 2018).

Faroe Islands: The Faroe Islands constitute a self-governed (autonomic) part of the Danish Kingdom with their own legislative parliament (Føroya løgting) and government, which is chaired by the prime minister (løgmaður) and two other ministers. The Faroes are organized in 30 municipalities, the largest being Tórshavnar with 20,885 inhabitants in 2017. Although Denmark is a member state of the European Union, the Faroe Islands have chosen to remain outside the union. Accordingly, the Faroe Islands negotiate their own trade and fisheries agreements with the EU and other countries. A treaty between the Faroe Islands and Denmark, which is enacted in legislation, provides Faroese autonomy in foreign relations. The Faroe Islands participate actively in a range of international fisheries management arrangements and organisations in the North Atlantic. Marine environmental protection is regulated according to the Marine Environmental Act, with regulations implemented in line with requirements under international conventions such as the MARPOL convention for the Prevention of Pollution from Ships and the OSPAR Convention for the Protection of the Marine Environment in the North Atlantic. The responsible authorities are the Environmental Agency, the Faroese Maritime Authority and the Faroese Fisheries Inspection. To take care of the rich bird life in the Faroe Islands, the government has appointed three areas as Ramsar sites: Mykines, Nólsoy and Skúvoy. Several national acts and decrees exist to protect the nature and limit the use of resources. A number of emerging policy conflicts are visible here, including different opinions regarding whale hunting, and between ecosystems and tourism expansion. Furthermore, the increasing levels of plastic pollution, industrial chemicals, heavy metals and PCBs found in fish, pose an international threat to the traditional Faroese food culture (see Sørensen, Roto, & Tunón, 2018).

6.5.3 Participatory measures in the implementation of policy

Participatory measures are central to the governance of biodiversity and ecosystem services – and for water management – in all Nordic countries, but these processes are organised in different ways. In this section, policy instruments such as cross-border cooperation and participatory measures from water governance and case studies, are presented and discussed.

In *the Sound* case study, it is pointed out that there is a well-developed cross-border cooperation between municipalities/regions and environmental authorities. High policy density in the Sound has led to incoherence and thus streamlining and developing strategies is needed. However, although there are on-going initiatives for stakeholder participation in the regional association "Öresundsfiskarna" with hopes to bridge opinions between fishers, the case study shows that there is a need for participation and communication between authorities and commercial/ recreational fishers in the area. This is particularly relevant as marine protected areas often conflict with fishing interests. Commercial and subsistence fishers in Scania currently feel marginalised and call for more knowledge and flexibility amongst local authorities, along with a looser regulatory framework as the current framework limits potential to develop local markets. These issues could be relevant to address when planning for marine protected areas in the Northern parts of the Sound (see case study the Sound: Tunón, ed., 2018).

At the same time, the Swedish part of the Sound is managed under the WFD, while the Danish part is managed under a combination of the WFD and the EU Marine Strategy Framework Directive (MSFD, which provides a number of different examples of how stakeholder participation can be organized. Different authorities handle different regulations that affect water quality work, each with different perceptions of how efforts should be balanced between e.g. water quality and water use. Marine managers identify the Sound as part of the Greater North Sea, due to its marine nature and the presence of the shallow sill at its southern end. River basin managers identify the Sound as part of the Baltic, due to the watershed at its northern end. Even smaller catchments used to group measures on land, do not match the marine underwater topography. These mismatches can cause difficulties when evaluating work at a regional level.

In Sweden, participatory measures within water governance are visible mainly within two administrative schemes: the *Water Delegations* (a maximum of eleven expert delegates making formal decisions in each Water District) and the Water Boards (125 local Water Boards, open for all actors affected by the water who participate water governance decision-making). Water Boards do not make any decisions, but are informal organisations for local cooperation. They enable dialogue with water stakeholders within a water district and accumulate local knowledge (Swedish Water Authorities, 2014a). Through providing a forum for discussing and adjusting proposals before decisions are made, the Water Boards represent an attempt to make sure that decisions on water management are easier to implement for authorities and municipalities (Swedish Water Authorities, 2014b). However, their status is unclear, as is the relationship between municipalities and water authorities. Local cooperation in local watersheds is important, in particular regarding issues such as nutrient leakage affecting eutrophication, where active participation from landowners is required for successful mitigation. Successful collaboration regarding concrete measures to improve the environment, such as wetland construction programs, are heavily dependent on the institutional setup regarding stakeholder participation (Franzén et al, 2015). The Swedish organization for stakeholder participation under the WFD can be compared to stakeholder participation for water and marine management in Finland, where each ELY-centre nominates a cooperation group consisting of representatives of regional stakeholders from relevant public and private sectors. The cooperation group is then consulted during the preparation and implementation of the RBM plans/PoM and marine strategy. Regional Councils provide environmental support for environmental initiatives and are responsible for land use planning. Regional Councils are also responsible for Marine spatial planning (according to the EU MSP directive) in cooperation with several other councils and regional actors. In Åland, Water Framework work has led to cooperation in several different stages and at different levels, both locally in Åland, nationally with Finland and internationally in cooperation with the other Nordic countries. Consultation and information meetings are held in conjunction with the development of management plans. Initial information meetings often result in more specific meetings on agriculture, forestry, fish farming and meetings for agencies of the provincial government and subordinate agencies, as well as invitations of various industries and operators to consultations. Municipalities, NGOs, politicians and the public are invited to information meetings through the yearly aquatic seminars organised by the Environment Agency. The meetings result in a list of different measures proposed for water bodies, where the need for different tools and resources are pointed out. The Environment Agency compiles information gained through the consultation process and develops proposals for action. Consultative rounds are run with as many stakeholders as possible (e.g. politicians, other authorities, operators and NGOs). To ensure transparency, the public is informed of their opportunity to respond to material available on government websites through advertisements in local media. Once the documents are finalised, the Environment Agency initiates consultations with the elected politicians in the government. The Åland Government then makes the final decision on determining the river basin management plan and the water action program for the Åland waters. When the decision is made, it is up to the Environment Agency to co-report to the EU (via Finland) and initiate the implementation of the Water Action Plan and other strategic work linked to the management cycle.

The Disko Bay case study (Poulsen, 2018) points out that Greenlandic governance institutions have been criticized for their colonial heritage of centralization and lack of democratic participation. In the same manner, Greenlandic fisheries management is notorious in academic literature for its centralized and locally illegitimate character (Jacobsen & Raakjær, 2012). Greenlandic governance institutions are subject to the power structures taken over from Denmark at the inception of Home Rule on May 1, 1979 (Jacobsen & Raakjær, 2012). Participatory decision-making does not necessitate bottom-up democracy and equity, nor does it always play a role in increased efficiency (Jacobsen & Raakjær, 2012). Since 1999, the Hunting and Fishing Law in Greenland has required local knowledge to be considered in the government's decision-making. It has however been difficult to do so in practice, as it is almost impossible for decision-makers to get information on the local knowledge. Advice from scientists is often based on systematic scientific research by biologists from the Greenland Institute of Natural Resources (GINR) and the Danish Centre for Environment and Energy (DCE). The quality of this research is reviewed and approved by other scientists. Advice based on local knowledge is rarely based on systematic observations and approved by other local experts. It is therefore not surprising that decisions regarding the use of living resources are based more on advice from biologists than advice from fishers and hunters. The parties Siumut, Inuit Ataqatigiit and Partii Naleraq have entered a coalition agreement where it is said that management decisions should be based on advice from both biologists and users (fishers and hunters). In the GINR strategic plan for 2013–2017, the Institute recognizes that fishers and hunters hold extensive local knowledge of the Greenlandic nature, which should be included in the scientific work of the Institute. Our Disko Bay case study in Greenland provides one example of involving local citizens in environmental monitoring (i.e. a community-based monitoring system). Fisheries control is partly carried out by reporting from fishermen. The method of reporting depends on boat size. Boats under 30 feet / 9.4 meters must report catch to the place of purchase. Boats over 30 feet / 9.4 meters must keep an updated logbook with recordings of all catches. Hunters must report all catch annually via the Greenland hunting and catch registration system "Piniarneq". Standardized monitoring of the catch is based on Piniarneq. The information from fishers and hunters however, needs quality assurance in line with scientific data, as the Institute must not compromise on scientific methods.

6.5.4 Innovative governance in the Nordic: co-management examples

In the Nordic region, there are a few examples where participatory management has been taken one step further – towards co-management. In this section, innovative governance solutions for biodiversity and ecosystem management in Laponia and Näätämö are presented. In the last part of this section, an example of ILK-involvement in governance from Disko Bay in Greenland is presented.

Collaborative management and joint governance is usually, if it has legal or meaningful mandates, thought to be constructed from a dual approach: 1) Joint knowledge flows from ILK and science to inform decision-makers of the situation, baselines and changes in a given context; 2) joint decisions (usually consensus or 50–50) on the uses and governance of natural resources and territories. It is also expected to result in better compliance when it comes to specific decisions. Actual arrangements may vary. The various official recognitions of ILK and local-traditional knowledge depend on the scale and level of governance. Internationally, there is a wealth of academic literature on management initiatives that focus on the inclusions of ILK. For the Nordic countries, the situation differs greatly. Out of the arrangements in place, only Laponia and Näätämö (see further details below) are recognized internationally as "true" collaborative management initiatives, as they contain the two-tiered model of knowledge flow leading to joint management. Co-management systems, provided that they contain the principles and context of co-governance, should be seen as an innovative tool for the future and good governance of biodiversity in the Nordic space.

Laponia: Sweden has implemented the first-ever official collaborative management system in the Nordic countries, in the large national parks known jointly as Laponia[37] in Norrbotten, Sweden. The region is also protected as a UNESCO World Heritage site due to the presence of strong Saami culture, ways of life and economies both outside and inside the parks. The World Heritage site was founded in 1996, but the management structure was not easy to develop in a way that was acceptable to the stakeholders. Hence an agreement was reached in 2006 to develop a structure of co-management. The co-management function Laponiatjuottjudus was launched in 2013. The road to an organization that was acceptable to the different stakeholders, was long and filled with disagreement. It took a lot of effort and new legislation in order to create a new management organization. Governance of the parks and the environment rests on consensus between local Saami villages, municipalities, county administration and the state (see e.g. Zachrisson, 2009). Therefore, Laponia is often hailed as the "best existing model" for the governance of aquatic and terrestrial ecosystems in the European North.

Näätämö: The first collaborative management project in Finland was initiated in 2011 in the Näätämö river basin, with funding from the United Nations and Nordic Council of Ministers. The key organizations participating in the co-management of Atlantic Salmon resources include Metsähallitus,[38] Institute of Natural Resources LUKE and the ELY-centres. The Saa'mi Nue'tt cultural organisation, the Skolt Saami Village Council and the international Snowchange Cooperative form the key components of this co-management arrangement. Näätämö co-management has no legal status. Instead, it is an on-going project that implements the methods and structure of a full arrangement of joint governance – the first of its kind in Finland. In short, the knowledge flow combines Indigenous Saami and local-traditional knowledge of observations, monitoring, cultural indicators and locations of altered ecosystems with the latest scientific and limnological interpretation to offer a view of the basin. The Näätämö co-management project has taken some pilot-style steps to restore lost habitats due to past land uses, such as the Vainosjoki sub-catchment area. ILK and science is used to improve living conditions for salmonid species, Skolt Saami and other users of the river. The Näätämö project works closely with the Inuvialuit Joint

[37] https://laponia.nu/en/
[38] http://www.metsa.fi/web/en

Secretariat in Northwest Territories in Canada, to investigate, analyse and exchange experiences of collaborative management (Mustonen, 2018a).

Näätämö basin is under the jurisdiction of the Finnish-Norwegian border river treaty. The general tendency in the Finnish case study areas (see the Näätämö and Puruvesi case studies: Mustonen, 2018a & b) is a system of top-down governance of natural resources, ecosystems and socio-ecological systems. This can potentially result in a number of slow-simmering conflicts, which do not necessarily expand into open conflicts, but contain abrasive experiences for local and indigenous stakeholders. While in Näätämö basin positive steps have been taken over the past five years through the first co-governance of the Atlantic Salmon, ultimately the fisheries and management of the river still rests with the Ministry of Agriculture and Forestry and Finnish-Norwegian border river commission. This means that the Skolt Saami, the primary Saami group involved in this river, feels their ILK and ways of being with the river are not heard or taken into consideration when power is exercised in the basin. Puruvesi Lake is divided between two administrational regions, South Savo and North Karelia. It is the home of the most traditional seining culture in Finland, with records from the beginning of the 1300s. In the 1990s, the negotiations between Metsähallitus and the commercial fishers of the lake, resulted in seines and fish traps only being used on the lake to preserve the unique vendace stocks. This began to shift so that trawling was permitted on the lake by the end of 2010. Potential other future conflicts include the harvest of gravel from the lake bottom on Puruvesi and the erosion of the Savo – Karelian border for commercial harvests to allow "outsiders" to operate on this extremely productive fishery.

Overall in Finland, many coastal and aquatic systems portray elements of joint governance, and more recently Akwé: Kon guidelines (CBD, 2004b) in times of conflict (Full name: Akwé: Kon Voluntary guidelines for the conduct of cultural, environmental and social impact assessments regarding developments proposed to take place on, or which are likely to impact on, sacred sites and on lands and waters traditionally occupied or used by indigenous and local communities). These include, for example, the local fisheries bodies, which have the power to decide on stocking and restoration measures within their jurisdiction. Policy analysis shows however, that the level of governance and power to rule over natural resources remains weak. These systems are more to be seen as state governance than shared responsibility. Therefore, concepts of joint governance and co-management that address past equity issues with the Saami, or address other grievances in natural resources management in Finland, should be contextualized as early emerging systems at this stage.

Disko Bay: In Greenland, The National Institute gathers information from local knowledge through meetings with resource persons during the planning of studies, the creation of local networks with active involvement in research projects, collaborative projects, scientific interviews and information from catch and fishing reporting. However, when the scientific advisers lack data based on biological research, they advise according to the precautionary principle, and hunters and fishers claim that populations of certain species are larger than the figures the restrictions and quotas are based on. Systematic data gathering and a process for reviewing and approval are therefore needed if hunters and fishes are to be heard. This is why a number of authorities and organizations, including the Ministry of Fisheries and Hunting (APN), Qaasuitsup Municipality and KNAPK, have since 2008 been testing the use of locally-based monitoring of living resources in communities in Disko Bay and other places in Qaasuitsup Municipality in North West Greenland under a program called PISUNA.[39] In the PISUNA program, village councils appoint 5–12 members of local Natural Resource Councils, comprised of experienced fishers, hunters and other environmentally interested people. They observe the living resources and the marine and coastal environment whenever they travel, fish and hunt. Every three months they summarize, discuss and interpret their observations. They propose management recommendations to the municipal government and they submit a standardized report with their findings to the municipal and central government. PISUNA was at first met with considerable skepticism from both scientists and local hunters and fishers. Most of this skepticism has since been overcome as the program has addressed challenges, tested solutions and adapted as required. The program therefore now provides a great example of how local people can participate in environmental monitoring in Greenland and elsewhere (Poulsen, 2018).

6.6 Opportunities and challenges for policy and decision-making

The overview and the examples provided in this chapter show that biodiversity goals are difficult to implement in practice, even in the "green" Nordic region with a long-standing culture of consensus building and cooperation. Policy density is high, with a lot of different policies to handle: this affects policy integration and policy coherence and a number of emerging and on-going policy conflicts are evident. With many different objectives to achieve, policy makers and bureaucrats need to weigh the costs and benefits – and prioritize – not only between economic/social goals and ecological goals – but also between different environmental goals. In addition, integration of ILK through stakeholder participation, as well as cross-regional and cross-border cooperation and coordination, is necessary in many cases to make sure that policies are coherent, built upon correct information and able to balance different policy goals and interests. Many stakeholders want to safeguard their interests and put pressure on politicians and decision makers to make favourable decisions. In such a context, the ILK-groups are generally seen as relatively weak groups. Despite similarities in political culture, different solutions for participation and ILK-integration exist in each country. A number of examples of when cooperation across borders works well in order to overcome policy conflicts and national boundaries has also been provided.

A number of different challenges need to be handled in the future. The case study areas in this report, and the examples given in this chapter, are subject to slightly different preconditions and thus slightly different challenges with regard to biodiversity

[39] http://www.iucn.org/news/marine-and-polar/201701/pisuna-community-based-monitoring-management

management. The Sound area is crowded. The Helgeland Coast and the Quark, Kalix, Laponia, Näätämö, 254Puruvesi, Disko Bay and Faroe Islands are large and sparsely populated areas. The Baltic Sea around Åland is affected by the actions in the many different nations surrounding it. Environmental problems in the Faroe Islands are at large caused by pollutions spread from other parts of the Atlantic.

In the Sound, trends of declining fish stock and increasing local pressures have been observed. The consequences of these pressures depend on future handling of existing administrative tools and regulations. Eutrophication load has been lowered locally, but it is difficult to handle the load coming from Kattegat and the Baltic Sea. At the same time, two different national policies, a number of regional and local policies, along with two EU policies (Marine and Water policy) need to be coordinated, in order to reach a coherent policy for the Sound. However, the case study also shows that people are starting to take action in the Sound because they want to protect their environment, even though they are not required to. The case study of the Helgeland Coast shows that kelp forests are important carbon sinks, but these areas are not protected by policy: this is a challenge for future policy to handle. Different challenges for artisanal fishing, stakeholder involvement and flexibility in administering the EU-regulations exist in Kalix and in the Sound.

Thus, one challenge for policy-makers and bureaucrats to handle is how different international policies and EU-directives are implemented in national policy – and to coordinate this across policy sectors, policy levels and national borders, while inviting all relevant stakeholders into this process. It is important to balance ecological, social, cultural and economic aspects in decisions regarding the use of biodiversity and ecosystem services. Since climate change will affect Nordic marine biodiversity profoundly in the future, it is of paramount importance that efficient governance is developed for other pressures, as to mitigate its effects on ecosystem services. Less overfishing, less eutrophication, less pollutants and better land-use and nature protection, are measures that will improve the resilience of Nordic coastal environments (see also Chapter 4 in this report: Svedäng *et al*., 2018). In designing new governance systems to manage biodiversity and ecosystem services, another challenge is to deal with different transitional problems that may arise with institutional reorganization, such as those we see in both Sweden and Norway. One example of this is the role of national and regional water authorities in relation to municipalities in Sweden, where unclear power structures has led to uncertainties regarding who has the responsibility for what. Knowledge regarding the management of ecosystem services that takes departure from the ecosystem itself, instead of departing from the administrative structure, is lacking and needs to be developed. The challenge is how not to drown in detailed data requirements when imposing new governance models.

6.7 Detected uncertainties and options for the future

Biodiversity goals are difficult to implement in practice, even in the "green" Nordic region with a long-standing culture of consensus building and cooperation. Knowledge gaps regarding ecosystems and their function need to be addressed in order to ensure their continued provision of ecosystem services. The importance of these services need to be highlighted for society and the link between biodiversity, ecosystem services and local cultural identity needs to be identified. Ecosystems need to be managed in a way that makes the most common good today and for the future.

In order to address priorities, risks and trade-offs, monitoring of ecosystems in sparsely populated areas with many water bodies needs to be developed. Here, both ILK and scientific knowledge is needed to get the full picture of biodiversity and ecosystem services challenges and possible solutions. Consequently, to develop good governance, there is a need to include more citizen science and community based monitoring systems in decision-making.

Furthermore, more social science research on already existing ecosystem based management systems, on participatory and collaborative management solutions currently in place, and on policy coherence within international, EU and Nordic environmental management is needed. This will help to improve the design of systems for governance and provide guidelines for how to handle policy conflicts and trade-offs in a way that ensures participation and enhances biodiversity and ecosystem services.

The EU Strategy for biodiversity and ecosystem services, along with other international policy directives, have led to increased awareness and action at all policy levels and across sectors within the EU. However, biodiversity and ecosystem services are not a prioritized issue from political and economic perspectives. Other issues are generally seen as more important. The WFD and our case studies provide illustrative examples of the need for a transformation in awareness and demands for new institutional settings to tackle environmental issues, where ecosystem services provide a powerful tool that is now being introduced in local municipal planning in for example Sweden. The heterogeneity both in institutional and ecological settings, and the different preconditions in the Nordic countries, emphasize the need for adaptive and flexible policy instruments for sustainable governance. At the same time, increased cooperation is needed between local stakeholders, as well as across borders (Halleraker *et al.*, 2013). The current systems for handling these issues in the Nordic region attempt to ensure stakeholder involvement and ecosystem based management. However, the different Nordic management systems all struggle with different problems regarding power structures, trade-offs and policy conflicts.

It is essential to note that as environmental policy integration in all policy areas is a requirement (under the EU treaty) for all EU member states, environmental issues should not be treated as special interests – rather, environmental issues are of relevance for all of society and should be taken into account within all sectors – in energy policy and land use planning, as well as in policies for climate change mitigation and adaptation. Biodiversity and ecosystems services are fundamental for the long-term survival and development of human society and are linked to various policies that aim to promote human well-being and improve resilience and sustainability of society. Therefore, the concept of ecosystem services, including consistent evaluation and assessment approaches, should be mainstreamed in all policies (e.g. health, education, transport, land-use, environment, etc.).

At the same time, it is important to highlight the need for clear political guidance on how to handle the detected policy conflicts arising from contradicting policy signals. How should bureaucrats prioritize when balancing different EU directives, national laws, environmental and economic interests etc.? Our case studies and focus on water quality management in the Nordic region indicate that contradictive policies and lack of clear guidelines for how trade-offs are to be made constitute a major obstacle for achieving healthy biodiversity and ecosystem services. It is also essential to follow-up on the need for better data – monitoring programs and priorities that are based on a systems thinking need to be designed. They need to allow for comparative analyses adapted to policy priorities and trade-offs. Furthermore, future governance systems that are able to meet uncertainties and adapt to new knowledge need to be developed if a coherent system for biodiversity management is to be achieved.

6.8 Knowledge gaps

- It is essential to follow-up on the need for better data – we need to design monitoring programs and priorities that are based on a systems thinking and allow for comparative analyses adapted to policy priorities and trade-offs;
- There is a need for a better understanding of the role and impact that institutions and governance on different levels have on biodiversity and ecosystem services. For this, we need more social science research on already existing ecosystem based management systems, on participatory and collaborative management solutions currently in place, and on policy coherence within international, EU and Nordic environmental management, in order to be able to improve the design of systems for governance and provide guidelines for how to handle policy conflicts and trade-offs in a way that ensures participation and enhances biodiversity and ecosystem services.

6.9 Policy recommendations

- Environmental policy integration in all policy areas is a requirement for all EU member states. It is recommended that environmental issues should not be treated as special interests. Environmental issues are of relevance for all of society and should be taken into account within all sectors;
- The concept of ecosystem services, including consistent evaluation and assessment approaches, should be mainstreamed in all policies. Biodiversity and ecosystems services are fundamental for the long-term survival and development

of human society and are dependent on various policies that aim to promote human well-being and improve the resilience and sustainability of society;

- There is a need to prioritize between different environmental goals, not only between economic/social goals and ecological goals. Policy density is high – with a lot of different policies to handle: this affects policy integration and policy coherence. Emerging and on-going policy conflicts highlight an increasing need to prioritize;
- It is recommended that the ongoing integration efforts should continue in the Nordic region. Stakeholder participation, as well as cross-regional and cross-border cooperation and coordination, is necessary in many cases in order to make sure that policies are coherent, buildt upon correct information and are able to balance different policy goals and interests;
- To investigate what legislation and regulations that counteract incentives for the conservation and sustainable use of biodiversity in coastal areas in the Nordic region in order to avoid policy conflicts and improve policy coherence;
- Involve science-based assessments and priorities in policymaking in terms of identifying most needed conservation and management policy initiatives;
- Safeguard the right to public access of coastal areas, as access to nature maintains access to a number of non-material NCP, such as identity, physical and psychological experiences, knowledge and inspiration, as well as material benefits such as food and ornaments. This collectively helps maintain society's sense of duty to protect the environment;
- Implement ecosystem-based adaptation to increase the coastal region's resilience to climate change;
- Draw benefits from technological developments that reduce the region's ecological footprint.

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Sammanfattning

Rapporten beskriver biologisk mångfald och ekosystemtjänster i nordiska kustområden, en miljö som är gemensam för alla nordiska länder. Rapportens struktur följer delvis det ramverk för kunskapssammanställning som används av IPBES, den mellanstatliga plattformen för biologisk mångfald och ekosystemtjänster.

Den här studien baseras främst på kunskaps-sammanställning från tio fallstudier i kustområdena runt Danmark, Finland, Island, Norge och Sverige, samt från de autonoma områdena Färöarna, Grönland och Åland.

Syftet med kunskapssammanställningen är att beskriva status och trender för biologisk mångfald, ekosystem och ekosystemtjänster i kusten, samt att identifiera drivkrafter och belastningar som ger effekter för människor, samhälle och förvaltning. Sammanställningen baseras på litteratur från naturvetenskapliga och samhällsvetenskapliga studier. Den kan ge stöd till beslutsfattare och politiker i Norden för att samverka till en hållbar utveckling av kustområden.

De nordiska kustområdena varierar på många sätt, som klimat och geomorfologi med arktiska förhållanden på Grönland, den norska kustens kelpskogar och branta fågelberg samt skärgårdar och flacka kustområden i Östersjön. Kustvattnets karaktär, från Nordsjökustens höga salthalt till de sötvattensliknande förhållandena i Bottenviken, styr utbredningen av växter och djur. Människans påverkan på kustzonen varierar i de olika områdena, där kustvattnets ekologiska status i nordost Atlanten är god, men i egentliga Östersjön och Finska viken bedöms vattenkvaliteten som måttlig. Populationerna för exempelvis säl och havsörn har ökat under de senaste decennierna efter att användning av miljögifter som PCB och DDT förbjudits. Däremot finns i dag negativa trender för andra arter, som exempelvis den kraftiga minskningen av ejderpopulationen i Östersjön.

Nordens kustområden påverkas av en mängd miljöfaktorer, som klimatförändring, effekter av nya kemiska ämnen, övergödning och mikroplaster samt invasiva främmande arter.

Gemensamt för de flesta av Nordens kustområden är det ökande exploateringstryck som en följd av samhällsutveckling och befolkningsökning i vissa områden. Det finns därför behov av att ytterligare utveckla förvaltningssystem som minskar risken för negativ påverkan på ekosystem och som tar hänsyn till naturområdenas bidrag till människans välbefinnande. Det behövs ett fortsatt arbete med förvaltning av det kustnära fisket samt förbättrade instrument för lokal och regional planering för att motverka negativa effekter på kustområdena. Det är viktigt att inkludera lokalbefolkningen i början av detaljplaneringen och i den fortsatta förvaltningsprocessen av kust- och skärgårdsmiljöerna. Kustmiljöer samt enstaka arter har även en stor kulturell roll för människor och påverkar livskvaliteten.

Studien pekar på de nordiska kustområdenas olika miljöförhållanden liksom på gemensamma faktorer, som befolkningens intresse för natur och miljö samt ländernas likvärdiga sociala och politiska styrmedel. Detta visar att det nordiska samarbetet har stor betydelse för en hållbar förvaltning av kustområden och bör stärkas i det framtida arbetet.

Annexes

Chapter 5 (Supplementary Material)

The Chapter 5 Supplementary Material will be provided upon request, please contact:

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Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment Volume 1. The general overview

This report describes the status and trends of biodiversity and ecosystem services in the Nordic region, the drivers and pressures affecting them, interactions and effects on people and society, and options for governance. The main report consists of two volumes. Volume 1 The general overview (this report) and Volume 2 The geographical case studies. This study has been inspired by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES). It departs from case studies (Volume 2, the geographical case studies) from ten geographical areas in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) and the autonomous areas of Faroe Islands, Greenland, and Åland. The aim was to describe status and trends of biodiversity and ecosystem services in the Nordic region, including the drivers and pressures affecting these ecosystems, the effects on people and society and options for governance. The Nordic study is structured as closely as possible to the framework for the regional assessments currently being finalized within IPBES. The report highlights environmental differences and similarities in the Nordic coastal areas, like the inhabitants´ relation to nature and the environment as well as similarities in social and policy instruments between the Nordic countries. This study provides background material for decision-making and it is shown that Nordic cooperation is of great importance for sustainable coastal management and should be strengthened in future work.

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