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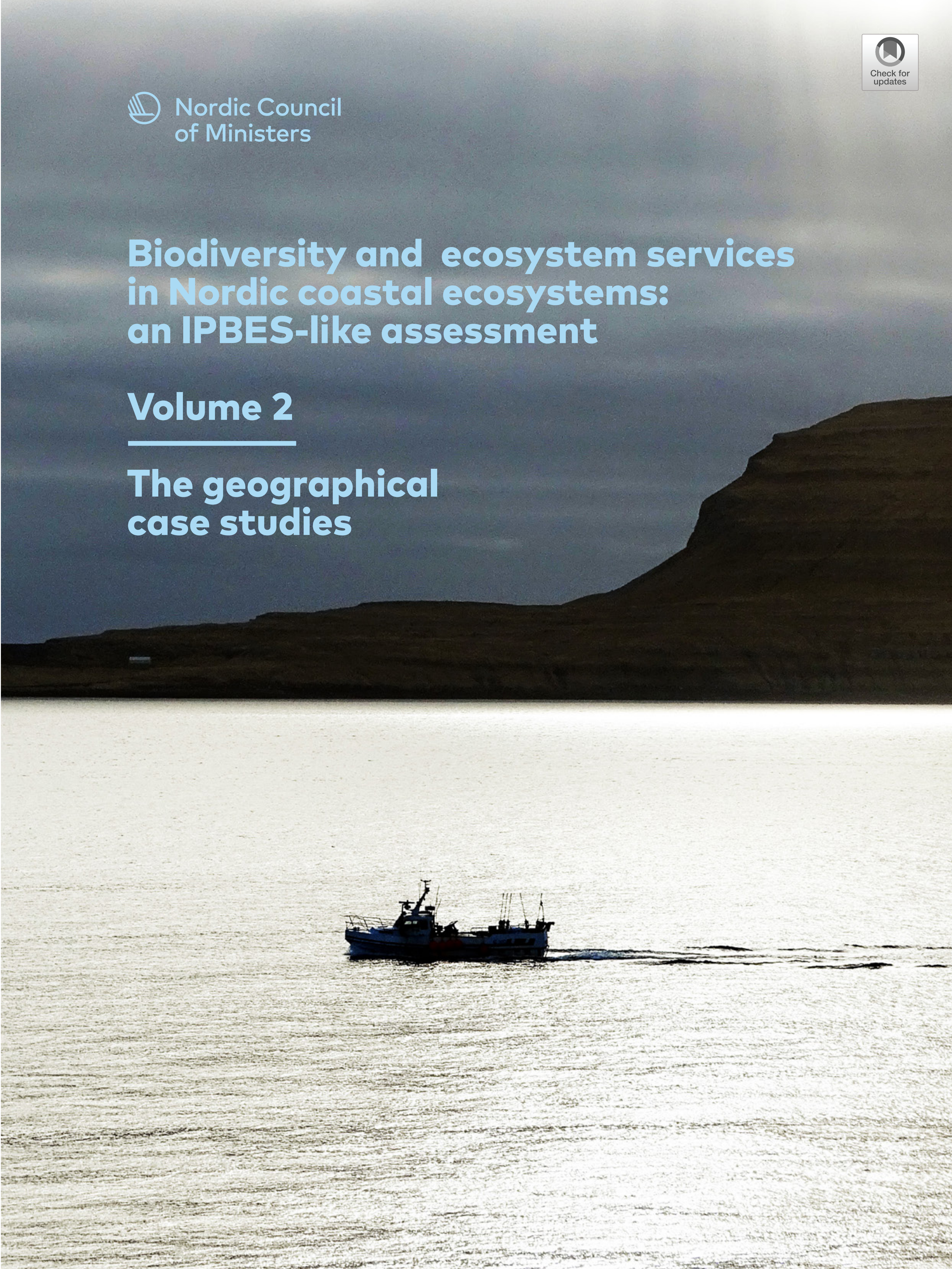



Nordic Council of Ministers

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

## Volume 2

## The geographical case studies

# Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment. Volume 2. The geographical case studies

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*Project-leader: Gunilla Ejdung and Britta Skagerfält.*

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Nordic Council of Ministers/Publication Unit
Ved Stranden 18
DK-1061 Copenhagen K
Denmark
Phone +45 3396 0200
pub@norden.org

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Ved Stranden 18
DK-1061 Copenhagen K, Denmark
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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

# Abstract

This report constitutes background material to a Nordic IPBES-like assessment of biodiversity and ecosystem services in Nordic coastal ecosystems and departs from case studies from ten different geographical areas in the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) as well as the autonomous areas of Faroe Islands, Greenland, and Åland. The purpose is to reflect upon the local situation regarding biodiversity and ecosystem services, e.g. status and trends, drivers of change and policies for governance, and what future we are to expect. These case studies describe the situation in the Näätämö catchment area (FI), the Kalix archipelago (SE), the Quark (FI/SE), Lake Puruvesi (FI), the Bay of Lumparn (ÅL/FI), Öresund (SE/DK), the Helgeland archipelago (NOR), the Faroe Islands (DK), the northern coastline of Iceland, and Disko Bay (Greenland/DK), respectively. Consequently, these areas stretch from fresh water areas to ecosystems in the Atlantic Ocean and from urbanised areas with heavy pressures on the ecosystems, e.g. Öresund, to sparsely populated areas, like Greenland with a population of around 0,03 habitants/km$^2$.

**Figure 1: Cormorants drying their wings**

Note: The increase of great cormorants (*Phalacrocorax carbo*) in the Baltic Sea area over the past decades is a speaking example of the interdependency between biodiversity and human activities. Previous centuries of hunting and persecution of a competing species resulted in a very small population in the 1940s, but since then the numbers have increased dramatically and the cormorant is again causing strong feelings.

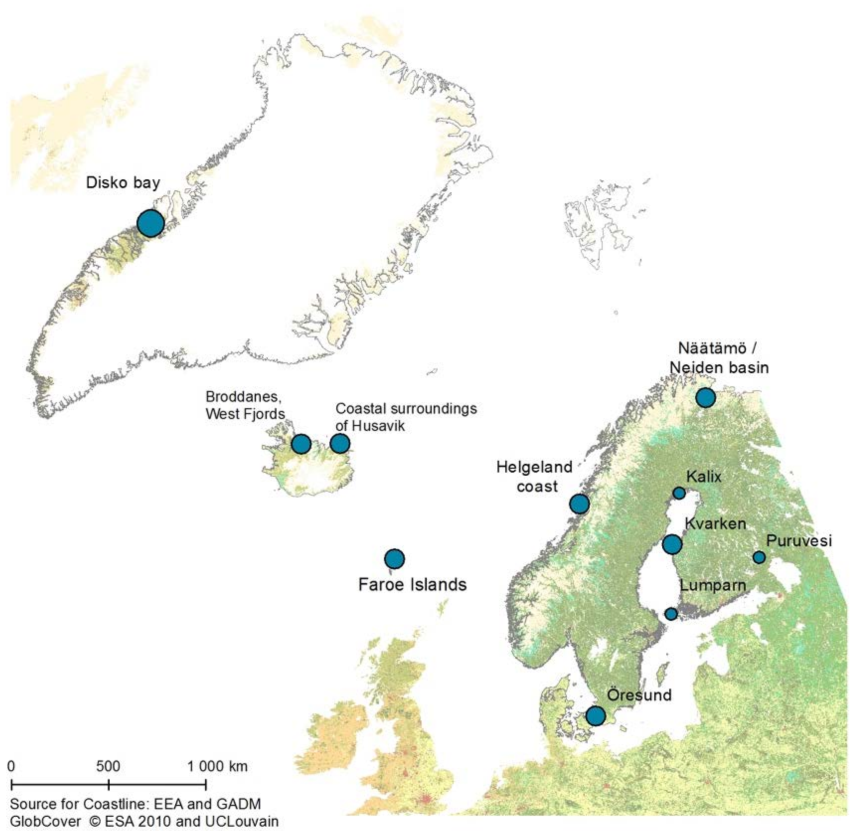
Photo: Håkan Tunón.

# Introduction

## Important characteristics of case study sites

This report summarises the status and trends in biodiversity and ecosystem services and function in ten case study sites in the Nordic region (i.e. Denmark, Finland, Iceland, Norway, and Sweden, as well as the autonomous areas Åland, Faroe Islands and Greenland) (fig. 2). It reflects on the opportunities for sustainable use of biological resources available to Nordic societies. The main purpose of this report is to function as background material for the main report (Belgrano (Ed.), 2018), by analysing the present situation when it comes to biodiversity, ecosystem services and people's relationship to them as well as highlighting similarities and differences between the case study sites. In particular, the report showcases the intricate relationship human societies have with their natural surroundings, along with the cultural diversity in the Nordic countries.

**Figure 2: The ten case study sites**




Source: ESA 2010 and UCLouvain.

Case study sites were selected to represent different conditions in salinity, biogeographical regions, population density and environmental pressure. The gradient in salinity shifts from freshwater in the Näätämö catchment area and the Näätämö/Neiden basin, brackish waters in Kalix (3–3.5 psu), Kvarken (3.5–5.5 psu) and Lumparn (5.5–5.99 psu), intermediate salinity in Øresund (10–30 psu), and Atlantic sea water conditions at the Helgeland coast, Faroe Islands, Iceland, and Disko Bay (33–37 psu). Consequently, there are large differences in ecosystems and biodiversity. While the Disko Bay (Greenland: 0.03 habitants/km$^2$) and Näätämö (0.3 habitants/km$^2$) areas are sparsely populated, the Øresund region (190 habitants/km$^2$) is much more densly populated, and thus the pressures from urban development are much higher. Living conditions differ considerably. The habitants of some areas are heavily dependent on local biological resources, both for subsistence and cultural use, while people in urban areas mainly use local resources for recreational purposes.

The following is a short introduction to the case study sites.

### *1. The Näätämö catchment area*

The Näätämö catchment area is a sub-Arctic river system in Finnish Lapland that extends across Norwegian, Russian and Finnish borders at approximately 69°50′N 28°55′E. The Näätämö River, which is of great national importance due to spawning of Atlantic salmon, runs in to the Varanger Fjord of the Barents Sea. The catchment area is the Skolt Saami home territory. In 2011, the Skolt Saami initiated the very first collaborative management project in Finland to combat climate change and reductions in water quality, and provide answers to past equity issues in the basin. This co-production of knowledge has provided a new science – indigenous and local knowledge (ILK) relationship, which has allowed for the development of a new model for river governance in the North of Finland. In 2017 the co-management actions led the Skolts to restore, as a historical first for the Finnish Saami areas, the Kirakkakoski and Vainosjoki streams that had suffered from past negative impacts due to state-led forestry practices. Näätämö River is also subjected to northern climate change impacts.

### *2. The Kalix archipelago*

The Kalix archipelago lies in the northern part of the Bothnian Bay at approximately 65°50′N 23°10′E and extends over the fishing waters, shores and islands of five villages. The main employment is in industry, health care and municipal services. Small scale fishing, hunting and gathering wild food is a vital part of the local population's livelihoods and quality of life. The reindeer herding community, Kalix Sameby, has its main winter grazing areas in the area.

The Bothnian Bay area was released from the inland ice sheet about 9,300 years ago. The land rise from the postglacial rebound is the fastest in the world – between 8 and 9 mm per year. Thus vegetation is dominated by first generation succession forests, which is unique in a global perspective. The shores are low-lying and flat, with shallow waters and as the land rises so fast in the area, the coastline is constantly changing. The sea is characterised by shallow coastal waters with very low salinity.

The villages have formed a community-based organisation, Kustringen, working with local sustainable development and governance of biological resources. Knowledge holders from the local communities in the Kalix villages, for whom traditional fishing, reindeer herding, hunting and gathering or general recreation in nature are still important parts of life, underline that it is important to focus not only on "nature's contributions to people", but also on what people do and need to do for the long term functioning of ecosystems. This might include measures for conservation of fish populations, fishing restrictions, socio-ecological considerations in forestry and in infrastructure development, etc. In the Kalix archipelago, small-scale fishermen have closely followed changes in the abundance, distribution and health status of different fish species over the past decades as a community based monitoring project. Similarly, small scale fishermen and reindeer herders from Kalix Sameby (the local reindeer herding community) also follow changes in populations of wild mammals and around 30 different bird species, registering changes in weather and ice conditions, climate change and ecosystem changes related to infrastructure development and forestry. There is clearly a potential for a more formal community based monitoring, for increased dialogue between the state and local communities and for self-management or co-governance of local, small-scale fishing and the use of other biological resources in the Kalix archipelago.

### *3. The Quark (Kvarken)*

The Quark (Kvarken) is the narrowest place between Finland and Sweden in the Gulf of Bothnia in the northern Baltic Sea (approximately 63°31'N 20°43'E). The strait serves as a shallow threshold between the Bothnian Sea and the Bothnian Bay. The distance from coast to coast is about 80 km and only about 25 km between the outermost islands. The area experiences a rapid rate of land uplift, which continuously increases land surface area and shapes the landscape with bedrock and moraine. In 2006 the cross-border area of High Coast/Kvarken Archipelago obtained UNESCO's World Heritage status, because it is the best place in the world to witness land uplift and the effects caused by the melting of the ice sheet following the last ice age.

Vast areas of shallow water with a huge number of islands and skerries characterizes the Quark area. This allows for a rich flora of underwater vegetation and offers excellent habitats for birds and fish species. The salinity is low, only about 5 psu, making a challenging underwater environment where both marine and freshwater species meet. The Quark is also covered with ice during 4–5 month each winter.

People from both sides of the strait have a long tradition of utilizing the sea. Fishing and seal hunting have been the principal activity up to the end of the nineteenth century. Farming has been small-scale and focused on raising cattle since the barren soil and climate limited agriculture. Nowadays agriculture, forestry and high-tech industry (i.e. paper products, forestry machines, chemical products and energy solutions) are important occupations, with growing employment in tourism. The region hosts several large international companies, which reflects on high growth rates of the cities of Umeå and Vaasa.

Today the sea is used for shipping, fishing and recreational purposes. The ecological status of the water and sediments are inadequate along the coast. Hazardous substances, eutrophication and dredging, as well as high pressures from physical exploitation of the coastline are threatening ecosystems. Active measures are necessary on both sides of the Quark to improve the water quality and secure human health and future ecosystem services.

### *4. Lake Puruvesi*

Lake Puruvesi, located in North Karelia and Savo Provinces in Eastern Finland (61°90'N 29°51'E) is a relatively pristine, sea-like large freshwater body. It is connected to the Lake Saimaa system, which is one of the biggest in Europe. The water is very clear with 12 metres visibility in the clearest parts of the lake. There are endemic species in the lake, including the Saimaa ringed seal, a special freshwater seal, as well as land-locked Atlantic salmon. The lake is home to the winter seining culture, which has thrived since 1300 AD. This seal-friendly professional fishery targets vendace, which has been designated the EU Geographical Indicator to certify the authenticity of the product. The seining also removes biomass from the lake, reducing eutrophication and other stressors. The traditional knowledge of the winter seiners is an important data source to monitor ice and water quality. The oral histories of the winter seiners are on the list as an applicant to be included in the Finnish UNESCO intangible cultural heritage list.

### *5. The Bay of Lumparn*

The Bay of Lumparn, in the middle of the archipelago of Åland in the Baltic Sea (60°N 20°E), is a water body created by a meteor impact. The city of Mariehamn is located along the western shore of the bay. Located in the heart of the mainland of Åland, it is an archipelago landscape with a long history of fishing, hunting and shipping, and the use of ecosystem services linked to the sea has been very important through history. Today, the Lumparn region is still dominated by relatively small-scale agriculture and forestry. Small enterprises, hunting, fishing and tourism make up a very important source of income. Water quality in and around the Lumparn varies. The ecological status of the various bays north of Lumparn is classified as moderate, poor or bad. Eutrophication has resulted in the deterioration of the water quality. People's awareness of problems concerning water quality has increased in recent years. Local projects around Lumparn are ongoing, with the aim of improving water quality in the long term. However, additional measures are needed from various actors.

### *6. The Sound*

The Sound ("Øresund", "Öresund") is located between Denmark and Sweden (from 56°20'N 12°58'E to 55°33'N 12°68'E). The Sound constitutes one of three major straits that connect the water masses of the Baltic Sea with the North Sea/Skagerrak. The hydrographic conditions (distribution of salt, temperature and water movement) determines the structure of the marine ecosystems in the Sound. It is a very dynamic area characterised by strong currents. Although highly variable, the hydrography has a typically estuarine circulation pattern, with a surface layer of outflowing (northward direction) brackish Baltic Sea water and a deep counter-current of high saline bottom water. For over a thousand years it has geopolitically been the most important area of the Baltic Sea. The Sound provides vital ecosystem services including the rich herring fishery that has been important through history. The Sound region is extensively urbanised and is now the most densely populated area in Scandinavia with about 2 million inhabitants in the coastal municipalities.

The Sound is a reasonably well-functioning ecosystem with relatively high biodiversity. Environmental protection actions, a general precautionary approach in relation to the environment, as well as unintentional actions have all helped to preserve ecosystem services. Because of the intense shipping through the strait, a ban on trawling was enforced in 1932 for navigational reasons. This has proven to be beneficial for the local fish stocks, albeit the herring stock and a few others are still fished at unsustainable levels.

The general improvement of ecological status is reflected by the indicators given by the EU Water Framework Directive. The Sound is a vital area for staging, moulting and wintering waterbirds, and hence a popular area for birdwatching. The coasts and the open watersheds are also used for recreational activities such as fishing, boating, bathing and diving. The steady development of the urban areas is reinforced by continuous urban migration. The increasing population and changes in lifestyle lead to a higher demand for better housing and outdoor recreational facilities. This exploitation jeopardises natural areas and reinforces crowding effects, resulting in conflicts of interests that put strain on planning and policy instruments.

### *7. The Helgeland archipelago*

The Helgeland archipelago is a coastal stretch on the Norwegian west coast (from 56°08'N 12°58'E to 55°38'N 12°78'E) covering more than 12,000 islands and islets. The marine life in this area showcases a typical North-East Atlantic Ocean coastal ecosystem. It holds a sparse human population and the region has large areas of pristine nature. Helgeland comprises fjords and bays, white beaches, and steep mountains. A wealth of iconic species lives in the area, including seals, puffins, eagles and whales. Key marine ecosystems in Helgeland are kelp forests, maerl beds, sandy and soft sediments, seagrass meadows, intertidal areas, islands, and bird cliffs. These distinct physical and biological structures form different ecosystems that support high biodiversity and provide a wide variety of functions and services. Major ecosystem services are linked to fisheries (e.g. cod, haddock, herring, and crab), harvest of kelp for food business and bioprospecting, along with recreational values. Recently, the high potential for carbon storage by kelp forests has received public attention. Along with other Nordic coastal habitats, the key ecosystems of Helgeland are subject to anthropogenic and climatic pressures that threaten biodiversity and ecosystem services. For instance, overfishing has decreased important fish stocks and impacts may have cascaded down to negatively affect kelp forest abundance. Increased eutrophication, acidification and temperature rise is further shown to negatively impact marine life and biodiversity along the Norwegian coast. To protect and improve the coastal habitats, both national and international programs have been implemented, such as the "Norwegian nature index" and the European Water Framework Directive. In addition, a regional coastal plan is under development for Helgeland, to facilitate sustainable use of the resources related to fishing, aquaculture, traffic, tourism, cultural heritage and nature conservation. "Vegaøyan", a part of the Helgeland archipelago, is an UNESCO World Heritage Site due to the extraordinary pristine nature, the rich coastal biodiversity and the well-preserved indigenous culture of eider down harvesting, fishing and farming in the area.

### *8. The Faroe Islands*

The Faroe Islands (approximately 62°17'N 6°72'W) are characterized by ice-carved mountains covered in grass and heather without any tree-like vegetation, strongly marked by centuries of grazing sheep. There are few terrestrial species in the Faroe Islands, besides the many native seabirds, many of which breed on sea cliffs. The clean temperate waters and strong currents around the Faroe Islands provide ideal conditions for many species of fish, marine mammals and shellfish.

The Faroe Islands are fundamentally dependent on the sea and marine resources. The economy is almost entirely based on offshore fisheries and aquaculture, but subsistence hunting, farming and fishing is common. Fishing and sheep farming are the most important parts of traditional everyday life in the Faroes. Particular traditions, including pilot whale hunting, and seabird and egg harvesting, are still kept alive and are considered an important cultural heritage, as well as a social institution that is significant for the household economy.

The recent changes in climate characteristics and sea temperatures have influenced the ecosystems in the area. The stock sizes of the most important fish species (cod, haddock and saithe) are historically low and recruitment has suffered for several years. The number of seabirds has also decreased significantly during the last decade.

### *9. Disko Bay*

Disko Bay or *Qeqertarsuup tunua* is situated on the west coast of Greenland/*Kalaallit Nunaat*. Greenland constitutes an autonomous part of Denmark. The case study site is located approximately 69°53'N, 52°35'W and covers some 45,000 km$^2$, and includes Disko Island, inner Disko Bay, Vaigat Strait, and the marine area just west and north of

Disko Island. The area has more than 10,000 inhabitants, many of whom are full-time or part-time hunters and fishers. Fishing is the primary industry of Greenland and contributes more than 90% of the country's total export value, and the marine ecosystem of Disko Bay sustains a large part of Greenland's fisheries. It is also an attractive tourism destination. The total population of Greenland is 55,860 people and about 88% are Greenlandic Inuit.

The Greenland Institute of Natural Resources (GINR) provides the Greenland Self Rule with biological advice on the sustainable exploitation of living resources and safeguarding of the environment and biodiversity. The scientific advisers are however located as far as Nuuk or even in Denmark. However, international conventions, the law in Greenland and more recently, the coalition agreement between the ruling parties, request that ILK is recognized and used in matters regarding the management of natural resources. Local fishermen and hunters are now developing and testing a scheme, PISUNA, whereby they regularly report their observations of living resources and share their interpretations and their management recommendations based on their ILK. At first, PISUNA was met with considerable scepticism from both scientists and the local hunters and fishermen. Most of this scepticism has since been overcome as the program has addressed challenges, tested solutions and adapted as appropriate. It is today an excellent example of a community-based monitoring scheme when it comes to status and trends of coastal biodiversity.

### *10. Coastal Iceland*

Coastal Iceland is a Nordic periphery. The study sites are the Broddanes (65°,59'N 21°29'W) and Húsavík areas (66°02'N 17°20'W). This case study consists of two examples that focus on the spiritual and cultural values of ecosystems as defined by the local community. Traditional livelihoods and oral knowledge on the landscapes still survives in these edges of the Nordic space. Seal hunters of Broddanes and Húsavík maintain a subsistence harvest of a range of seal species, including the hooded and harbour seals. In West Fjords the harvests have focused on netting of the seals. In Northeastern Iceland the hunt also includes more active methods, such as shooting of the seals. Seal hunters utilize all parts of the seal for food and cultural delicacies. They also monitor and observe the ocean and coastal changes around the harvest areas. In the Húsavík area, the seal hunters use endemic place-based harvesting methods, such as attracting seals using smoke on the shoreline. The seal hunting represents a little-known and unbroken socio-ecological system in Iceland.

Women in the Húsavík region have their own knowledge of landscapes and seascapes of Iceland. This gender-based knowledge is reflected in the various subsistence activities carried out by women, including berry picking and visiting culturally important stones and rocks. The women of Northern Iceland have preserved knowledge of traditional weather prediction, including northern lights, star and moon lore. By exploring the oral histories and the observations of these women, assessments of biodiversity can be expanded. A recognition of gender-specific methods and monitoring approaches is needed to make sure all stakeholders are included, particularly at these edges of the Nordic space.

**Table 1: Comparative table of nature's contributions to people that are highlighted in the case studies. The Iceland cases are not included as they differ slightly in content**

| Nature's contributions to people | | The Quark | Kalix | Näätämö | Lumparen | Puruvesi | The Sound | Helgeland | 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 |

The purpose of using case studies in this assessment is to bring the global IPBES discussions to a local level. At the same time, the case studies provide basis to make a synthesis of the bigger picture at a regional level. IPBES is sometimes sceptically viewed by representatives at the local level, as the terminology used is regarded as overly theoretical and difficult to understand. Furthermore, representatives at the local level generally perceive that they already have a balanced picture of the status and trends of biodiversity and ecosystems in their area. They live off the land and spend almost every day in the field. This could be argued against, but several studies have shown that local hunters and fishermen have a good perception of the surrounding biodiversity and changes over time (Danielsen *et al.*, 2014 & 2016; Karlsson *et al.*, 2012). There is also the suspicion that no matter what conclusion an IPBES-like assessment will draw, the decision-makers will not take it into full consideration. To identify status and trends, as well as drivers of change on a local level, will hopefully be more down to earth than a more generalized assessment over a much larger area. In this study we depart from ten different local areas in order to get the bigger picture. At the same time, the local studies stand on their own.

While work on these case studies was being carried out, the IPBES' multidisciplinary expert panel highlighted a need to change the term ecosystem services (ES) to nature's contributions to people (NCP) in order to make it more inclusive (Pascual *et al*., 2017; Díaz *et al*. 2018). However, since the definition of NCP differs slightly from ES and because previous scientific studies have focused on the latter, the authors have generally felt the need to stick to the term ES. Each case study is organized similarly to a general IPBES-assessment, with the same sections and chapters, improving their applicability in future assessments and other work. They are built on available data from numerous sources. The Iceland case is an exception, as it is solely built on information from local people with traditional lifestyles that are closely dependent on local biological resources.

## References


Belgrano, A. (Ed.) (2018). *Nordic IPBES-like Assessment of Biodiversity and Ecosystem Services in Coastal Ecosystems. Vol. 1. General overview*. TemaNord 2018:536. Copenhagen: Nordic Council of Ministers.

Danielsen, F., Topp-Jørgensen, E., Levermann, N., Løvstrøm, P., Schiøtz, M., Enghoff, M. & Jakobsen, P. (2014). Counting what counts: using local knowledge to improve Arctic resource management. *Polar Geography*, *37*(1), 69–91.

Danielsen, J., Frederiksen, P.O. & Mølgard, T. (2016). Local Observations from the PISUNA Network (PISUNA-net). In P. Jakobsen, N. Levermann, B. Lyberth, M. K. Poulsen, & F. Danielsen (Eds.), *Ilulissat: Qaasuitsup Kommunia*. Copenhagen: NORDECO Nuuk: Ministry of Fisheries and Hunting, and Greenland Fishers and Hunters Association.

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., *et al*. (2018). Assessing nature's contributions to people. *Science 359*(6373), 270–272.

Karlsson, J., Støen, O.-G., Segerström, P., Stokke, L.-H., Persson, S., Rauset, G.-R., Kindberg, J., *et al.*, (2012). *Björnpredation på ren och potentiella effekter av tre förebyggande åtgärder*. Rapport från Viltskadecenter 2012:6.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., *et al.* (2017). Valuing nature's contributions to people: the IPBES approach. *Current Opinion in Environmental Sustainability, 26*, 7–16. https://doi.org/10.1016/j.cosust.2016.12.006

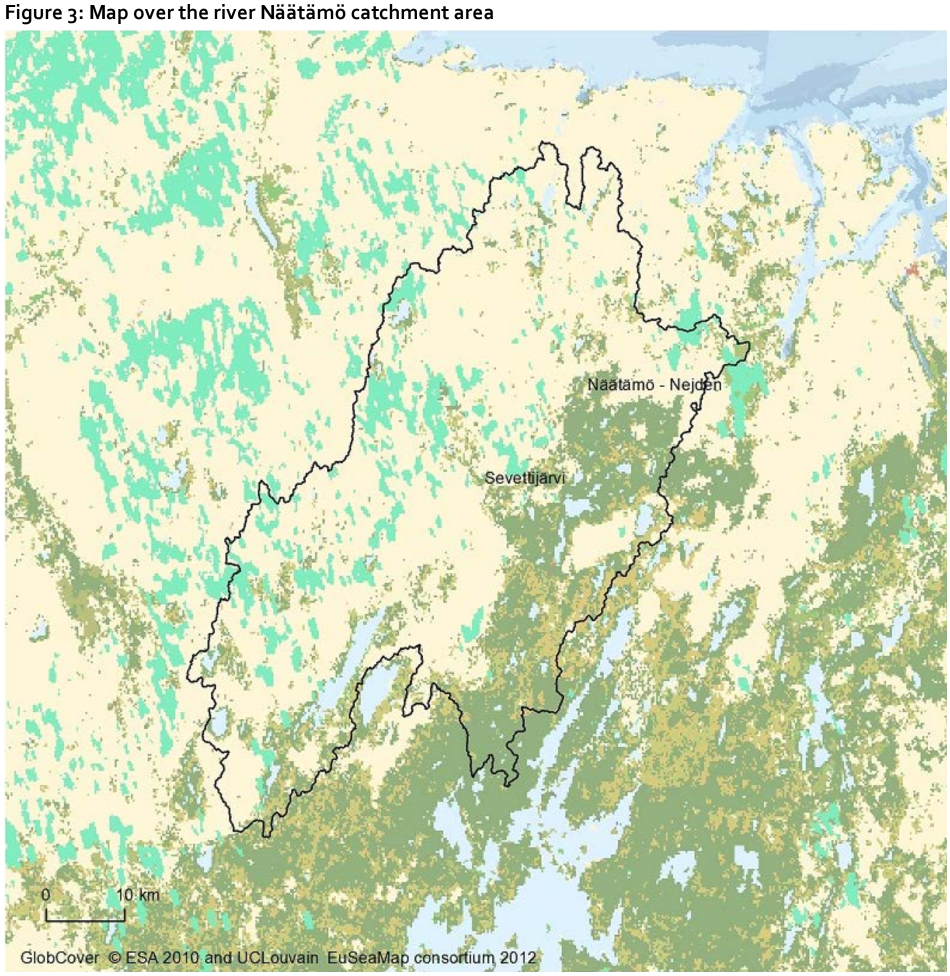
# 1. Neiden/Näätämö

*Tero Mustonen*

## 1.1 Setting the scene

River Näätämö, is a Skolt Saami Arctic river that crosses Finnish and Norwegian borders. This case study is limited to the Finnish part of the watershed.

**Figure 3: Map over the river Näätämö catchment area**




Source: ESA 2010 and UCLouvain EuSeaMap consortium 2012.

### 1.1.1 *Background information*

**Area**

River Näätämö is located in northern Finland and northern Norway and its outlet is in the Varanger fjord and the Barents Sea. The source of the Näätämö River is Iijärvi Lake in Finland. The river is 79 km long, 52 of which flow on the Finnish side of the border. In a few places the river broadens and forms lakes, of which the biggest are Kaarttilompolo, Vuodasluobal and Opukasjärvi. In Finland the river is located in the municipality of Inari, on the northern side of the village of Sevettijärvi. Näätämö watershed, which is part of the EU Natura 2000 network in Finland, belongs partly to the Kaldoaivi wilderness area, and is 3,160 $km^2$ of which 2,570 $km^2$ (81.3%) is on the Finnish side. The wilderness area is a nesting site for various Arctic migratory birds and large birds of prey. It is also one of the very few sites for occasional Arctic fox (*Vulpes lagopus*) nesting in Finland. The Näätämö delta is a bioregion and the Neiden fjord one of the national fjords of Norway.

**Figure 4: Skolt Saami fishermen Jouko Moshikoff and Teijo Feodoroff checking winter nets on river Silisjoki, Näätämö catchment area**

Photo: Gleb Raygorodetsky.

Näätämö basin is an important socio-ecological territory. It is home to the indigenous Skolt Saami people, who mostly live in the villages of Sevettijärvi and Näätämö in the basin. This population arrived in the region in the late 1940s following the forced relocation from territories ceded from Finland to the Soviet Union. A Skolt Saami tribe lived in the Näätämö watershed before that, but integrated to the Norwegian population by the early 1900s. In literature Skolts are often referred to as the "most traditional" of the Saami people (e.g. Mustonen & Mustonen, 2013). This is reflected, for example in the preservation of the village decision-making body "Siid-såbbar" that exists to this day, but has been lost elsewhere amongst the Saami groups.

## 1.2 Key Ecosystem Services

### 1.2.1 *Cultural Services*

The legally defined home area of the Skolt Saami is the Näätämö watershed, where the endangered Skolt Saami language is spoken. River Näätämö is considered to be of particular significance for the formation of the Saami culture in Finland. Traditional Skolt Saami livelihoods and skills are practiced in the area, including reindeer herding, handicrafts and subsistence fishing (Mustonen & Mustonen, 2013; Feodoroff & Mustonen, 2013). The Skolt Saami have a rich traditional music and oral culture, including the traditional *leu'dd* songs, which express the destinies of various Skolt families, along with aspects of nature, animals, reindeer herding and fish.

In the summer season there is fishing and outdoor tourism in the area, which has had significant impact on popular sites. In the winter, tourism activities include travel on snowmobiles and ice fishing for Arctic char (*Salvelinus alpinus*).

### 1.2.2 *Provisioning*

Skolt Saami fishing is a culturally valued subsistence activity. Most of the catch is used within the families and for traditional handicrafts (Mustonen & Mustonen, 2013). Very little is sold to outsiders. The main catch consists of Atlantic salmon (*Salmo salar*), grayling (*Thymallus thymallus*), whitefish (*Coregonus lavaretus*), lake trout (*Salmo trutta*), Arctic char, northern pike (*Esox lucius*) and burbot (*Lota lota*). Fishing tourism exists in the Näätämö basin, especially between late June and early August.

### 1.2.3 *Regulating services*

River Näätämö is an important spawning site for the Atlantic salmon and sea trout. Most of the spawning areas for salmon are on the Finnish side of the river. This feature makes the Näätämö River central for salmon and trout as a cross-border area and basin.

## 1.3 Biodiversity and ecosystem characteristics

### 1.3.1 *Habitats*

The Arctic rivers are characteristically oligotrophic, with clear, cool and fast flowing waters with little or no humus and sand and gravel substrates. The watershed area is pine heaths with barren sandy forest soil.

### 1.3.2 Key Species

Key species in Näätämö River are Atlantic salmon, grayling, trout, the endemic whitefish stocks and freshwater pearl mussel (*Margaritifera margaritifera*), the latter of which is now lost as a viable population. The main reason for this loss has not been discovered. In the early 1900s mussels were harvested, but populations in neighboring catchment areas remain viable. Acidity and changes in water quality are potential explanatory factors.

### 1.3.3 Ecosystem quality

The quality of water in the river is excellent (water is drinkable) and the whole watershed area contains large amounts of excellent quality ground water. For the Atlantic salmon, the river and the catchment area is of great importance. Primary spawning areas are located on the Finnish side, i.e. in the upper parts of the catchment. The population of salmon varies annually, but scholars have not been able to determine a definite trend in the population. The juvenile salmon stocks in the headwaters of the river, such as around Silisjoki sub-catchment, are lower than what the ecological status of the environment could provide for. Reasons for this may include climate change or other unknown drivers. Annual catches of salmon have averaged around 8 tonnes between 1972–2014, with peak years producing over 14 tonnes (1991, 1992, 2001, 2006). In early parts of 2010s the amounts have been around 6 tonnes. Skolt Saami have taken steps to identify lost and damaged spawning areas of trout and salmon. In the summer of 2017, the Skolts initiated the first restoration of these habitats in the Vainosjoki and Kirakkajärvi subcatchment area.

### 1.3.4 Key features

Näätämö River is an important spawning area for Atlantic salmon. It is one of the few freshwater pearl mussel habitats in its natural state remaining in Finland. However, a population collapse has occurred, with debates on this having occurred due to climate-related acidic peaks during spring run-off from the catchment area.

On the Norwegian side of the river, the Kven (Finnish speaking) minority practices *käpälänuotta*-salmon seining with average catches of 1 tonne per year. *Käpälä*, which means bear paw, is the tool used for the practice. It has been perfected for the Skoltfoss rapids, which are only a few meters wide, and allows practitioners to catch salmon as they travel upstream. It was originally a Skolt Saami practice that the Kven-Finns acquired from the now-assimilated Neiden Skolts (not to be confused with the present day Skolt Saami who arrived in late 1940s).

## 1.4 Drivers and pressures

Only 350 people live in the watershed area, and about half of the population lives in the two villages of Näätämö and Sevettijärvi. Human-induced nutrient loading is fairly limited and there are no significant problems with water quality. Agricultural practices beyond reindeer herding are non-existent. Reindeer herding can have a potential negative impact on the water quality of small lakes and ponds in the watershed, predominantly in cases where reindeer have been fed hay and fodder on the lake ice during the winter season. The urine and feces retained in the small ponds are thought to be a source of nutrient loading in the system (Feodoroff & Mustonen, 2013). Erosion from the larger lakeshores such as Sevettijärvi, may be impacting spawning areas locally.

### *1.4.1 Direct*

Forestry has been practiced since early 20th century at the headwaters and other parts of the Vainosjoki catchment. The industry is considered one of the main threats to the integrity of the natural environment (Feodoroff & Mustonen, 2013). There is possible minor point loading from scattered rural permanent and seasonal settlements. Plans for the construction of a railroad from Rovaniemi to the Arctic Ocean coast will lead to intensified landuse, lowering water quality and negative impact on Saami culture. The Saami and other local people have been active in voicing their opinion against this process.

### *1.4.2 Indirect*

Climate change is a major driver of change in the region. Alterations in migration patters and shifting species ranges may lead to large amounts of new invasive species moving north. For instance, the Skolt Saami fishermen noted the occurrence of a scarabaeid beetle (*Potosia cuprea*) during community-based monitoring work in the basin. Climate change causes severe weather events, such as flash floods and drought, which are reflected in changes in flow in Näätämö river.

### *1.4.3 Activities*

There is seasonal fishing tourism in the area with resulting pressures on the salmon population, land erosion and eutrophication. Trekking and riverside camping can have local impacts on the more popular sites. Fish farming in the fjords in the vicinity of the Barents Sea, such as in Bugøynes, is causing concern for the populations of wild Atlantic salmon, as fish escaping from the farming bin may spawn in natural salmon habitats and may also be carrying sea lice and other diseases. Salmon farming in the nearby Pechenga region in Russia is of concern since the high density of fish leads to increasing risks for diseases.

### 1.4.4 Threats

Introduced and invasive species cause great concern for the integrity of native species populations in the area. Fish diseases and parasites (especially *Gyrodactylus salaris*) are of particular concern. Saami fishermen have reported to have caught Pacific salmon (introduced in the Soviet Union to the Barents Sea) from the river. While this population is not yet threatening the Atlantic salmon per se, it is an indicator of risks of human interventions in the highly vulnerable Arctic systems. Changes to coastal land use in the Neiden fjord puts pressure on the environment. For example, mining in the Kirkenes area affects the upstream migration of salmon returning to Näätämö. Pollution from past mining activities, increased shipping, and potential transport corridors constitute issues of concern for the Näätämö system. As the salmon is anadromous, i.e. providing an interface between the sea and the inland habitats through its life cycle, it is affected by changes out at sea, such as warmer temperatures, higher acidity, changes in the ocean food chains and high sea fisheries. One way to address these threats is to maintain and in some cases restore spawning habitats of the fish to build resilience.

As identified by several large-scale Arctic Council science assessments in the Arctic, climate change remains a constant destabilizing element in the Näätämö basin. Extreme heat spells with over 30 °C surface temperatures in May 2013 affect the water temperature and encourage algae growth, ultimately reducing survival of salmonid fish. Fish species that benefit from the warmth, such as northern pike, expand their ranges along the river. For example, the Silisjoki sub catchment area is rather shallow and responds quickly to warm spells and pike numbers started to grow during the last decade. Flash floods and extreme rain events enhance erosion. For example, Lake Sevettijärvi, which is already an eroded site, is experiencing increased erosion from the banks leading to increased amount of sand in the waters and the destruction of spawnig areas. In the winter, above-zero degree spells keep the waterway open well into January, causing problems for transport and traditional livelihoods. Climate impacts on Näätämö should be assessed as a cumulative system wide change that needs to be looked at comprehensively, including ILK-based monitoring.

## 1.5 Governance of ecosystem services and influencing policies

### 1.5.1 International / EU

There is an international salmon fishing agreement between Finland and Norway. Näätämö watershed is part of Finnish-Norwegian water management area and is also affected by NASCO (North Atlantic Salmon Conservation Organization) and ICES (International Council for the Exploration of the Sea) monitoring and management directions.

### 1.5.2 National

The basin is part of the wilderness areas governed by Metsähallitus, the state forestry agency. The Ministry of the Environment, Agriculture and Forestry controls and governs the use of land and natural resources.

### 1.5.3 Regional / Local

Näätämö basin is the Skolt Saami Home Area and subject to a special law called the Skolt Saami Act. This Act guarantees some rights and participation of the Skolt Saami Village Council in matters affecting the Saami in the basin (Feodoroff & Mustonen 2013). It is unique traditional governance body, one that exists only for the Saami groups in Finland. The municipality of Inari is responsible for the zoning and services in the basin, such as the school and other public services. The Province of Lapland, located in Rovaniemi, has the legal power to control the regional zoning and planning processes.

### 1.5.4 Participation / Co-management

The first ever-collaborative management project of Finland (Feodoroff & Mustonen 2013) was initiated in 2011 in the Näätämö river basin with funding from the United Nations and Nordic Council of Ministers. The key governmental organisations participating in the co-management of Atlantic salmon resources include Metsähallitus, the Institute of Natural Resources – LUKE, and the Center of Commerce, Transport and the Environment. Saami and research community organisations participating include the Saa'mi Nue'tt cultural organisation, the Skolt Saami Village Council and the international Snowchange Cooperative.

The Näätämö co-management project has no legal status. It is still an ongoing project that, for the first time in Finland, implements the methods and structure of a full arrangement of long-term joint governance (Feodoroff & Mustonen 2013). 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 then taken some pilot-style steps to restore lost habitats due to past land use, including the Vainosjoki sub-catchment area. This acts as an extension of joint governance, i.e. taking care of the basin using a combination of ILK and science to improve conditions for salmonid species, Skolt Saami and other users of the river. The Näätämö project works closely with the Inuvialuit Joint Secretariat[1] in Northwest Territories in Canada, to investigate, analyze and exchange experiences of collaborative management.

[1] The worlds longest running co-management system since early 1980s.

Overall in Finland many local arrangements of coastal and aquatic systems portray elements of joint governance, and more recently Akwé: Kon[2] guidelines (CBD 2004) in times of conflict. These include for example the local fisheries bodies,[3] which have the power to decide on stocking and restoration measures within their jurisdiction. Policy analysis shows, however, that the local level of governance and power to rule over natural resources remains weak and these systems are more to be seen as state governance than a true 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 contextualised as initial steps in the process of strengthening local and indigenous participation.

### 1.5.5 Policy conflicts

While positive steps have been taken in Näätämö basin over the past six years through the first co-governance of the Atlantic salmon, ultimately management of the river still rests with the Ministry of Agriculture and Forestry, and the Finnish-Norwegian border river commission. This means that the Skolt Saami, the primary Saami group invested in the river, feel that their ILK and traditional interactions with the river are not heard in decision-making (Mustonen & Mustonen, 2013).

Potential future conflicts over land use and governance of natural resources may result due to fishing, hunting, industrial land use and infrastructure projects. For example, the railroad from Rovaniemi to Kirkenes on the coast of the Barents Sea is expected to raise conflict between national government and the Saami community due to impact on ecosystems, Saami culture, and Saami rights as indigenous people.

The Näätämö system is governed through Finnish and Norwegian policy, along with international agreement on the Barents Sea. The local Skolt Saami have maintained and renewed their traditional governance system, the Village Council. It is the only Saami community to retain traditional systems in to the modern era. Climate change is having impact on the Näätämö catchment and therefore Skolts have developed the first co-management actions in Finland to monitor and restore habitats that have been affected by past land uses.

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[2] Voluntary guidelines, developed within the UN Convention on Biological Diversity, 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.

[3] Kala and osakaskunnat.

## 1.6 Insights from indigenous and local knowledge

**Figure 5: Vladimir Feodoroff, Skolt Saami knowledge holder, cleans a grayling on river Näätämö, September 2014**

Photo: Chris McNeave, used with permission.

Skolt Saami living in the basin of Näätämö are often referred to as the most traditional Saami group today. They have a unique, endangered language and the uses of the family territories combined with the traditional siida village governance are in place. Näätämö is also the location of the first official co-management project in Finland (Mustonen & Mustonen, 2013; Feodoroff & Mustonen, 2013). The Saami have detected ecosystem changes over the past decades, both from climate change impacts resulting in the arrival of new species, to habitat degradation on Vainosjoki. In the past seven years, ILK has contributed to several peer-reviewed articles and assessments of Arctic change, making the methods and model a pilot for the Saami area (e.g. Bonebrake *et al*. 2017; Johnson *et al*. 2015; Mustonen 2015; Pecl *et al*. 2017).

## 1.7 References


CBD. (2004). *Akwé:Kon Voluntary guidelines for the conduct of cultural, environmental and social impact assessment 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*. Montreal: The Secretariat of the Convention on Biological Diversity.

Bonebrake, T. C., Brown, C. J., Bell, J. D., Blanchard, J. L., Chauvenet, A., Champion, C., Chen, I.-C., *et al*. (2017). Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science. *Biological Reviews*, https://doi.org/10.1111/brv.12344

Feodoroff, P. & Mustonen, T. (2013). *Näätämö and Ponoi River Collaborative Management Plan*. Kontiolahti: Snowchange Cooperative.

Johnson, N., Alessa, L., Behe, C., Danielsen, F., Gearheard, S., Gofman-Wallingford, V., Kliskey, A., *et al*. (2015). The Contributions of Community-Based Monitoring and Traditional Knowledge to Arctic Observing Networks: Reflections on the State of the Field. *ARCTIC*, *68*, Suppl. 1, 28–40. http://dx.doi.org/10.14430/arctic4447

Mustonen, T. & Mustonen, K. (2013). *Eastern Sámi Atlas*, 2nd Print. Kontiolahti: Snowchange Cooperative.

Mustonen, T. (2015). Communal visual histories to detect environmental change in northern areas: Examples of emerging North American and Eurasian practices. *AMBIO*, *44*(8), 766–77. http://dx.doi.org/10.1007/s13280-015-0671-7

Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I.-C., Clark, T. D., *et al*. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science*, *355*, 1389. http://dx.doi.org/10.1126/science.aai9214

# 2. Kalix archipelago: Biodiversity, ecosystems, local knowledge and customary use

*Marie Kvarnström and Joakim Boström*[4]

## 2.1 Setting the scene

The case study area extends over the fishing waters, shores and islands of the Kalix archipelago (see map in figure 1). Five villages, Påläng, Ryssbält, Storön, Nyborg and Ytterbyn with approximately 1,760 inhabitants are located here. These villages have formed a community-based organisation, Kustringen, with the aim of working for local sustainable development and local governance of biological resources. The main employment is work in industry, health care and municipal services. One reindeer herding community, Kalix Sameby, has its main winter grazing areas on the islands in the area.

The archipelago is located in the northern part of the Bothnian Bay. In the northwest, waters from the Töre River enter the bay and in the northeast, the much larger Kalix River discharges into the area. The Bothnian Bay area emerged from the inland ice sheet about 9,300 years ago, and the land rise from the postglacial rebound is the fastest in the world, rising between 8 and 9 mm per year. Vegetation on new land is dominated by first generation succession forests as a result of land emerging, which is unique in a global perspective. The shores are generally flat, and the shore line shifts quickly. The sea is characterised by shallow coastal waters. The absence of hydropower dams in the Kalix River facilitates the movement and regeneration of migratory species like *salmon* (*Salmo salar*) and *sea trout* (*Salmo trutta trutta*). The seabed is moraine and sand in shallow waters, alternating with soft bottoms at greater depths.

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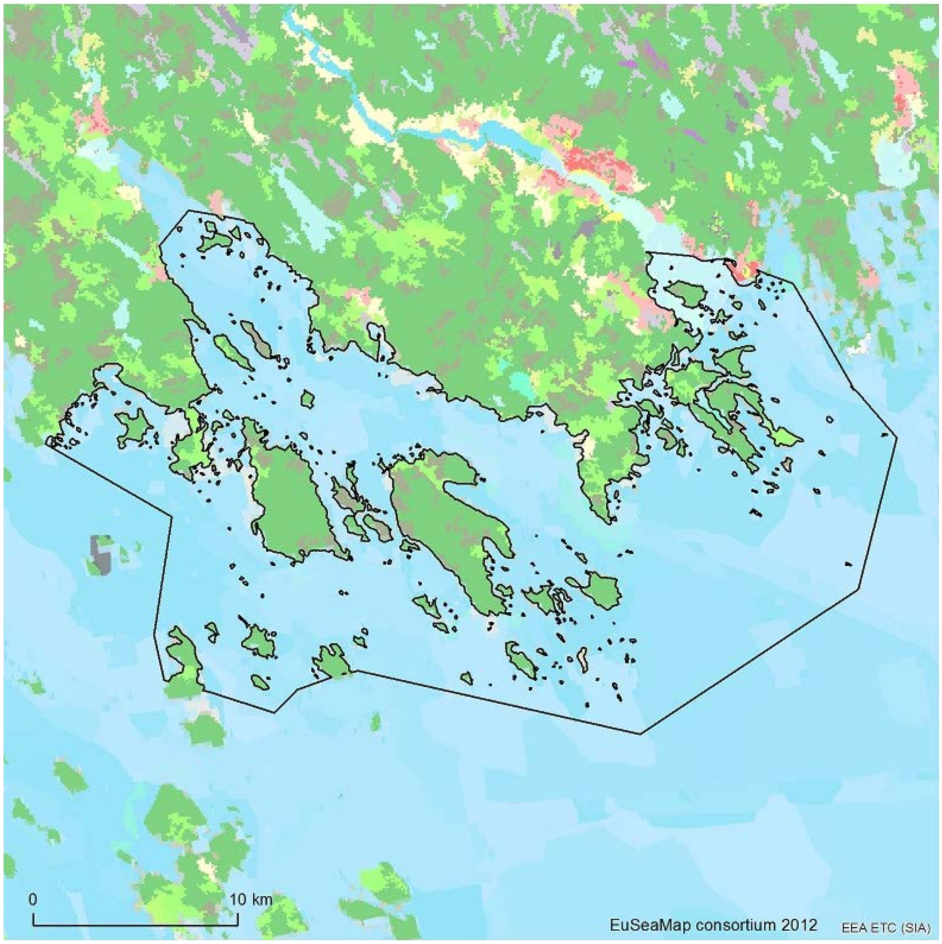
[4] Note on authorship: M.K. and J.B. are joint authors of this case study report, in consultation with knowledge holders in the Kalix villages. Some sections are written by J.B. from the perspective of a local knowledge holder. Authors, as specified, of other sections are Anna-Märta Henriksson, Storön, Kalix and reindeer herders Marina Jägerving and Rolf Söderholm, Kalix sameby.

**Figure 6: Map over the case study area**




Source: EuSeaMap consortium 2012.

The Kalix coast belongs to the northern boreal vegetation zone with pine and mixed forests as the primary vegetation on land. The climate is characterised by long winters, annual average temperatures around 2 °C and annual precipitation between 400 and 500 mm. The area is clearly affected by the current climate change; above all, winter temperatures have risen markedly in recent years (see below). In the past, the whole of Bothnia was always ice-covered in winter, but the spread and duration of ice is now decreasing significantly and in general, rather unpredictable.

The salt content in the Bothnian Bay is low; in the surface waters about 3–3.5 per mille and in the deeper waters about 4–5 per mille. In the shallow archipelago area off the Kalix River there are generally freshwater conditions, and the salinity varies with fluctuations in river flow. The ocean currents flow westward from the Finnish side through the archipelago and continue south.

**Figure 7: The know-how of when, where and how to fish in the Kalix archipelago has been transferred from generation to generation**


Note: This photo shows Sven and Einar Olofsson fishing vendace in the 1950's. The catch was so large that they had to skip a precious day of moose hunting to clean and process the fish. Today, Sven's great grandchildren are learning the art of fishing from their elders.

Photo: Jan-Olav Innergård.

### 2.1.1 Local and traditional knowledge

This case study is written primarily from a local perspective and much of the content is based on local knowledge and local observations. We also make reflections about how different forms of knowledge can meet and interact, as well as opportunities and benefits of co-governance, where local knowledge is used in managing nature's contribution to people.

**Box 1: Local and Traditional Knowledge – A local knowledge holder's reflections**

*(Joakim Boström)*

In my perspective, local and traditional knowledge (LTK) is the unique knowledge about nature, environment, culture, ecosystems and biodiversity passed on from generation to generation in the local community. It is the knowledge and experience that people in the local community often gladly share with each other, as its primary objective is sustainable governance of natural resources in the local community, ecologically, socially and culturally.

The LTK includes unique knowledge of populations and availability of fish, game and berries, observations of changes in biodiversity, population sizes, abnormalities, diseases, variations in climate, temperature, snow cover, ice cover, etc. In the long run, LTK is important as it is vital for the conservation, valuation and sustainable use of local natural resources. LTK unites people in the local community and the exchange of knowledge between people, which is usually oral or practical, is of major importance for social interactions and coherence.

The exchange of LTK is also important across larger geographic areas; when we meet people with similar backgrounds and experiences from other small local communities, we can share information of mutual use and value. An example is the exchange of knowledge of fishing methods and changes in ecosystems that I have often discussed with people from other local communities in Sweden, from other Nordic countries and from other parts of the world.

In simple terms, one could say that LTK is unique knowledge that is widely passed between people and local communities where self-sufficiency, long-term sustainability, and knowledge about and respect for animals and nature is a must for survival. When I talk about LTK, I usually call it "ungoogleable" – it cannot be found on the internet.

LTK can be about learning to read patterns and change in nature. To give a simple example, in my hometown you can use the flowering of the bird-cherry (*Prunus padus*) to decide when it is time to go to a special reef to fish Baltic herring.

LTK where I live is largely about life in a small coastal community at the Bothnian Bay. I think that for people in the local community, LTK is strongly linked to identity. It is knowledge that I am proud to have learned and knowledge that I really want to keep alive and pass on to future generations, in the same way that I have learned it from previous generations and people in my vicinity.

## 2.2 Governance of ecosystem services and influencing policies

### *2.2.1 IPBES categories*

Ecosystem services are the products and services from nature's ecosystems that contribute to human life and well-being.

Recently, IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) has decided to move from use of the term "ecosystem services" to "nature's contributions to people (NCP)", and we will use the new term here. IPBES defines three broad categories of NCP: regulating contributions, material contributions and non-material contributions, Annex 1 provides a summary of NCPs in the Kalix case study area according to the IPBES categories (IPBES, 2017).

It is important to note two things:

1. Knowledge holders from the local communities in the Kalix villages, for whom traditional fishing, reindeer herding, hunting, gathering or general recreation in nature are still important parts of life, underscore that it is important to focus not only on "nature's contributions to people" or "ecosystem services," but also on what people do, and need to do, for the long term functioning of ecosystems. This might include conservation of fish populations, fishing restrictions, socio-ecological considerations in forestry and in infrastructure development, etc.

2. The different "nature's contributions" or "ecosystem services" are interconnected. The regulating contributions are preconditions for the material contributions, which are interlinked with the non-material contributions. As IPBES writes:

> "Western science emphasises the need for disaggregated NCP categories which represent mainly unidirectional flows (from nature to people, both seen as separate entities). The proposed set of 18 specific NCP categories pertain to this perspective and are generally closely associated with the concept of 'ecosystem services'.
>
> Other knowledge systems, notably those of many indigenous peoples (and relational approaches in environmental-social sciences and humanities) conceive the linkages between nature and people with less starkly defined boundaries between them. Therefore, the level of disaggregation of NCP categories presented … is not always compatible with these approaches. The IPBES conceptual framework recognises this broader understanding of NCP through the term 'nature's gifts' … This broader perspective, which is an emerging theme in the science-policy interface on biodiversity, ecosystems, and society, precludes a clearcut disaggregation of NCP categories. Therefore, further thinking is underway regarding the conceptual and methodological specifics of this perspective on NCP and its inclusion in the on-going and future IPBES assessments." (IPBES, 2017, p.4)

### 2.2.2 Nature's Contributions to the local communities

**Box 2: Fishing – the biocultural heritage of the local communities**

*Anna-Märta Henriksson, Storön*

Traditionally, fishing has been the basis for life in the village. Many fisher families had a small farm to sustain household needs, which meant that most people in the past had an acceptable living standard. The old fishermen had broad knowledge, inherited through generations, about the various fishing spots, the role of the wind for fishing, etc. Nowadays, one is not so dependent on that kind of knowledge, when technical aids like sonar can replace the oral traditions.

The village's fishing waters are not divided between different owners, but are shared in a community association. Each fishing rights holder uses the different fishing spots according to a rotational system that has been in place for a long time. In the 70's, a written manual for rotation between fishing spots was compiled, while some of the old tribe were still alive, since the younger generation found it difficult to remember all the details. Other villages have similar systems, where fishing spots are auctioned for limited periods rather than rotated.

Most of the vendance that supply roe for "Kalix löjrom" is landed in my village. The product was awarded the culinary label "Protected Designation of Origin" some years ago and is a renown delicacy beyond Sweden and sought after by exclusive restaurants. The preparation of the roe from "fish to gourmet product" has been largely developed by women in my village. Truly a living example of traditional knowledge!

Local practices that have been lost were largely related to the development of fishing gear. The smells of tar and "tåla" (colour used to dye the cotton yarn in fish traps and nets) are no longer experienced. Nobody boils seal blubber in the big black iron pots, as sealing is no longer part of local livelihoods.

The coastal forest has also been used by the local community. Many local people still pick berries and hunt elk and small game. Our flora contains a large number of rare plants and forest areas have been protected, often in consultation with landowners, to preserve plants species and old forest areas. The municipality and town members have marked a Path of Seven Orchids, which is mentioned as one of the municipality's favourite spots.

To illustrate the importance of the marine ecosystems for the quality of life of the people in the Kalix case study area, below is a collection of statements about the importance of fishing in a local context. The statements were provided by fishers (mostly commercial fishers) in a local workshop in February 2017 at Storön village, Kalix, organised by the community association Kustringen:

**Box 3: What does fishing mean for local fishermen in the Kalix archipelago?**

*Notes from fourteen fishers*

- "Fishing gives an incredible sense of freedom. Being able to get out on the water and catch fish that can be gutted, salted and grilled over the fire brings peace to the soul. We have lived from fish since times immemorial and the fish are in our genes. Some words that summarise its importance: freedom, joy, friendship, happiness, fatigue, sunset, etc. The list can be made long and includes joy, hard work and sorrow."
- "The significance of fishing can, to some extent, be compared to being able to go out and pick berries or mushrooms in the woods, to be able to retrieve resources from nature for the household. It is our culture, our past and present, it is something that gives us identity and togetherness. Being able to fish for the household needs also has an economic aspect. It is also environmentally more sustainable compared to fish in the store that have been transported long distances."
- "It means a great leisure activity, a passion, recreation, getting out to sea and catching fresh fish for your own use."
- "Fishing means so much to a coastal community member that it cannot even be imagined by a "08" (nickname for an urban person in the South, given by the phone area code for Stockholm) or by a bureaucrat. It is freedom."
- "It means a lot! I really realised its importance when the 3-meter restriction came and the spring and autumn fishing was ruined. You are never sure if you lay your nets on a legal depth. The authorities' relentless pursuit of "thief fishermen" is stupid."
- "It means freedom, outdoor life, excitement, fresh produce, organic food, local heritage, a pleasant leisure activity, a countryside that is alive."
- "It means quality of life and excellent food. It is a socially important part of life. Economically it is also a bonus. The 3-meter limit means that we are deprived of our fishing rights guaranteed in the constitution. The seal problem is also growing every year."
- "It supports our quality of life and motivates being out in the archipelago and the cottage both summer and winter."
- "It is a way to be out in nature. Catching some fish and eating it grilled over a fire is recreation. It means life in our beautiful archipelago."
- "I'm not a fisherman myself but I'll try to answer anyway. Fishing in Kalix is a major part of the local tradition. It offers jobs, a richer cultural life and food on the tables. Fishing contributes to keeping our rural area alive."

- "For me fishing is a fun, relaxing leisure activity. It has been inherited through several generations."
- "Fishing for me means that you can get out to the archipelago and carry the traditions forward, bring old memories to life and be part of a living archipelago and not an archipelago dominated by control and suspicion with coast guards sneaking around our cottages and boat rails."
- "I am interested in the sea and boats and nature. I have been fishing since I was a child. Not being able to fish would be a big loss of my freedom of choice and general sense of freedom. Fishing should be for everyone, not just for the rich with the "right" fishing methods."
- "Fishing enriches life a lot and provides welcome food supplement."

**Figure 8: Fishing Luck – Joakim Boström gets a good catch of herring in the Kalix archipelago**

Photo: Roland Nyman, 2013.

**Figure 9: Young Kalix fisher Axelia Henriksson**


Photo: Anna-Märta Henriksson.

### *2.2.3 Cultural heritage linked to fisheries and to the Bothnian Bay ecosystems*

It is very evident that fishing has shaped the local culture and landscapes along the Bothnian Bay. Wherever you go to in the coastal villages, you find traces of fishing. Many of these are historical remnants, but there are many ports, fishing cabins, sheds and boats that have been used for centuries and are still in use today. For a very long time, fishing has been necessary and a natural part of the livelihood of the coastal villages. Today, it is still an important contribution to the household and a vital form of recreation.

In each of the villages of the Kustringen area, there are several ports with fishing sheds, docks and berths used by fishers in the area. The sheds are often built in the same traditional style. They are used for the storage of fishing gear as well as for the preparation of the catch.

Several important fishing camps are located throughout the archipelago, each connected to a certain village. Historically, these were usually very simple cabins that were built to be reached rowing or sailing, allowing one to get closer to the fishing spots. "Gistgårdar", wooden stands used to dry fishing gear for hundreds of years, or remnants of them, are still found at the cabins.

Ice cellars and ice sheds in the vicinity of fishing at the camps are still in operation. They usually have thick walls insulated with sawdust. Here you can put blocks of ice or coarse-grained, wet snow during the spring, to chill and store fish until you go to the mainland. These traditional fishing camps are mainly used for recreational fishing today.

On many islands there are remains of boat landings. Today these are often located several meters above sea level due to the constant land rise.

Near the fishing villages along the coast you can often find mythical mazes, in the local language called "trombolistáns", some of them dating from the 13th century. Their use is surrounded by mysteries and speculations. They might have been used in ceremonies to appease weather, winds, fish or gods.

The most spectacular building to be found in the Kalix archipelago is Malören's Chapel, "the archipelago's little cathedral". The chapel has an octagonal shape, which was fairly common in Norrbotten in the mid-17th century. The construction helped raise the height of the building without reducing the stability, the chapel to be used as a sailing mark. During the 1700s there were up to 200 fishing teams out on Malören. It was these fishers who built the chapel in 1769–1770 with economic support from the bourgeoisie in Torneå city.

Further cultural heritage related to the fisheries are boat building works, cooperages (for making fish barrels) and small factories for wooden fish boxes. Also the skills for preservation, salting and fermentation of fish and roe, and recipes for this, are examples of intangible cultural heritage that remains alive today.

## 2.3 Status and trends for biodiversity and ecosystems

The low salinity in the Bothnian Bay is reflected in the area's biodiversity. The number of species is lower than in the southern Baltic Sea, but biodiversity is distinct through the mixture of fresh and saltwater species. Among species that have their northern borders in Kvarken and are thus *not* found in the Bothnian Bay are bladder wrack (*Fucus vesiculosus)*, European flounder (*Platichthys flesus*), European sprat (*Sprattus sprattus*), cod (*Gadus morhua*) and blue mussel (*Mytilus edulis)*.

The Bothnian Bay, as a whole, is characterised by low salinity, low temperatures, a long period of ice cover, low primary productivity and energy supply (<50g C/m$^2$ and year compared with >150g C/m$^2$ and year for the Baltic Sea), low levels of nutrients, particularly phosphorus, and a high ratio of energy supply from riverine runoff and industrial load (Kronholm *et al*., 2005).

Instead of the red and brown algae found further south, the hard and soft bottoms of the bay have predominantly green algae, phanerogams and mosses (such as *Fontinalis dalecarlica)* (Kronholm *et al*., 2005*)*. Annual plant species dominate due to the climatic conditions. The hard bottoms are dominated by the green algae *Aegagropila linnaei* and *Cladophora glomerata*, and by epiphytic diatoms. The soft bottoms have a somewhat richer biodiversity. Here, the yellow-green alga *Vaucheria dichotoma* is common and often grows in (sometimes floating) mats. Shallow, protected soft bottoms harbour the characteristic *Limosella* vegetation with the phanerogams *Eleocharis acicularis*, *Limosella aquatica*, *Subularia aquatica* and *Callitriche hermaphroditica.* The shores and shallows include a variety of northern plant species including the endemic yellow hair grass (*Deschampsia bottnica*). The bottom-living fauna consists of snails, freshwater mussels and insect larvae. The microfauna of the Bothnian Bay waters is dominated by a relatively small number of species of copepod and cladoceran crustaceans. The macrofauna is dominated by *Monoporeia affinis*, a glacial relict, and *Saduria entomon*. *Monoporeia* populations decreased in the past decade, but are now increasing. Burrowing polychaete worms of *Marenzelleria* spp. have established dense populations on the soft bottoms of the Baltic Sea and they have also been found in the Bothnian Bay.

*Among the fish* there are about twenty freshwater and eight saltwater species. The fish can also be divided into warm water and cold water species. The warm water species found in shallow coastal areas, include perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), Eurasian ruffe (*Gymnocephalus cernuus*), common bream (*Abramis brama*), ide (*Leuciscus idus*), pike (*Esox lucius*) and common bleak (*Alburnus alburnus*). The coldwater species, which are found in deeper waters, are dominated by Baltic herring (*Clupea harengus membras*), vendace (*Coregonus albula*), European whitefish (*Coregonus lavaretus*) and fourhorn sculpin (*Myoxocephalus quadricornis*). They move across larger areas and also enter into shallow water in the winter. Of the approximately 25 fish species of the open Bothnian Bay, three are considered to be marine (Baltic herring, lesser sand eel (*Ammodytes tobianus*) and sand goby (*Potamoschistus minutus*). Quantitatively, herring, whitefish and vendace are most important for the commercial fisheries, while salmon and sea trout are also economically important fish. The most important species for smallscale artisanal and household fishing are perch, whitefish, burbot (*Lota lota*), pike, herring and vendace.

### *2.3.1 Current status and projected trends of ecosystems and biodiversity*

According to the Swedish national monitoring of status and trends of ecosystems and biodiversity in Swedish coastal and sea waters, some of the current trends in the Bothnian Bay are (Svärd *et al*., 2016):

- the salmon populations are increasing, as are the sea trout populations although from low levels;
- the yearly length and thickness of ice cover is decreasing, with potentially complex effects for ecosystems. This may negatively affect the reproduction of the ringed seal (*Phoca hispida)*;
- the Bothnian Bay is the least eutrophied of the Swedish marine areas. Levels of phosphorus are low and decreasing, and the oxygen levels are good in the deeper areas. However, increasing levels of nutrients entering from the Baltic Sea and from riverine runoff may have negative implications and 20% of the coastal waters now show signs of eutrophication;
- the levels of mercury and brominated flame retardants in herring are higher than in other parts of the Baltic Sea. The levels of many other harmful chemicals have decreased in recent years;

- the status and trends of the sea trout populations are of particular interest to the local Kalix communities. The trout hatch in rivers and migrate to the sea to feed and grow before returning to their river home to spawn. Overexploitation, habitat destruction, "cleaning" of river beds, pollutants and acidification have contributed to earlier population declines. Another reason for declining populations may be thiamine deficiency (Hansson, 2017). By-catches of trout while fishing with gill nets have been thought to be a major factor for the declining trout populations, and from 2006, a new Swedish law, FIFS 2004: 36 5 ch. 6 §, prohibits fishing in waters less than 3 m deep in the Bothnian Bay and Kvarken between April 1st and June 10th and between October 1st and December 31st. The purpose was to protect the sea trout population in the area. Recent studies however point out that information on the actual impact of fishing pressure is lacking (ICES, 2011; Havs- och Vattenmyndigheten, 2015) and that the ultimate cause of weak trout populations is not known (ICES, 2011). In recent years, the sea trout populations in the Bothnian Bay have increased from 60% of expected maximum in 2001 to a mean of 74% 2012–2016 (Havs- och Vattenmyndigheten, 2018).

### *2.3.2 Monitoring of ecosystems and biodiversity*

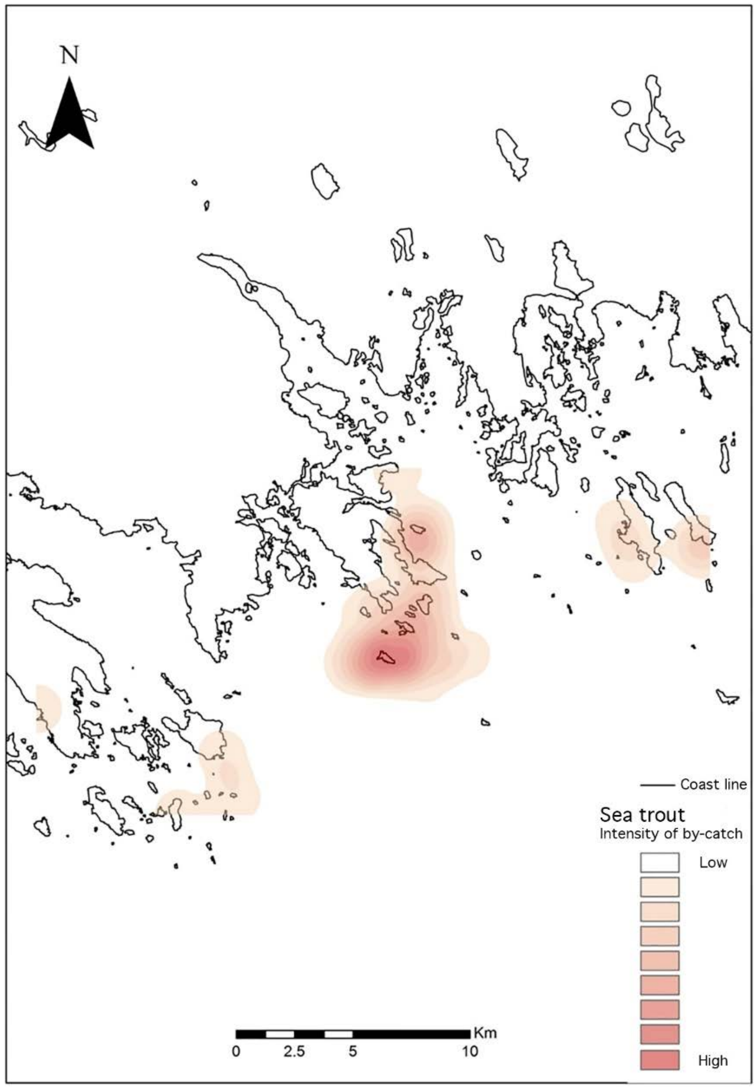
Sweden has a system for national and regional monitoring of the environmental status of its coasts and seas (Svärd *et al*., 2016). A recent review by the EU commission stated that the present Swedish monitoring is insufficient, and the Swedish national agencies have concluded that a higher ambition is needed (Svärd *et al*., 2016). In the Bothnian Bay, monitoring is generally restricted to low frequency sampling (i.e. once/year) in very few areas. Sampling of fish stocks is done once per year in one area only (Rånefjärden) (Ericson, 2015). There is much less research in the Bothnian Bay compared with other Swedish marine areas, probably due to its geographical location far from most marine research centres (anonymous, 2017). Also, monitoring methods used in other parts of the Baltic Sea are not always applicable to the Bothnian Bay, due to differences in species compositions and abundance (Albertsson, 2014).

**Figure 10: Local fishers mapping fishing spots and species abundance in the Kalix archipelago**

Photo: Roland Stenman, 2011.

In the Kalix archipelago, local communities have observed and mapped the abundance of fish stocks since around 1980. In a WWF funded mapping project by Kustringen 2011–2014, around 40 local fishers mapped fishing sites and fishing trends. Invitations were sent through local contacts and community associations. The participants provided information on fishing sites, species, catch frequency, seasonality of fishing, etc. based on memory and documentation from the 1950's until present The results are qualitative and show major trends. One important result is maps of areas where by-catches of sea trout have been frequent, and areas where no trout have been caught over the years. These areas are currently subject to the 3m fishing prohibition, and Kustringen suggests that in the areas with few by-catches of sea trout, the prohibition could be lifted in order to maintain the important traditional cultural heritage around fishing, without affecting the sea trout population. The local fishing communities could also help provide needed information on by-catches and identify important areas for sea trout, areas where locals could help conserve and protect sea trout and other sensitive species through local fishing rules, local vigilance and support measures. Below is a sample of results.

**Figure 11: Map of areas with high and low intensity of by-catches of sea trout as reported by the local Kalix fishers in Kustringen**




Note: Kustringen proposes that the fishing prohibition could be lifted in the areas with few sea trout by-catches in order to maintain the important traditional cultural heritage around fishing, without affecting the sea trout population.

### Observations from a local knowledge holder (Joakim Boström) on changes in abundance and catch of fish species over the past 20 years

Regarding fish species, their occurrence and catches, the following can be said:

The catches of burbot in my waters have increased steadily over the past 20 years. The burbot that you catch today is in much better condition than before. Earlier (until about 20 years ago) it was very common for the burbot caught to be sterile, without milt or roe, and tumours and black spots on the liver were common, as well as crooked spines. Now the burbots caught are healthy, they are all fertile and the livers are bright and nice.

The pike catches are unchanged over time for more than 20 years.

The perch catches are unchanged over time, the only noticeable difference is that the size of perches caught has increased, since the fishing has been directed and increasingly done with traps.

We have clearly seen in our archipelago over the past decade that the stocks of carp fishes such as roach, common bream, Crucian carp (*Carassius carassius*) and silver bream (*Abramis bjoerkna*) have risen very quickly. Catches of these species are now taking place further out in the archipelago. Carp fishes are usually associated with eutrophication and it is therefore of concern.

The catches of whitefish in my waters have been largely unchanged over the last 20 years. Catches in spring vary due to wind and food availability. Unfortunately, it is increasingly difficult to assess the populations of whitefish when changed fishing rules put an end to the possibility of fishing on the traditional fishing grounds in spring and autumn.

The number of graylings (*Thymallus thymallus*) obtained in the form of by-catches in the nets has increased steadily over the last 20 years.

By-catches of sea trout have increased over the last 20 years. Older fishermen say they are more common now than at any time from the 1950s onwards.

The catches of salmon have increased over the past 20 years; the catches are large and stable. Observations of salmon with skin damage, stains, rashes and poor quality of meat are becoming more common.

The catches of vendace have been increasing over the last 20 years and the current trend suggests an increase.

The catches and the presence of herring have been increasing over the past ten years, before that time I have no clear picture since I fished very little herring then.

The presence of species like smelt (*Osmerus eperlanus)*, ruffe and fourhorn sculpin is unchanged over time for more than 20 years.

### Birds, mammals: Observations from a local knowledge holder (Joakim Boström)

Over the past 10–20 years, people in my vicinity and I have observed a number of changes in the natural environment where I live and work.

The white-tailed eagle population (*Haliaeetus albicilla*) has increased, especially during the past ten years.

The number of cormorants (*Phalacrocorax carbo sinensis*) has increased steadily over the last 20 years. In the past you saw a flock every now and then, especially in the spring. During the past five years, we see cormorants every time we are in the outer archipelago.

The greylag goose *(Anser anser)* in the outer part of the archipelago seems to have peaked about 20 years ago and has steadily declined over the past ten years. The Canada goose *(Branta canadensis)* now takes over more and more in the outer archipelago, while the observations of greylag geese are becoming less frequent.

The number of nesting cranes *(Grus grus)* and whooper swans *(Cygnus cygnus)* have increased drastically in the archipelago over the past twenty years.

The little gull *(Larus minutus)* was first observed in the archipelago around year 2000, but is more common today than the black-headed gull *(Chroicocephalus ridibundus)*, which seems to be in steady decline.

The common tern *(Sterna hirundo)*, the Arctic tern *(Sterna paradisaea)* and the common gull *(Larus canus)* are steadily decreasing.

The number of mallards (*Anas platyrhyncos*), tufted ducks (*Aythya fuligula*), common pochards (*Aythya ferina*), Eurasian wigeons (*Anas penelope*), teals (*Anas crecca*), northern pintails (*Anas acuta*), and northern shovelers (*Anas clypeata*) have decreased markedly over the past 20 years.

The number of common and red-breasted mergansers (*Mergus merganser*, *M. serrator*) is slightly decreasing. The stone chat (*Oenanthe oenanthe*) seems to decrease. The number of ravens (*Corvus corax*) has risen dramatically. You now see large raven flocks roaming the islands, especially islands and reefs where other species usually breed.

Observations of otter (*Lutra lutra*) in the archipelago have gone from almost none 15 years ago, to observations of tracks in the archipelago every winter. The seals, both gray seals (*Halichoerus grypus*) and ringed seals (*Pusa hispida*), have increased since the 1960s to the present, from largely non-existent to large populations today. They significantly affect coastal fishing (see further below).

The ticks (*Ixodes ricinus*) have increased in number on the islands in the outer part of the Kalix archipelago. The first ticks were observed around twenty years ago, and now it is increasingly common for animals and people to suffer, especially during spring and early summer.

### Observations from Rolf Söderholm and Marina Jägerving, reindeer herders in Kalix sameby

The woods have become quieter. In the past, there were sometimes such concerts of thrushes that one couldn't hear the reindeer bells. This doesn't happen today. The song thrushes (*Turdus philomelos*) are much fewer, you only hear a few here and there. The cuckoo (*Cuculus canorus*) has also decreased. The Siberian jay (*Perisoreus infaustus*) has largely disappeared. There is less of virtually everything. The house martin (*Delichon urbica*) has disappeared. In the village I come from, there were easily five hundred nests in the past, but if you see a single martin today you are lucky. The barn swallow (*Hirundo rustica*) has nowhere to nest. People close their barns from the swallows because they say they're messy. The magpie (*Pica pica*) is a very big predator of small birds, it has increased a lot. The raven has also increased and is common today.

The seabirds have disappeared. When I was a boy, there were lots of ducks: mallards, teals, goldeneyes (*Bucephala clangula*) and mergansers. The ducks have largely disappeared. We have a lot of mink (*Mustela vison*) and they clean every nest. The ravens and crows (*Corvus corone*) also take a lot. The crows have, however, decreased in recent years.

Geese and whooper swans have increased. There are fewer greylag geese, but the Canada geese have increased. The swans chase away ducks, I have seen that myself. The Canada geese also oust the bean goose (*Anser fabalis*).

The black woodpecker (*Dryocopus martius*) has decreased, it was often seen here before. The chiffchaff (*Phylloscopus collybita*) has disappeared, it used to be common. The willow warblers (*Phylloscopus trochilus*) are much fewer, now you only hear a few. The chaffinches (*Fringilla coelebs*) are also fewer. The reed buntings (*Emberiza schoeniclus*) have disappeared; they are not heard these days.

### The coastal landscape

Very large areas have been clearcut. The clearcuts are enormous; one can walk from here to Kiruna (300 km) on clearcuts only. The remaining old forests are privately owned, whereas most of the corporate and state owned forests are cut. These days they don't even leave trees along the rivers and creeks. The philosophy is "take everything you can and leave". All forests with lichens are felled and there is little left (the old forests with lichens are important for reindeer winter grazing). It is the same on the islands. On the big islands, much of the forest is owned by companies.

Roads are built everywhere, and a new railroad has been built through our area. Fences are put up, which is both good and bad. They restrict the reindeer from entering the roads, but they also cut off the migratory routes. Summer cottages are built in many places and this is a problem for us – the cottage owners see the reindeer as a nuisance.

Wind parks are planned on Bergön. The authorities say everyone should co-exist, but on whose terms? The reindeer herding is in decline. The predators have increased, especially bears (*Ursus arctos*), but also lynx (*Lynx lynx*) and wolverines (*Gulo gulo*). We have seen wolverine tracks all the way down to the coast. The predators are "devouring" us; the bear population is an enormous problem.

## *2.3.3 Seals – a "new" and serious threat to local fishing in the Kalix archipelago (local reflections by Joakim Boström, summarised and translated by Marie Kvarnström)*

Seals have been an important source of food and pelts for local communities in the Kalix area for many centuries, probably millennia. Today, grey seals (*Halichoerus grypus*) and ringed seals (*Phoca hispida*) occur in the Bothnian Bay. In the 18th century, seals were regarded as pests and hunting was not restricited. In the 19th century a bounty was introduced to increase the incentive to hunt seals. Even today, there are people from the older generation who tell stories about seals and seal hunting, and share their local and traditional knowledge on how to use the seal as a valuable resource. The seal hunt is part of the local intangible bio-cultural heritage. An interesting local description of the historical seal hunt can be found on the web page of the Kalix village Storön (http://ww1.storon.se/byns-historia/saljakt-och-saljagare/).

In the 20th century, the seal population declined drastically as a result both of hunting and of sterility, presumably caused by organochlorines. In 1974, seal hunting was banned and seals in Swedish waters became a protected species.

**Figure 12: Brothers Sven and Henning Olofsson from Storön, Kalix, on a seal hunt in the southern part of Bothnian Bay in the 1930's**

Note: The photographer was probably another brother, either Gustaf or Knut Olofsson.

During the last four decades, the seal populations in the Baltic Sea have recovered in a remarkable way. The seals' health has been restored and the seals have returned as voracious fish eaters. This has caused increasing damage to fisheries, which is now so substantial in the Kalix archipelago that it is almost impossible to fish in some areas. Lately, the negative impacts on fishing and fish populations have also been noted by researchers. For instance, Lunneryd and Königson (2017) and Hansson *et al.* (2017) have noted the impacts through damage to harvest and equipment, less obvious damage such as scaring off or removing fish without leaving traces, and the dispersal of parasites in fish.

My first encounter with seals in the Kalix archipelago took place an early spring day in the beginning of the 90's when we spotted two seals on an ice sheet far out at sea.

By the mid 90's, seals were common and the fishers had to adjust their nets and traps with stronger yarn to resist the seals. The tools most frequently damaged in the Kalix archipelago were traditional fyke nets and combination traps used to catch salmon, trout, whitefish and perch. During vendace fishing in autumn, we also started to hear about seals, both grey seals and ringed seals, attacking the fyke nets used to catch vendace. At that time it was uncommon to hear about ordinary nets being damaged, and it was still possible to keep the nets in water for up to 48 hours.

During the second half of the 90's we started to hear stories of vendace nets being damaged. Around year 2000 the incidence of damaged nets increased. Fish were often damaged or lost and there were big holes in the nets.

Year 2001 brought a big change for the fishers who use fish traps for salmon, trout, perch, herring and vendace; the "push-up" trap had been developed and approved and was a new alternative to reduce seal damage. In 2001, protective hunting of seals was also introduced, but in practice this is extremely difficult (see further below).

Since year 2000, the seal problem for fishers in the Kalix archipelago has increased exponentially. Both grey seals and ringed seals have increased so much that the traditional net fishing is practically impossible in some areas. The seals are unafraid and are attracted to nets and boats.

The winter of 2008 was relatively mild with low ice cover, which led to a high concentration of seals in the inner part of the Bothnian Bay. It was now possible to count the seals in hundreds and thousands. Many fishers changed their tactics and only left their nets in the water during daytime. Fishing had become more stressful and difficult. The fishers started to depart in the early morning darkness to fish for one to four hours, in the hope of being one step ahead of the seals.

By 2016, we could no longer leave the nets at all. Instead, we kept the nets in the water for 20–30 minutes. Sometimes we were lucky, thanks to another boat and fisher whose nets right next to ours fed the seals while we could get a catch. Going out in just one boat typically resulted in no catch at all. We would count an average of 15 seals around the boat each time we were out during the vendace fishing. This year we had seals in our nets also during the summer's herring fishing.

The year 2017 was the ten-minute-year: when you have five to ten seals around the boat after ten minutes of fishing it begins to feel pointless to even try catching any fish. We don't want to think about what the coming years will be like.

**Figure 13: Vendace damaged by seal, autumn 2017**

Photo: Roland Stenman.

In 2001 protective hunting of seals was introduced by the Swedish Parliament as a means to reduce seal damage on fisheries in the Baltic Sea. However, the protective hunting regulations are very complex, resulting in many potential hunters desisting from hunting in fear of doing wrong or possibly even committing a crime. First, you need training and certification in seal hunting if you aim to hunt seals from a boat. You also need hunting rights in the waters or on the land from where you hunt. When a seal is killed, it needs to be reported by phone to the Environmental Protection Agency. Any potential body parts retrieved should be sent to the Museum of Natural History for research (compensation for this is paid to the hunter). Since 2016, protective hunting is only allowed within 200 m from fishing gear damaged by seals. A riffle with ammunition of class 1 or 2 is required, but firing these from a boat that is often rocking is challenging and dangerous. Considering the risks for people near the boat, and the likelihood of wounding and losing the seal, it is in my eyes a risky and unethical business. A change from protective hunting to license hunting that could be done from land or from the ice is a first step towards local management of today's seal populations. Most importantly, the complex processes and regulations surrounding seal hunting need to be simplified.

The present EU ban on selling seal products also needs to be changed. Historically, seals have been a source of food, pelts and oil with a multitude of uses. Today, in the transition toward ecologically, socially, culturally and economically sustainable ways of living, it seem strange not to use seal products, particularly as this would help manage seal populations sustainably and reinstate conditions for local sustainable fishing. In the Baltic Sea, seals have no major natural predators. Thus, beyond disease vectors, the steady increase in seal populations can only be controlled by humans.

The EU ban on trading in seal products has an exception for Inuit hunting of seals (see box 4). Seal hunting in the Kalix archipelago and the Bothnian Bay has a long tradition of subsistence use, and an EU exception for seal hunting for sustainable management of seals in the Baltic Sea, could be introduced along the same lines as the present exception for Inuit seal products.

**Box 4: EU-ban on seal products**

In 2009, the EU adopted Regulation (EC) No 1007/2009 banning the trade in seal products in the European Union. The ban applies to seal products produced in the EU and to imported seal products. The Commission adopted implementing Regulation (EU) No 737/2010. Both acts became applicable on 20 August 2010.

The ban was amended in 2015 in order to reflect the outcomes of WTO rulings in the EC-Seal products case. The amendments to Regulation (EC) No 1007/2009, which also repeals Regulation (EU) No 737/2010, became applicable on 18 October 2105. The Commission adopted a new Commission Implementing Regulation (EU) 2015/1850, also applicable as of 18 October 2015.

*Inuit exception – Article 3(1) of Regulation (EC) No 1007/2009 as amended*

The seal hunt is part of the socio-economy, culture and identity of the Inuit and other indigenous communities and it contributes greatly to their subsistence and development. For this reason the Regulation provides for an Inuit exception. It allows the placing on the European Union market of seal products which result from hunts traditionally conducted by Inuit and other indigenous communities if the conditions under Article 3(1) of Regulation (EC) No 1007/2009, as amended, have been met.

**Figure 14: Reindeer herding continues in Kalix sameby based on traditional knowledge from past generations but with new challenges from forestry, infrastructure development and increasing predator populations**

### *2.3.4 The potential for future community based monitoring*

There is a clear potential to continue community based monitoring practices in the Kalix archipelago. The practices provide a strong base for subsistence fishing and co-management of fish stocks, as well as for co-governance for sustainable reindeer herding. In the past, the Kustringen organisation has tried to initiate communication with local, regional and national authorities to discuss the potential for co-management of small scale artisanal and household fisheries. The response from authorities has not been very encouraging despite several meetings held. One observation from Kustringen is that dialogue with the county administrative board has been hampered by lack of interest from the officers of the County Administration Board.

The organisation of professional coastal fishers in Norrbotten practice self-management of fish resources, in consultation with the Swedish Agency for Marine and Water Management and supported by research by the Swedish University of Agricultural Sciences. This could be applied as a good-practice model in the development of a co-management strategy for the small scale artisanal and household fishers in the Kalix area.

## 2.4 Direct and indirect drivers

### 2.4.1 *Direct drivers*

#### Natural drivers

As has been stated in chapter 4 of the IPBES-like assessment (Belgrano (Ed.), 2018), natural variation in plant and animal population dynamics is an intrinsic part of evolution. In the Bothnian Bay, the main natural drivers include postglacial land rebound, natural extreme weather events and longterm eutrophication and sedimentation from freshwater runoff.

#### Climate change

Climate change is expected to be the main factor of change in the Bothnian Bay in the coming decades. Its impacts will be manifold and complex, but not very much research has been done related to the Kalix area (Bredefeldt, 2015). Some expected changes include:

- increased $CO_2$ levels, as well as increased acidic runoff from the watersheds of the Bothnian Bay, which may lead to intensified acidification in the future, with potentially very significant impacts on marine life. This is supported by the falling pH level in the Bothnian Bay (SMHI, 2009);
- cold water species such as burbot, salmon, trout, vendace, whitefish and herring may be directly negatively affected by increased temperature, while warm water species like perch, pike and roach may increase in numbers;
- a stronger thermocline may increase the risk for low oxygen levels in deeper waters;
- the expected increase in precipitation and stronger precipitation events may bring more nutrients, harmful chemicals and humus into the Bothnian Bay. More nutrients could mean more phytoplankton, higher productivity and an increase in fish stocks, but it could also mean darker waters and a subsequent decrease in the macroflora and harsher conditions for the bottom fauna, more bacteria, more heterotrophic conditions and a decrease in fish stocks (Bredefeldt, 2015);
- new research (Jonsson *et al*., 2017) predicts that methylmercury may increase 3 to 6-fold in zooplankton in the Bothnian Sea through expected biogeochemical and ecological changes from climate change, with continued bio-accumulations further up in the food chain;
- rising sea water levels are projected to be off-set in the Bothnian Bay in the foreseeable future through the post-glacial land rebound. However, there is research that indicates the risk of much faster rise in sea water levels than previously predicted (Hansen *et al*., 2015).

### Overconsumption

Present levels of consumption of biological resources and burning of fossil fuels in Sweden and globally, are clearly unsustainable. Sweden is among the world's top consumers according to the *Living Planet Report 2016* (WWF, 2016). The report suggests that if everyone in the world lived like a Swede, the global population would need the resources from 4.2 Earths. Consumption is both a direct and indirect driver, contributing to climate change, eutrophication, overfishing, fragmentation of ecosystems, etc. Consumption patterns in Sweden are also likely to indirectly influence consumption in other countries, and lowered consumption levels in Sweden could have benefits far beyond our boundaries. WWF argues that to reverse the trend, politicians need to limit fossil fuel emissions and consumers need to dramatically change their habits. The local values, traditional knowledge, and customary use of local resources in the Kalix area can serve to inspire a transition towards more local resource use and contentment with life and recreation in the local landscape. The international photographic initiative "We Feed the World" worked to portray this in a visit to Kustringen in Kalix in 2016. The initiative presented the role of small families in feeding 70% of the world's population. The visit resulted in articles on the Gaia Foundation website and in the magazine *Langscape*, whose mission is educating minds and hearts of the importance and value of biocultural diversity (Price & Benson, 2017; Gaia Foundation, 2017).

### Habitat degradation

Forestry and infrastructure development are significant direct drivers of change that negatively affect reindeer grazing and seasonal migration. Wind parks are planned, and it has been noted in other reindeer herding communities that wind power stations negatively affect reindeer, whose grazing patterns are changed since they tend to avoid considerable areas around wind mills (Sandström, personal communication, 10 March, 2016).

### Pollution

The Bothnian Bay is affected by acidification and point loading of hazardous chemicals, nutrients and heavy metals from industry pulp and paper mills, metal and chemical plants, from communities and from tributyltin (TBT) in boat bottom paint (Svärd *et al*., 2016). Hazardous substances may also reach the Bay from atmospheric downfall. Discharge has decreased substantially over the past 40 years thanks to legislation and developments in wastewater treatment technology. However, current depositions are still well above pre-industrial levels. According to recent studies, the level of the organic toxins PCB, DDE, HCB and HCH are decreasing in the Baltic Sea, including the Bothnian Bay (Svärd *et al*., 2016). Levels of e.g. dioxin, PFOS and mercury, are still significantly higher than background levels in fish samples from the Bothnian Bay, but below limits for safe human consumption (Svärd *et al*., 2016). Of particular concern is the possible future increase in load of methylmercury caused by future climate change (see above). The goals of the HELCOM Baltic Sea Action Plan (see further below) in respect of hazardous substances are:

- concentrations of hazardous substances close to natural levels;
- all fish are safe to eat;
- healthy wildlife;
- radioactivity at the pre-Chernobyl level.

### Invasive alien species

Around 17 non-indigenous species had been observed in the coastal waters of the Bothnian Bay until 2009; most are brought to the region by shipping, and the number has increased in recent years (HELCOM, 2012). Of the non-indigenous species, some are observed to have impacts on the local ecosystems and are thus classified as invasive alien species. *Marenzelleria* spp. are among these, and the ecological impacts in the Baltic are complex. At present there seems to be up to three different *Marenzelleria* species in the Bothnian Bay, but species identification is difficult. *Marenzelleria* may or may not outcompete other species, it may help aerate and decompose sediment layers, it may increase the load of previously bound harmful chemicals in the food chains, and it may increase the nutrient content of the sea and result in increased algal/cyanobacterial blooms (Maximov *et al*., 2015; Norkko *et al*. 2012; Gren *et al*. 2016). Its potential impact in the Bothnian Bay remains largely unknown. One study indicates a potential cost of *Marenzelleria* in the Baltic Sea that ranges between SEK 167 billion and SEK 732 billion, depending on the effect of *Marenzelleria* on sequestration of phosphorus (Gren *et al*. 2016). At present, the alien species round goby (*Neogobius melanostomus*) is spreading in the southern Baltic Sea and in other parts of Europe and the US. In some areas of the Southern Baltic it has outcompeted native fish populations. It should be expected to spread to the Bothnian Bay and may bring significant impacts on ecosystems in the future.

On land, the American mink (*Muscula vison*) has a negative impact on coastal bird populations according to local observations. The raccoon dog (*Nyctereutes procyonoides*) has established a population in the area. It is also classified as an invasive alien species and may pose a future threat to bird and amphibian populations. A control program aims to keep populations at a low level.

## 2.5 Current and future interactions between nature and society

Fisheries and life in the coastal communities have been affected and changed to a great extent in recent decades. Traditional small-scale artisanal fishing practices have been negatively influenced by the recent fishing prohibitions. This has had a negative impact on people's quality of life.

As noted above, since 2006 fishing is prohibited in waters less than 3 m deep in the Bothnian Bay and Kvarken between April 1st and June 10th and between October 1st and December 31st. The purpose was to protect the sea trout population in the area. However, this also meant that fishing was prohibited in large areas where it has been a vital part of the local household economy and way of life for many generations. The traditional artisanal fishing practices for whitefish, perch and pike during spring and autumn are now almost non-existing, since the prohibition periods coincide with the main traditional fishing periods.

IPBES acknowledges that different kinds of knowledge and values need to be taken into account in decision making. Ecosystem services can embody relationships with nature that are inextricably linked to people's sense of identity and to a meaningful life (Pascual *et al.*, 2017). This is very evident in the case of the Kalix communities, as exemplified in the comments above in Section 2.2 on what fishing means for local people in Kalix. The present fishing prohibitions may lead to a loss of the sense of connection with nature, which is a key part of local culture. This connection boosts the local sense of responsibility for the local biodiversity and ecosystems, and is a key factor for an alive and thriving community in the Kalix archipelago. The same sense of loss and frustration with restrictions developed outside the communitiy, which seem uncalled-for from a local perspective, have been noted elsewhere, e.g. by Sejersen (2004), who describes local Greenlandic hunters' frustration at the regulation of hunting, which was felt to be insensitive and poorly conceived. Sejersen underscores that "the intimate attachment and sense of belonging to the landscape emphasise local bonds to place, as well as the extensive time span in which people have experienced it".

Policy- and decision making institutions aiming at sustainable futures would benefit from recognition of the broad range of knowledge and values in the local communities. This requires the ability to engage in bridging and to mobilise transdisciplinary collaboration across disciplines and with local communities (Pascual *et al.*, 2017). The first step in this process would be a willingness on the side of authorities to enter into dialogue, where both the local communities and the government representatives could listen and learn from each other. The Kalix communities, represented by Kustringen, are hoping that this dialogue can begin in the near future.

## 2.6 Governance of ecosystem services

### *2.6.1 General institutions and policies*

*HELCOM Baltic Sea Action Plan (BSAP)* is a programme to restore good ecological status of the Baltic marine environment by 2021 (HELCOM 2010).

The Plan was adopted by all the coastal states and the EU in 2007. It incorporates scientific knowledge and innovative management approaches into strategic policy implementation, and stimulates goal-oriented multilateral cooperation around the Baltic Sea region. The BSAP is regularly updated in ministerial meetings.

*The EU Water Framework Directive* is a framework has two main aims: to protect all inland, freshwater, groundwater and coastal waters in EU and achieve a 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 iterative 6-year water management cycles. Information and consultation is mandatory in specific phases of the WFD water management cycle and active participation is encouraged. In Sweden, five regional water authorities coordinate the work to implement the WFD by establishing and implementing regional environmental quality norms, action programmes and management plans. Local catchment partnerships have formed (Kalix belongs to Norra Bottenvikens kustvattenråd), where problem issues are raised, conflicts identified, information is provided from the water authorities, etc. Members of the catchment partnerships are municipalities, forestry, energy and mining corporations, NGOs and interested individuals.

*The Convention on Biological Diversity* (CBD) is an international convention dealing with all the world's biodiversity and ecosystems, terrestrial, freshwater and marine. 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.

The convention's *article 8(j)* requests its parties to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices".

*Article 10(c)* requests the CBD parties to "protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements".

The conference of the parties to the CBD has agreed on a *Strategic Plan for Biodiversity*, including the *Aichi Biodiversity Targets*, for the 2011–2020 period. This Plan provides an overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system and all other partners engaged in biodiversity management and policy development. *Aichi Target 18* reads "By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels."

### *2.6.2 Fishing regulations (Joakim Boström, from a local perspective)*

Fisheries and life in the coastal community have been affected and changed to a great extent in recent decades, as noted above. The possibility to continue traditional small scale artisanal fishing for household needs has been negatively influenced by extensive changes in regulations. This has had a negative impact on many people's way of life and quality of life (see e.g. section 2.2 above and Nilsson & Tivell 2010).

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.

### International regulations: EU Common Fisheries Policy 2014–2020

The EU has a common fishing legislation that applies to all EU member states. It deals with how many fish can be caught, how the fish should be labelled and what support should be given to fishers. The EU has implemented regulations to prevent overfishing. The Common Fisheries Policy (CFP) lays down that:

- EU member states have joint fisheries legislation that all member states must adhere to;
- the EU introduced new rules for its fisheries policy in 2014 with a stronger focus on long-term sustainable fishing and compliance with EU environmental legislation.

The EU's objectives of the Common Fisheries Policy are to:

- restore and preserve fish stocks;
- fisheries should be sustainable in the long term;
- fishing should be economically viable and competitive;
- those who work with fishing should have a reasonable living standard;
- consumer interests should be taken into consideration.

Through the EU Control Regulation of 2009, Article 55, a ban was introduced on selling fish caught by recreational fishers in the sea. Selling fish and fish products from the sea is prohibited without a professional fishing license. The new regulations have meant that local community members in Kalix no longer can sell any surplus fish, unless they acquire a professional fishing licenses – a process which is costly and complicated.

The *International Council for the Exploration of the Sea (ICES)* assesses the sea trout populations in the Bothnian Bay as endangered.

The *EU* has introduced a ban on import and trade of all seal products in the EU from 2010. This ban has been tried by *The World Trade Organization*, *WTO*, and the final decision is that the EU's ban on trade in seal products does not violate world trade rules. The ban on imports and trade of seal products in the EU from 2010 thus remains.

### National regulations

*The Swedish Agency for Marine and Water Management* – responsible for managing the use of Sweden's marine and freshwater environments. Extensive regulations and control of fishing, licensing, stock management, quotas, monitoring and control of landed fish, etc.

*The Coast Guard* – Supervision and control of compliance with laws and regulations in the archipelago. During spring and autumn, considerable resources are used to check that the 3 m rule is adhered to. Aircrafts, hoverers and various vessels are used, as well as dragging for nets and fishing gear inside the 3 m depth curve of the current chart. Coastal surveillance also ensures that occupational fishers follow the rules governing fishing as well as registration of the vessels used in fisheries. They perform crew checks, landing checks, logbook checks and equipment inspection on the ships.

*The Swedish Environmental Protection Agency* has created the regulatory framework that governs the protective hunt for seals associated with fishing (Naturvårdsverket, 2017; http://www.naturvardsverket.se/Var-natur/Jakt/Jakt-pa-sal/).

*The Swedish Board of Agriculture* is the Swedish authority responsible for the national marine and fisheries programme 2014–2020. It supports the development of sustainable fisheries and aquaculture in Sweden and implements of parts of the integrated marine policy and various EU directives (Jordbruksverket, viewed May 2017).

Regional/local level surveillance: the *County Administrative Board in Norrbotten* is responsible for monitoring, information and field control of fishing rules, including the 3 m rule, with hired boats, controllers and own personnel. The County Administrative Board is a referral body for applicants for professional fishing licenses in the county. The board may also grant licenses and exceptions for fishers who want to fish on shallower waters than 3 meters in spring and autumn (Länsstyrelsen Norrbotten, 2008).

The County Administrative Board is also involved in the protective hunt of seals in connection with fishing. The County Administrative Board may grant permission to trained hunters for protective hunting of seals on public waters in connection with fishing.

The many regulatory bodies mentioned above, illustrate the complexity of the Bothnian Bay fishing regulations. At the local level, the regulations are found to be complicated to relate to. The most striking example is the regulation of the professional salmon fishery. This is 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.

Many people in the coastal communities experience a loss of quality of life and of connection with their local land- and seascape as a result of the regulations introduced during recent decades. The local traditional knowledge about fishing is also likely to disappear if the 3 m rule continues to apply for a longer period. Many people feel mentally unwell and the local community has lost an important social unity. The knowledge and conversation around fishing, along with the possibility to fish for the household and for parts of the family income, has united people for many generations.

Since people no longer can fish at the fishing shoals and with the methods used for many generations, many with me have lost their desire and motivation for fishing. It is no longer fun or justified to lay their nets to catch fish for the family. The possibility of artisanal fishing for household needs has been taken away from us. The complex, shallow, re-bounding coast of the Kalix archipelago, with lots of shoals and reefs, makes it difficult to be sure of the position of the 3 m boundary. One may be committing a criminal act in order to keep alive traditional knowledge on fishing spots, methods and fish behaviour, to enjoy a good fish for dinner with one's loved ones.

In this context, it is important to strive for the creation of participation and co-governance around the local fishing and its complicated rules. There is no co-management at present, but Kustringen is striving for joint management of fisheries in the area concerned. Together with the local population, local actors, the county administrative board and the Sea and Water Authority, we in Kustringen are confident that joint management should work.

There is a great will among local people and local communities for local co-governance. Unfortunately, from the government, municipality, county administrative board and Sea and Water Authority are not always convinced that decentralised decision-making or local governance are to be regarded as sustainable.

Professional fishers engaged in trawl fishing in the Kalix area are part of a joint management scheme for vendace fishing and have worked together with artisanal fishers to promote and manage the vendace population with good results. However, the fishers' knowledge and views may not always be given enough weight in decision making.

Authorities and academics need to meet locals and natural resource users as equals and with a changed attitude. Our society must dare to take the local and traditional knowledge in to account and listen to what the local resource users have to say. The authorities and academics need to realise that laws, paragraphs, statistics and research are not always the only ways to create long-term sustainable management of biodiversity. What the local resource users have to say is not schemes to maximise personal benefits, but knowledge that has enabled people to live and manage their natural resources in a sustainable way for several generations.

### Test fishing – a proposal for the addition of local community based monitoring

The Department of Aquatic Resources at the Swedish University of Agricultural Sciences has carried out test fishing in August of every year in the bay outside Råneå, as part of the national environmental monitoring of coastal waters. At present, the test fishing is very limited; it is carried out at fixed locations and times and with restricted fishing methods.

Kustringen has carried out eco-mapping of fish and fishing for several years (Nilsson & Tivell, 2011). Changes and observations in ecosystems, fish stocks, catches, local fishing traditions etc. have been documented. There is potential to use this methodology in a co-management system where community-based monitoring contributes to the overall monitoring of the status and trends of the coastal ecosystem. Local fishers could contribute by carry out test fishing, covering a large area with frequent sampling, adding local knowledge on wind, temperature, water levels and currents.

In connection with Kustringen's work, proposals have been made for the introduction of local fishing regulations. The local fishing communities could help identify important areas for sensitive species such as sea trout, along with areas where locals could help conserve and protect sea trout and other sensitive species through local fishing rules, local vigilance and support measures.

Kustringen has mapped large areas in the inner archipelago, where the by-catch of sea trout has been marked as minimal or completely absent (cp. map fig. 11). These areas are currently subject to the 3 m fishing prohibition, and here Kustringen suggests that the prohibition could be lifted in order to maintain the important traditional cultural heritage around fishing, without affecting the sea trout population.

In the past, the local Kalix village communities have tried to initiate communication with local, regional and national authorities for possible co-management of small-scale artisanal fisheries, but the interest from the authorities has been lacking. The success of such initiatives is strongly dependent on personal interest in dialogue from the autorities' personnel. Inspiration can be drawn from the organisation of professional coastal fishers in Norrbotten, Norrbottens kustfiskareförbund. The organisation self-manages fish resources in consultation with the Swedish Agency for Marine and Water Management and is supported by research by the Swedish University of Agricultural Sciences (Norrbottens kustfiskareförbund, 2017).

## 2.7 References


Albertsson, J. (2014). *Uppföljning av naturtypen 1140 blottade ler- och sandbottnar i Bottenviken och Södra Östersjön. En pilotstudie*. Havs- och vattenmyndighetens rapport 2014:22.

Anonymous. (2017). Personnel at the County Administrative Board in Norrbotten. Personal communication, June 2017.

Belgrano, A. (Ed.). (2018). *Nordic IPBES-like Assessment of Biodiversity and Ecosystem Services in Coastal Ecosystems*. Report. TemaNord 2018: Copenhagen: Nordic Council of Ministers.

Bredefeldt, M. (2015). *Naturmiljö och klimatförändringar i Norrbotten – konsekvenser och anpassning.* Länsstyrelsens rapportserie 14/2015. Luleå. Länsstyrelsen i Norrbottens län.

Ericson, Y. (2015). *Faktablad – Resultat från övervakningen av kustfisk 2015:3 Råneå (Bottniska viken) 2002–2015*. Online. Viewed 21 June 2017. http://www.slu.se/globalassets/ew/org/inst/aqua/externwebb/k-lab/provfiske-vid-kusten/faktablad/2016/ranea-2002-2015.pdf

Gaia Foundation. (2017) *Finding new words for old knowledge in the Kalix communities in Northern Sweden*. Online. Viewed 23 January, 2018. http://www.gaiafoundation.org/finding-new-words-for-old-knowledge-in-the-kalix-communities-of-northern-sweden/

Gren, I.-M., Sandman Nyström, A. & Näslund, J. (2016). *Economic effects of the invasive worm Marenzelleria spp. in the Baltic Sea.* Working paper series. Uppsala: Swedish University of Agricultural Sciences, Department of Economics, 2016:11 https://pub.epsilon.slu.se/13889/7/gren_et_al_161213.pdf

Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V. *et al*. (2016). Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming is highly dangerous*. Atmos. Chem. Phys., 16*, 3761–3812. Online. Viewed 24 May 2017. http://www.atmos-chem-phys.net/16/3761/2016/, http://dx.doi.org/10.5194/acp-16-3761-2016

Hansson, T. (2017). Vitaminbrist som dödar. *Forskning och Framsteg* 7/2017. Online. Viewed 24 March 2018. https://fof.se/tidning/2017/7/artikel/vitaminbrist-som-dodar

Havs- och vattenmyndigheten. (2015). *Förvaltning av lax och öring. Havs- och vattenmyndighetens förslag till hur förvaltningen bör utformas och utvecklas*. Regeringsuppdrag Dnr 990:2015, delrapport.

Havs- och vattenmyndigheten. (2018). Fisk- och skaldjursbestånd i hav och sötvatten 2017. Resursöversikt. Göteborg, Hansson, S., Bergström, U., Bonsdorff, E., Härkönen, T., Jepsen, N., Kautsky, L., Lundström, K., , S.-G., Ovegård, M. Salmi, J., Sendek, D. & Vetemaa, M. (2017). Competition for the fish – fish extraction from the Baltic Sea by humans, aquatic mammals, and birds. *ICES Journal of Marine Science*, fsx207, https://doi.org/10.1093/icesjms/fsx207

HELCOM. (2012). *Observed non-indegenous [sic] and cryptogenic species in the Baltic Sea. HELCOM Baltic Sea Environment Fact Sheet 2012*. Online.Viewed 25 June 2017, http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/

ICES. (2011). *Study Group on data requirements and assessment needs for Baltic Sea trout* (SGBALANST), 23 March 2010 St. Petersburg, Russia, By correspondence in 2011. ICES CM 2011/SSGEF:18. 54 pp.

IPBES. (2017). *Update on the classification of nature's contributions to people by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. *IPBES/5/INF/2*.

Jonsson, S., Andersson, A., Nilsson, M. B., Skyllberg, U., Lundberg, E., Schaefer, J. K., Åkerblom, S., & Björn, E. (2017). Terrestrial discharges mediate trophic shifts and enhance methylmercury accumulation in estuarine biota. *Science Advances, 3*, no 1. Online. Viewed 4 June 2017. http://advances.sciencemag.org/content/advances/3/1/e1601239.full.pdf

Jordbruksverket. (no date). Online. Viewed 17 May 2017. http://www.jordbruksverket.se/amnesomraden/landsbygdfiske/programochvisioner/havsochfiskeriprogrammet20142020/omhavsochfiskeriprogrammet.4.724b0a8b148f52338a35c6f.html

Kronholm, M., Albertsson, J. & Laine, A. (eds.) (2005). *Bottenviken Life. Handlingsprogram för Bottenviken*. Länsstyrelsen i Norrbottens län, rapportserie 1/2005.

Länsstyrelsen Norrbotten. (2008*). Information om fiskeregler för Norrbottenskusten.* Online. Viewed 13 May 2017). http:/www.lansstyrelsen.se/norrbotten/SiteCollectionDocuments/Sv/djur-och-natur/fiske/Kustfiskeregler2008.pdf

Maximov, A., Bonsdorff, E., Eremina, T., Kauppi, L., Norkko, A. & Norkko, J. (2015). Context-dependent consequences of Marenzelleria spp. (Spionidae: Polychaeta) invasion for nutrient cycling in the Northern Baltic Sea. *Oceanologia*, 57, 342–348. https://www.sciencedirect.com/science/article/pii/S0078323415000871

Michalek, M. & Werner, M. (2012). *Abundance and distribution of* Marenzelleria *species in the Baltic Sea. HELCOM Baltic Sea Environment Fact Sheet 2012*. Online. Viewed 21 June 2017. http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/

Naturvårdsverket. (2017). *Jakt på säl*. Online. Viewed 3 April 2017. http://www.naturvardsverket.se/Var-natur/Jakt/Jakt-pa-sal/

Nilsson, P. & Tivell, A. (2011). *Kunskap är makt – lokal kunskap och lokalt inflytande.* Uppsala: Centrum för biologisk mångfald. Online. Viewed 13 March 2017. http://www.slu.se/globalassets/ew/org/centrb/cbm/dokument/publikationer-cbm/cbm-skriftserie/skrift56.pdf

Norkko, J., Reed, D. C., Timmermann, K., Norkko, A., Gustafsson, B. G., Bonsdorff, E., Slomp, C. P., Carstensen, J. & Conley, D. J. (2012). A welcome can of worms? Hypoxia mitigation by an invasive species. *Global Change Biology 18*, 422–434.

Norrbottens kustfiskareförbund. (2017). *Vårt fiske*. Online. Viewed 17 June, 2017. http://www.norrkustfiske.se/vaart-fiske/

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M. *et al*. (2017). Valuing nature's contributions to people: the IPBES approach. *Current Opinion in Environmental Sustainability, 26–27*, June 2017. Online. Viewed 17 May 2017. http://www.sciencedirect.com/science/article/pii/S1877343517300040

Price, F. & Benson, C. (2017). We Feed the World: Photographing Traditional Knowledge in the Kalix Communities of Northern Sweden. In: *LANGSCAPE MAGAZINE*, Volume 6, Issue 1, SUMMER 2017. *Through a Different Lens: The Art and Science of Biocultural Diversity.*

Sejersen, F. (2004). Horizons of Sustainability in Greenland: Inuit Landscapes of Memory and Vision. *Arctic Anthropology*, *41*(1), 71–89. http://dx.doi.org/10.1353/arc.2011.0019

SMHI. (2009). *Försurning av haven. Kunskapsbanken*. Online. Viewed 14 May 2017. https://www.smhi.se/kunskapsbanken/oceanografi/surnande-hav-1.7064

Svärd, M., Johansen Lilja, T., Lewander, M., Karlsson, M. & Backteman, K. (Eds.). (2016). *Havet 2015/2016. Om miljötillståndet i svenska havsområden.* Göteborg: Havsmiljöinstitutet.

WWF. (2016). *Living Planet Report 2016. Risk and resilience in a new era*. Gland, Switzerland: WWF International.

## 2.8 Annex: Nature's contribution to people in the Kalix archipelago

**Table 2: Nature's contribution to people in the Kalix archipelago**

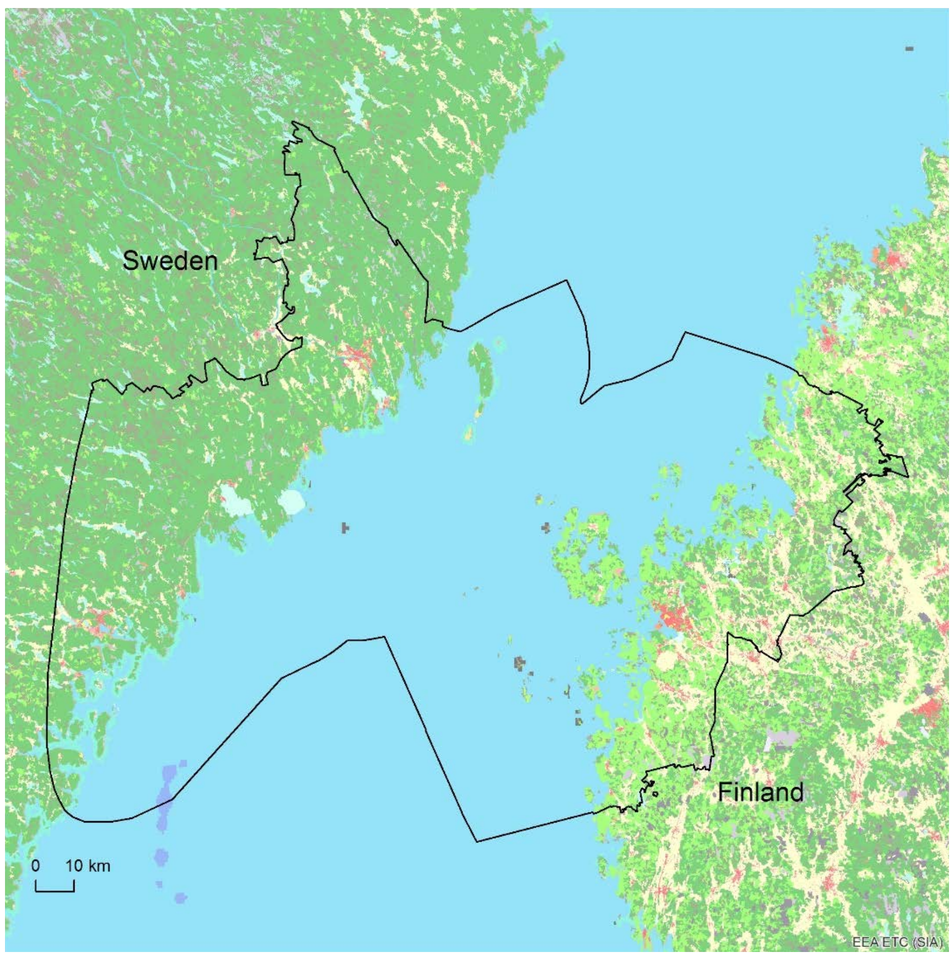
| Categories of nature's contributions to people | Brief explanation and some examples |
|---|---|
| Habitat creation and maintenance | Formation and production of ecological conditions necessary or favourable for organisms important to humans, e.g. nesting, feeding, and mating sites for birds and mammals, resting and overwintering areas for migratory mammals, birds and butterflies, nurseries for juvenile stages of fish |
| Pollination and dispersal of seeds and other propagules | Facilitation of movement of pollen and dispersal of seeds etc. by insects, birds, bats and other creatures; larvae or spores of organisms important to humans |
| Regulation of climate | Climate regulation by ecosystems (including regulation of global warming) through:<br>Positive or negative effects on greenhouse gas emissions (e.g. biological carbon storage and sequestration; methane emissions from wetlands)<br>Positive or negative effects on biophysical feedbacks from vegetation cover to atmosphere, such as those involving albedo, surface roughness, long-wave radiation, evapotranspiration (including moisture-recycling) |
| Regulation of ocean acidification | Regulation, by photosynthetic organisms, of atmospheric $CO_2$ concentrations and seawater pH, which affect calcification processes by marine organisms (such as diatoms) |
| Regulation of freshwater quantity, location and timing | Regulation, by ecosystems, of the quantity, location and timing of the flow of freshwater, including to the Bothnian Bay |
| Regulation of freshwater and coastal water quality | Regulation of water quality through filtration of particles, pathogens, excess nutrients, and other chemicals – by ecosystems or particular organisms |
| Formation, protection and decontamination of soils and sediments | Sediment retention and erosion control<br>Filtration, fixation, degradation or storage of chemical and biological pollutants (pathogens, toxins, excess nutrients) in soils and sediments |
| Regulation of hazards and extreme events | Reduction of impacts caused by floods, wind, storms, heat waves, high noise levels |
| Regulation of organisms detrimental to humans | Regulation, by ecosystems or organisms, of pests, pathogens, predators, competitors, etc. that affect humans, plants and animals, including e.g.:<br>Regulation by predators or parasites of the population size of marine and terrestrial animals<br>Regulation (by impediment or facilitation) of the abundance or distribution of potentially harmful organisms (e.g. venomous, toxic, allergenic, predators, parasites, competitors, disease vectors and reservoirs) over the landscape or seascape<br>Removal of animal carcasses by scavengers |
| Energy | Wood chips, pellets, fuelwood etc. |
| Food and feed | Production of food or feed from fish, game, reindeer meat, berries, mushrooms; meat from domestic livestock, dairy products, etc. |
| Materials | Production of wood, fibres, paper from coastal trees, etc. |
| Learning and inspiration | Landscapes, ecosystems or organisms give opportunities for learning and development of knowledge and skills for well-being, and inspiration for art, crafts and design |

| Categories of nature's contributions to people | Brief explanation and some examples |
|---|---|
| Physical and psychological experiences | Landscapes, ecosystems or organisms give opportunities for physically and mentally beneficial activities, healing, relaxation, recreation, leisure, tourism and aesthetic enjoyment based on the close contact with nature. E.g. recreational fishing and hunting, birdwatching, hiking, being by the sea side |
| Supporting identities | Landscapes, seascapes, habitats or organisms being the basis for religious, spiritual, and social-cohesion experiences<br>Opportunities in nature for people to develop a sense of place, purpose, belonging, rootedness or connectedness, associated with different entities of the living world<br>Basis for narratives and myths, rituals and celebrations provided by landscapes, seascapes, habitats, or species<br>Source of satisfaction derived from knowing that a particular landscape, seascape, habitat or species exists |
| Maintenance of options | Capacity of ecosystems, habitats, species or genotypes to provide options to support a good quality of life for future generations.<br>Examples include:<br>Benefits (including those of future generations) associated with the continued existence of a wide variety of species, populations and genotypes<br>Future benefits (or threats) derived from maintaining biodiversity to provide options for yet unknown discoveries and unanticipated uses of particular organisms or ecosystems that already exist (e.g. new medicines or materials)<br>Future benefits (or threats) that may result from on-going biological evolution (e.g. adaptation to a warmer climate, to emergent diseases, development of resistance to antibiotics and other control agents by pathogens and weeds) |

# 3. Kvarken – The Quark

*Hannele Ilvessalo-Lax, Johnny Berglund, Hans-Göran Lax, and Tero Mustonen*

**Figure 15: The Bothnian Bay in the North and the Bothnian Sea in the South are separated by a shallow and relatively narrow strait called the Quark, which divides the Gulf of Bothnia into two distinguishable areas, the almost fresh water Bay of Bothnia and the notably more saline (although still only 0.5–0.6%) Bothnian Sea**



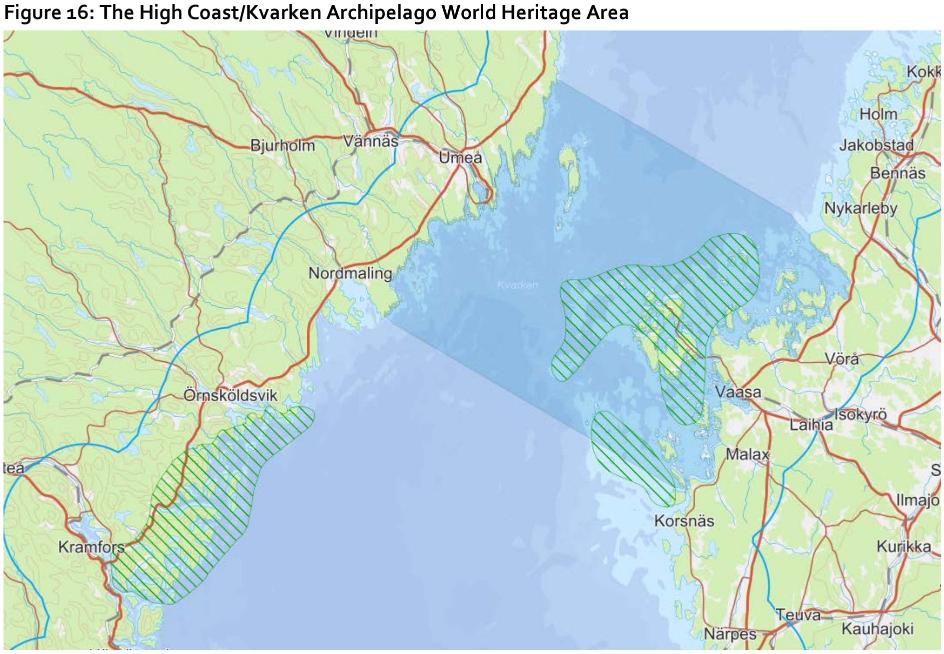

Source: EuSeaMap consortium 2012.

## 3.1 Setting the scene

Representing the Province: Temperate Northern Atlantic, Ecoregion: Baltic Sea (Spalding, *et al.*, 2007).

A part of the Quark area received UNESCO World Heritage status in 2006. Most of the information presented in this chapter is obtained from the process of establishing the High Coast/Kvarken Archipelago World Natural Heritage (UNEP WCMC; Hietikko-Hautala, 2012; www.kvarkenworldheritage.fi; High Coast/Kvarken Archipelago; Nostra Project, 2017).

**Figure 16: The High Coast/Kvarken Archipelago World Heritage Area**




The Quark area is situated in the middle of the Gulf of Bothnia, northern Baltic Sea. The 336,900 ha area forms a shallow underwater threshold that creates a transition zone between two sub-basins, the Bothnian Bay and the Bothnian Sea. The study area includes the common world heritage area: the *High Coast (HC)* in Sweden and the *Quark archipelago (QA)* in Finland. The distance from coast to coast is about 80 km, and only about 25 km between the outermost islands. The deepest spot in the narrowest part of Quark is about 25 m. A special feature of the area is that it can be partly or entirely covered by ice during winters. The wide outer archipelago areas experience pack ice, which has severe effects on the littoral substrate and underwater perennials.

*The High Coast* is the only hilly coastline in eastern Sweden, a region of steep-sided and flat-topped forested hills and cliffy coasts with particularly interesting geology and geomorphology. The area has been shaped by the combined processes of glaciation, glacial retreat and emergence of new land from the sea. The site affords outstanding opportunities for studying the processes that formed the glaciated and land uplift areas of the Earth's surface.

*The Quark Archipelago* forms a strait between the Bothnian Sea and Bay of Bothnia, with glacial moraines rising from the sea, creating 6,550 islands and islets. The land formations were mainly created by glacial action over a pre Cambrian peneplain during the last Ice Age. The major geomorphological feature is the unusual ridged washboard moraines, otherwise known as De Geer moraines, formed by the melting of the continental ice sheet. The archipelago is characterised by extensive moraine deposits and shallow brackish waters with a salinity gradient from 5.5 in southern parts to 4.4 psu in the north.

*The Quark area continuously rises from the sea in a process of rapid glacio-isostatic uplift. In this process* the land previously weighed down under the weight of a glacier, lifts at rates that are among the highest in the world creating a *dynamic landscape*, most obvious in flat and shallow areas where uplift is supplemented by sedimentation. The continously emerging shores are colonised by pioneer species, which are gradually replaced by a succession of plant communities as the land rises in various ways. The seashore habitats are thus very heterogenous and biodiverse, and represent several Natura 2000 coastal habitat types.

### 3.1.1 Habitants

*Swedish side (High Coast and Umeå)*: approximately 200,000 people live on the Swedish side, including the municipalities of Kramfors, Örnsköldsvik, Nordmaling and Umeå. Umeå is the largest city with around 125,000 inhabitants and Örnsköldsvik comes second with nearly 60,000. There are also a lot of small settlements and larger villages e.g. Docksta, Ullånger and Mjällom.

*Finnish side (Quark Archipelago)*: approximately 69,000 people live in the Finnish Quark archipelago. 2,500 people live in small settlements. The largest village communities in the core area are Björköby, Replot, Norra Vallgrund, Södra Vallgrund, Maxmo and Sundom (United Nations Environmental Programme). In the biggest city, Vaasa, there are about 66,400 habitants.

### 3.1.2 Visitors

*Swedish side (High Coast and Umeå)*: There are number tourist centres open during the summer, along with museums near Härnösand, Umeå, and Örnsköldsvik. Several hotels, cabins and camping grounds are also found in the area.

*Finnish side (Quark Archipelago)*: There are a number of hotels and motels close to the Vaasa, along with cabins and cottages by the beautiful nature and seaside. Sailors and visitors who rent summer cottages frequent the area. There are tourist centres, guided walks, lookout towers, hotels, cabins and camping grounds. Also the Museum Terranova is situated in the region.

### 3.1.3 Main sources of income

Fishing, agriculture, and industry (paper industry, chemical industry, energy production and energy solutions) are the main occupations, with growing employment in tourism following the region's allocation to the UNESCOs World Heritage list. Tourism is one of the fastest growing sectors in the region. In 2013, a rough estimation indicated that the tourism sector alone contributes at least EUR 189 million to the regional economy. These parts of Sweden and Finland host several large international companies, which is reflected by high growth rates. The regions of Umeå and Vaasa are among the most dynamic and fastest growing regions in their respective countries. Both the Finnish and Swedish parts of the Bothnian region account for a significant amount of the GDP in both countries.

Traditional industries are still present in the region. However, fishing has diminished, hunting has become more of a hobby and seal hunting has declined with the reduced number of seals during the 20th century.

### 3.1.4 History

*The Swedish High Coast*: 4,000 year old dwellings indicate that humans have been livigin in the area since the late Stone Age. An important iron age village, Gene fornby, which lies near the northern boundary of the region has been restored, and there are onco-coastal grave mounds dating from about 3,500–2,500 years ago. More recent remains of fishing camps with log cabins date back to the 16th century.

*The Quark Archipelago*: Settlements of the Quark islands are traced back to 1800–1600 BC, presumably consisting mainly of fishermen and seal hunters. Permanent fishing villages were established in the 14th century, but some islands were uninhabited till the 19th century.

## 3.2 Key Ecosystem Services in the Quark

### 3.2.1 Provisioning services

- Food provision (wild capture sea food, farmed sea food, shellfish). Commercial fishing is concentrated on Baltic herring (*Clupea harengus*), perch (*Perca fluviatilis*), white fish (*Coregonus lavaretus*) and salmon (*Salmo salar*). Pike (*Esox lucius*), perch, salmon and trout (*Salmo trutta*) are important species for recreational fishing. Shallow estuaries, bays and reefs are some of the key spawning habitats that support fish populations for fishery.
- Biotic raw-materials/non-food, genetic resources, medical and ornamental resources. The most important of these in the Quark is fodder fish, e.g. for farmed fish, and genetic resources of all organisms. This also includes the development of sustainable fish products.

- Energy including bioenergy from algae and seaweeds. There is growing interest for bioenergy, which also promotes blue growth. *Blue growth:* integrated maritime spatial planning for sustainable blue economy, to support sustainable growth in maritime sectors as whole in the Quark (e.g. aqua culture, fishery, energy production recreation and tourism (especially due to the UNESCO world heritage status), etc. An ongoing EU Interregional project called TransAlgae evaluates the possibilities of using microalgae for a fossil free future. The Vasa Energylab has also just been established to develop new methods for the production of bioenergy.

### 3.2.2 Regulating and supporting services

- Mediation of waste and toxins by biota and ecosystems involves the ability to remove or store pollutants, e.g. through bioremediation by organisms, filtration of harmful substances and storage and accumulation of them. Estuaries, large shallow bays and archipelago areas work as a filter for nutrients and organic pollutants.
- Mediation of flow, such as mass stabilisation and control of erosion rates, flood and storm protection etc. One example of this is the use of underwater vegetation in shallow bays to stabilise sediments.
- Maintenance of physical, chemical and biological conditions including primary production, lifecycles, habitat, gene pools, pest and disease control, decomposition and fixation processes, chemical condition of water, climate and atmosphere regulation (reduction on greenhouse gas concentration), disturbance prevention or moderation, such as prevention of eutrophication. Key Quark habitats, including estuaries, coastal lagoons and sheltered bays, store carbon and nutrients in biomass and sediments, and act as a filter runoff from land. These habitats are also important for migratory species and as nursery grounds for fish.

### 3.2.3 Cultural services

- *Physical and intellectual interaction with biota, ecosystems and the landscape*: The Quark provides cultural services in leisure, recreation and tourism. There is an increasing interest for tourism since the region received its UNESCO World Heritage status. There is a large interest in summer cottages, boating, swimming and diving. When it comes to services related to aesthetic interactions, it is worth mentioning services for overall wellbeing, for instance the experience of silence, beauty and relaxation. Educational services are of particular importance. People can learn much about geomorphological and ecological processes by visiting and expiring the Quark region. This is one of the reasons for appointing the area as a UNESCO World Heritage site.
- *Spiritual, symbolic and other interactions with biota, ecosystems and landscape*: The Quark has a strong and diverse cultural heritage and has provided a lot of

inspiration for the arts. Traditional fishing villages with small harbours and fishing cottages (*fiskarbastur*) on the islands form functioning landscape elements in some parts of the archipelago. In some villages are subjects connected with the traditional way of living collected in museums. Yearly happenings like fish markets and rowing/ sailing events with old boat types are arranged in many parts of the archipelago. One of the most spectacular is the postrace (postrodden) between Björkö and Holmön. The beautiful landscapes (hilly at the Swedish site, flat at the Finnish site) have provided inspiration for painting and songs. Inspiration for arts such as souvenirs made of fish skin (such as purses and key chains), post cards, de Geer jewellery, handicraft, world heritage soap etc.

The ecosystem services mentioned above are based on the Swedish–Finnish SeaGIS 2.0 Interreg-project analysis and identification of habitats and their ecosystem services. The project aims to map the different habitats and ecosystem components producing different services in the region. The main threats to the habitats are also mapped. More about the project can be found in box 5 and in the project web-page: www.seagis.org.

**Box 5: Infobox: SeaGIS 2.0 Botnia Atlantica – Interreg project is developing GIS-mapping tools for an ecosystem approach to sustainable marine policy**

The Interreg project SeaGIS 2.0 is financed by the Botnia Atlantica EU –program (https://www.botnia-atlantica.eu/). The time period for the project is 2015–2018. (www.seagis.org).

The project manager is Johnny Berglund (the County Administrative Board of Västerbotten/ Sweden) and the partners are: The County of Västernorrland (Sweden), The Center for Economic Development, Traffic and the Environment for South Ostrobothnia (Finland), The County of Ostrobothnia (Finland), The County of Central Ostrobothnia (Finland), Umeå Universitet (Sweden), Åbo Akademi (Finland), Metsähallitus/State Forest Enterprise (Finland).

Key goals for the project SeaGIS2 are:

- cross-border cooperation between Finland and Sweden to promote sustainable development in the Bothnian Bay, and to find solutions and tools for integrated sustainable planning for marine and coastal regions. Developing a map service is one of the key elements in this;
- to implement an ecosystem approach in the development of sustainable planning tools. Tools will be used to analyse the status of biodiversity and nature protection, along with the status of ecosystem components, function and services promoting regional wellbeing. Furthermore, the tools will be used to analyse the condition of ecosystems and their services by defining drivers of change and their impacts;
- to promote sustainable blue growth in the region in cooperation with other regional actors, as well as fishermen and other local citizens.

See also appendix, fig. 30, p. 98.

## 3.3 Importance of ecosystem services for security, health and quality of life in the Quark

The analyses below are based on expert evaluations performed as part of the SeaGIS 2.0 Interreg-project in the region. Background information has been collected from the baseline study performed as part of the NOSTRA project (Nostra Project, 2014).

### *3.3.1 Provisioning services*

Important provisioning services include:

- food production (white fish, salmon, Baltic herring etc.);
- economic security. For example, both commercial and recreational fishing are dependent on a high diversity of fish species, which requires ecosystems and habitats to be in good condition;
- energy security. The aim for the future is to produce more renewable energy. This requires the development of new forms of energy production, such as from algal biomass or wind power. Renewable energy is an important component in promoting sustainable blue growth;
- safe and nutrient rich food, such as fish, is important for the health of people in the region. There are a lot of traditional ways to prepare fish dishes;
- fish and fish products, as well as other "blue products" (supporting blue growth) are of high importance for livelihoods in the region, which in turn supports a high quality of life;
- livelihoods (e.g. fishery and tourism) play a key role in people's quality of life. Livelihoods depend on healthy and well-functioning ecosystem services. A new possibility of income is "Blue care" related activities (health care services/nature's benefits in physical and mental health);
- happiness and wellbeing of people relate to nature's benefits. Quality of life in the Quark has for long periods been dependent on coastal and marine ecosystems and their benefits. See more on this in section 3.6 *Indigenous and Local Knowledge of the Quark* (page 88ff).

**Box 6: Blue care promoting sustainable blue growth in the quark region**

Blue Care initiative in the Quark area promotes wellbeing by professional, target-oriented and responsible activities in water environments combined to social-, health-, education- and recreation services. The expertise is required by the service type and the Blue Care operating method and each service must include a safety plan that covers all safety issues pertaining to activities. Examples of Blue Care activities are fishing excursions for disabled people and canoeing trips in archipelago for people discovering from mental disorders. Blue Care activities promote blue growth and overall sustainable growth and wellbeing in the Quark region.

**Figure 17: Canoeing trip in the Quark**


Photo: Martta Ylilauri.

*Regulating services* are important for livelihoods and for the overall wellbeing of people and societies. These services form the very basis of living conditions in the region:

- regulating services are important for many livelihoods, such as fishery, tourism etc. Tourism is one of the fastest growing industries in the region. For continued success, it requires ecosystems to be in good condition;
- the pure and safe water with good bio-chemical quality is essential for all living conditions;
- filtering of run-off from land reduces impacts from harmful loads from agriculture, forestry, scattered settlements, industry etc.;
- storage of carbon and nutrients in biomass and sediments are essential regulating services and contribute to climate change mitigation;
- regulating services are important for recreational activities and to enjoy the time by the seaside (such services in good condition, keep the environment sound for seaside-related and coastal activities). Recreation and enjoying the landscape in several ways is good for mental and physical health;
- resilience, purification, accumulation, nutrient/hydrological cycling etc. all are essential elements for the quality of life in the Quark region. The coastline is important for many different activities, such as recreation, living by the sea, livelihoods, and tourism. All these activities require ecosystems to be in good condition.

*Cultural ecosystem services* refer to spiritual and inspirational wellbeing and are important for the mental and physical health of societies. The shallow wave-sheltered bays typical for the Quark area are important for recreational fishing, boating, swimming etc.

- Aesthetic, educational, inspirational, spiritual and religious services play a key role for many livelihoods in the Quark.
- There are mental and physiological health benefits from these services. There is interest in the region to put efforts in to developing new psychosocial and overall health promoting services. *Blue Care* brings together entrepreneurs, researches, developers, public authorities and other actors in the Quark for wellbeing for both man and nature. It uses the qualities of the tremendous and genuine nature in the Quark to promote wellbeing of people. The purpose of Blue Care is also to increase the understanding of waters and ecosystems in the Quark area.
- As example of Blue Care can be mentioned fishing excursions for disabled people and for people discovering from mental disorders. Nature based wellness tourism is one example of Blue Care.
- Sense of place and knowledge systems for local citizens.

## 3.4 Biodiversity and Ecosystem Characteristics in the Quark

The vast areas of shallow water that characterise the Quark region allow a rich flora of underwater vegetation to thrive. The vegetation offers excellent habitats for birds and fish important migratory route for birds. Mild climate allows many southern species of animals and plants to come to their northern limit of distribution here.

The eastern Finnish coast of the Quark is flat with small rivers, enclosed bays and shallow waters, which make the area susceptible to local eutrophication. The western part of the Quark, i.e. Swedish coast, is more open and steep with large and mainly oligotrophic rivers. Rivers from Finland and Sweden contribute equal amounts of water to the Quark, but the amount of organic material in the Finnish rivers is much greater compared to Swedish levels of organic matter.

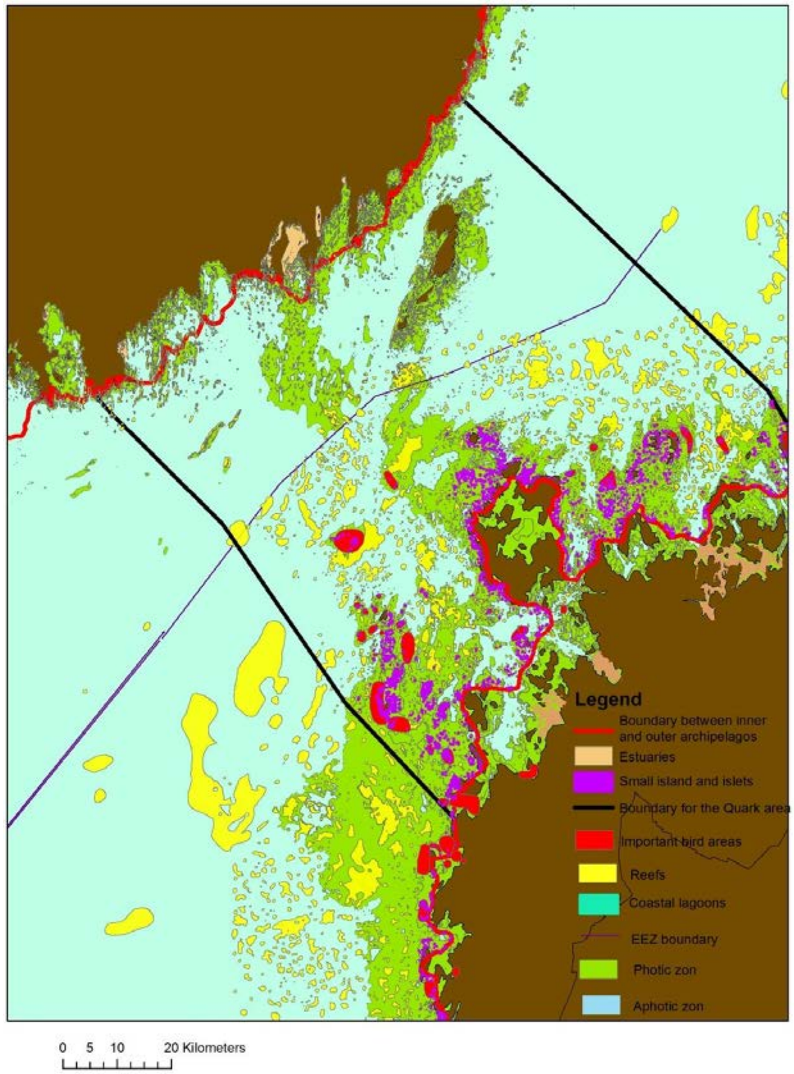
The basins in the Quark region show differences in freshwater run-off, load of allochtonous dissolved organic carbon, hydrography and food web structure. This results in differences in the cycling of nutrients and pollutants, which in turn affects system resilience and sensitivity to human-induced disturbance. The Finnish coast is shallow and its water exchange is thus less effective than that of the Swedish coast with deeper waters closer to the shore.

The 8 mm/year land-uplift, big boulders and large shallow coastal areas with moraine on land and at sea are special characteristics of the Quark. The continual elevation of the land results in water areas being progressively cut off from the sea, shorelines being reshaped and new islands being born. The salinity ranges from about 5.5 psu in the southern parts, to 3.5 psu in the northern parts and almost fresh water conditions in the innermost parts of the archipelago. This provides a mix of brackish and freshwater habitats, allowing species of marine and freshwater to coexist in the same area (UNEP WCMC). Huge shallow areas with variation in salinity and bottom structure results in a high biodiversity (Nordic Council of Ministers, 2017). This wide photic zone with both macro- and microalgae results in these habitats being some of the most productive in the Northern Baltic Sea (fig. 18).

### *3.4.1 Status of waters in the Quark*

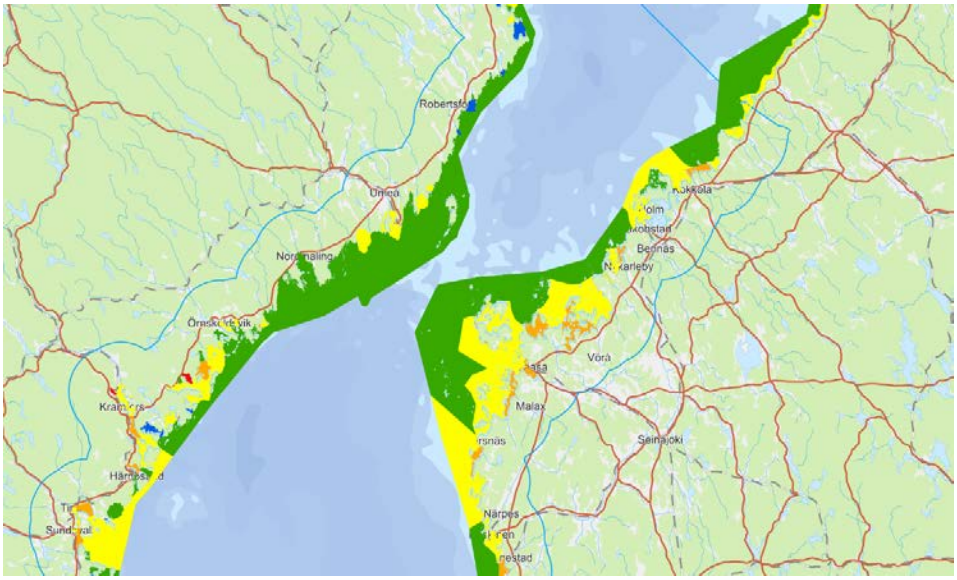
The ecological status of the coast is evaluated using criteria from EU Water Framework Directive (WFD). Large areas on the Finnish side are classified as having moderate status (fig. 19). Rivers with poor water quality have a strong impact on the shallow coastal waters due to limited water exchange with more open waters. The ecological status on the Swedish side is better because the coast is more open and the rivers and creeks contain water of better quality. On the Finnish side the rivers pass through agricultural land and relase more nutritients into the sea. Because of the impacts from the rivers the capacity of the shallow lagoons, bays and inlets to improve water quality by capturing and filtering sediments and organic wastes is exceeded.

**Figure 18: Important habitats of the Quark area**




Note: One typical feature for the Quark is the wide photic zone, another is the particularly large number of reefs. Estuaries function as important habitats especially for fish production. Red areas on this map refer to sites that are ecologically valuable for marine bird species (migratory and nesting).

**Figure 19: The ecological status of waters in the Quark area**




Note: Classification of the ecological status according to (WFD) in the coastal waters of the Quark. The colours illustrate classes as follows blue high status, green good, yellow moderate, brown poor and red bad status. The classification is for the period of 2017.

### *3.4.2 Characteristic habitats*

Characteristic habitats in the area are coastal lagoon (EU habitat code 1150), reefs (EU habitat code 1170), boreal Baltic islets and islands (EU habitats code 1620) in the outer archipelago and open sea zones. In the inner archipelago bays (fjärdar) are often connected with outer sea areas through narrow shallow inlets and straits. Estuaries (EU habitats code 1130) of different size are also typical for the area. The natural forests of primary succession stages of land upheaval coast (EU habitat code 9030) are typical for the terrestrial part of the coast (UNEP WCMC; Gundersen *et al*., 2017).

### *3.4.3 Key habitats*

The coastal lagoons in the region occur at different stages of becoming detached from the sea – in Swedish these stages are referred to as *flada/flad*, *glo*, *sjö*, *mosse*, which can be translated to flads, gloe lakes, lakes and bogs. Flads and gloes are sheltered habitats not exposed to waves. Typical for the flads and gloes is that the water temperature rises faster than in the surrounding sea in spring. These coastal lagoons are important habitats for water vegetation, especially for *Charophytes* and for many spring-spawning fish species (Gundersen *et al*., 2017). Another important habitat in shallow and sheltered areas is *Potamogeton* and *Myriophyllum* meadows.

The reefs in the area are of mineral origin and often consist of moraine with big boulders. Sometimes the reef consists of only a few very big boulders. The reefs are very important for the macro-algal vegetation, especially in the southern parts where many marine algae have their northern boundary. These habitats are one of the few habitats where the brown algae *Fucus radicans* occurs in the Baltic Sea.

**Figure 20: An example of a big solitary boulder with macrophyte species and macrofauna typical for reefs**

The boreal Baltic islets and islands in the outer archipelago and open sea zones are important structural elements of the archipelago. The biotope complex is made up of groups of small skerries and islets that generally consist of bedrock or moraine. This habitat is important for many of the water birds breeding in the area and is a resting site for seals. Due to the land rising the habitat allows for studies of plant succession by dating the age of the island (UNEP WCMC).

The natural primary succession forest is a habitat that includes pioneer deciduous, coniferous and mixed natural thickets. These forests, which include various succession stages, develop on the land upheaval coast in the area – on land that is recovering from the weight of ice during the last ice age. Close to the coast, the forests are usually composed of alder and birch. Climax forests are dominated by conifers, such as Norway spruce *(Picea abies*) (Murtomäki, 2017). The vegetation shifts in successional stages, from shore meadows for example species like spikerush (*Eleocharis* spp.) and silverweed (*Potentilla anserina*) through herb-rich scrub with sea buckthorn (*Hippohaë rhamnoides)* and a continuous belt of grey alder (*Alnus incana)* through rowan (*Sorbus aucuparia)*, aspen (*Populus tremula)* and birch species.

Estuaries are also important habitats in the Quark. Estuaries are fed by several large rivers with wide river mouths, such as the Kyrö and Umeå River, and by many smaller rivers. Estuaries are ecologically important habitats for many species, e.g. for migratory fish species such as salmon, trout and white fish, breeding birds, and the clam *Anadonta anatine* due to the low salinity. They are also typical for the inner archipelago and often rich in vegetation such as reeds, sedges and water lilies (*Nuphar lutea* and *Nymphaea alba*). As the isolated shallow bays warm early in spring they constitute important habitats for many fish species (spawning and nursery areas) (Gundersen *et al*., 2017).

### *3.4.4 Key species*

The selected key species include common, rare and threatened species. They are of particular importance for lifecycles in the Quark ecosystems.

#### Vegetation

Herb-rich scrubs are found along the coastline, with the common sea buckthorn (*Hippohaë rhamnoides*), endemic hairgrass (*Deschampsia bottnica*) and stonewort (*Chara tomentosa*) as some of the key species in the flads. In southern parts of the Quark, the macroalgae *Fucus radicans* grows along the coastline and reefs in the outer archipelago.

Meadows of pondweed (*Potamogeton* spp.) and watermilfoil (*Myriophyllum spicatum* and/or *Myriophyllum sibiricum*) typically occur in this region (UNEP WCMC).

#### Birds

The Quark archipelago is an important migratory route, but also offers excellent breeding habitats for birds. There are important Baltic populations of black guillemot (*Cepphus grylle*) (a quarter of the Baltic population) and razorbills (*Alca torda*). Common eider (*Somateria mollissima*) has its northernmost breeding area in the Baltic Sea in the Quark. The vast majority of Finland's endangered greater scaup (*Aythya marila)* population nests in the outer archipelago. The velvet scoter (*Melanitta fusca*) was quite common earlier, but the population has declined in recent years. The white-tailed eagle is a common predator in the Quark archipelago. The bird species causing the most mixed feelings among local citizens and fishermen is the cormorant (*Phalacrocorax carbo*), which is spreading close to summer cottage areas.

During the spring migration, thousands of rough-legged buzzards (*Buteo lagopus*) and common cranes (*Grus grus)* migrate through the Kvarken area. Other migrating species that frequent the area include the black-throated diver (*Gavia arctica)* and for the common scoter (*Melanitta nigra)* (UNEP WCMC).

The outer islands are also a key habitat and nesting area for the Arctic tern (*Sterna paradisaea*), presumabely because these areas resemble more northern Arctic nesting areas for the bird.

#### Mammals

Typical for the region are grey seal (*Halichoerus grypus*) and ringed seal *(Phoca hispida),* which occur on islets mostly in the outer archipelago areas. The ringed seal population was estimated for the whole Bothnian bay (both Finnish and Swedish sea areas) to about 3,000 individuals in the beginning of the 1990s and had increased to around 7,400 individuals in 2016. The grey seals in the Baltic Sea belong to the same management unit and they forage across the entire Baltic Sea. However, their abundance varies between sub-basins; in 2015 about 22,000 grey seals were counted in the Gulf of Bothnia, Åland and Archipelago Seas (Helcom Holas), which is much more than the all time low in the 1970s when the entire Baltic population was around 3–4,000 individuals. The otter (*Lutra lutra*) has returned to the archipelago in recent years. The American mink (*Neovison vison*) and raccoon dog (*Nyctereutes procyonoides*) are now quite common on the Finnish side of the Quark, predating on many species naturally living in the region. American mink is a common predator on seabirds on the Swedish side.

### Fish

The Baltic herring *(Clupea harengus)* is one of the typical fish species in the cold waters of the outer archipelago. In the warmer river mouths and waters of the inner archipelago, pike (*Esox lucius*), perch (*Perca fluviatilis*), roach (*Rutilus rutilus*) and bream *(Abramis brama*) dominate. The perch is important catch for fishermen. Different subspecies of whitefish (*Coregonus)* (migrating, sea-spawning and small populations of white fish spawning in river mouths) are common in the area. The whitefish has suffered from reduced natural breeding as a result of poor water status in rivers and embankments of rivers (UNEP WCMC).

Populations of the sea-spawning grayling (*Thymallus thymallus)* have decreased during the last twenty years in Sweden and even longer in Finland (Jensen & Alanärä, 2006).

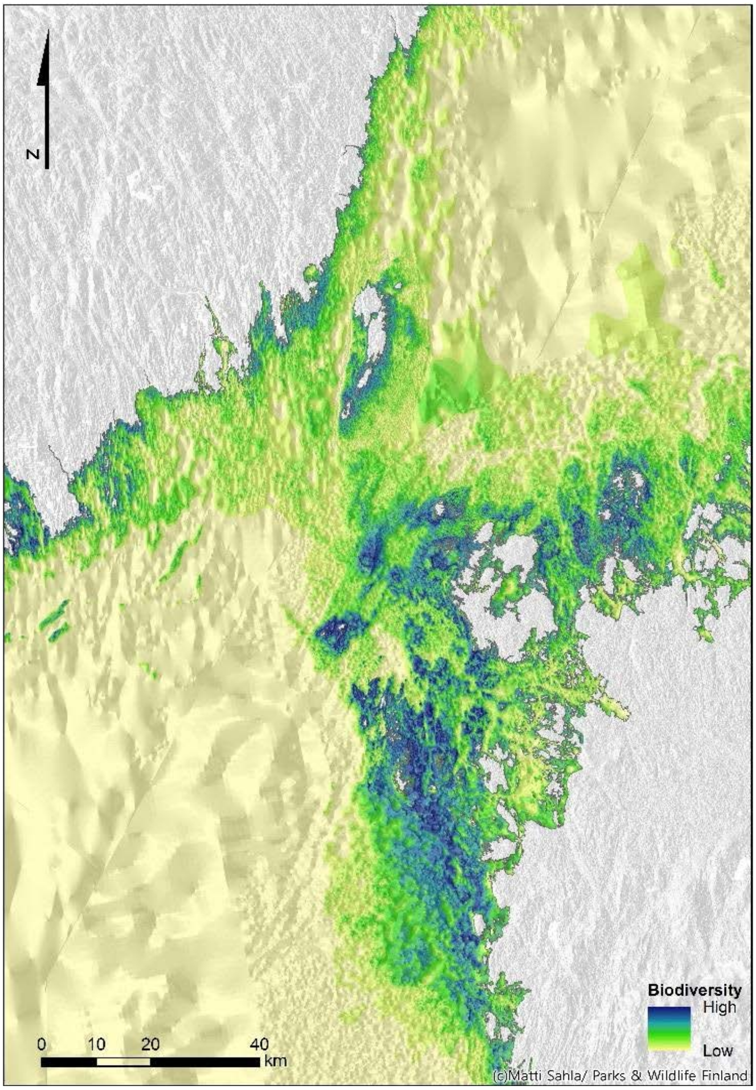
### Benthic fauna

The Quark is the northern limit of many marine species including *Mytilus edulis, Cerastoderma glaucum* and *Idothea*. The invasive alien polychaete *Marenzelleria* has become an important faunistic element on the soft bottoms. The effects of the polychaete on the native soft bottom fauna in the Quark is not yet known.

## 3.5 Biodiversity status of the Quark

The benthic diversity map (fig. 21) shows the areas with highest potential to have multiple biotopes and with many species. The draft model is based on 25 individual HUB (HELCOM Underwater Biotopes) biotope models of benthic plant and animal distributions. The biotope models are based on field inventory data and environmental variable data such as salinity, light availability and bottom exposure. The benthic biodiversity map has been calculated by summing up the individual occurrence probability models.

Figure 21: Benthic biodiversity map (SeaGis 2.0. M. Sahla)




Source: Matti Sahla, Parks & Wildlife Finland.

## 3.6 Direct and Indirect Drivers in the Quark

Many species reach their physiological tolerance limit of distribution at the Quark, which makes the area very sensitive to drivers of change.

### *3.6.1 Anthropogenic direct drivers – eutrophication, acidification and others*

This analysis is partly based on literature and partly on expert work included in the SeaGIS-project, which is due to be completed at the end of 2018. The project aims to analyse which direct drivers the ecosystem components are sensitive to, thus clarifying which are most critical for the region. An analysis of the effects these drivers have on coastal ecosystems, as well as on nature's benefits to people and quality of life, is presented in Table 3.

Nutrient and humus loads (Nostra Project 2014; Ecosystem Health of the Baltic Sea 2003–2007; Gundersen *et al*., 2017; Kronholm, Albertsson & Laine, 2005):

- the loads originate from agriculture, forestry and scattered settlements. Industry and population centres also play a significant role;
- the rivers with the highest nutrient content are situated at the Finnish site, Ostrobothnia. The rivers emptying in to the sea from the Swedish site have their headwater in the mountains, making them less nutritious (Kronholm, Albertsson & Laine, 2005).

Acidification and metal loading (Ecosystem Health of the Baltic Sea 2003–2007; Finnish Ministry of Agriculture and Forestry 2011; Kronholm, Albertsson & Laine, 2005):

- acid sulphate soils are common for the Ostrobothnia-region (West Finland around Quark archipelago). The drainage of land for agricultural use, forestry and other activities, is a central factor in creating the acidification and metal loading problem resulting in declined ecological and chemical status of coastal ecosystems;
- the acid waters also contain high concentrations of metals such as aluminium, nickel and cadmium released from the sulphate soils;
- mapping of acid soils can help to close knowledge gaps;
- according to the national strategy for mitigating the adverse effect of acid sulphid soils in Finland, the aim is to develop means for controlling soil acidity, sustainable land use and drainage solutions.

Habitat degradation (HELCOM, 2010; Kronholm, Albertsson & Laine, 2005):

- degradation occurs due to extraction of sand and gravel, which causes damage to the underwater habitat (HUB) structure. Dredging activities have additional impacts on the habitat;
- flood regulation causes hydro-morphological changes and results in the degradation of habitats;
- coastal wetlands have been ditched and drained, with deleterious effects on nutrient cycles and coastal habitats;
- the exploitation of the coast for housing, tourism and other activities causes further degradation.

Pollution from hazardous substances (Nostra Project 2014; HELCOM 2010; Kronholm, Albertsson, & Laine, 2005):

- hazardous substances from industry and settlements are among the biggest threats affecting living organisms and bottom sediments. Heavy metal loading in the 1980s and 1990s has since decreased and is visible in benthic fauna samples;
- baltic herring has the highest level of dioxin compared to other parts of the Baltic Sea. (Dioxin is a side product from paper and pulp industry);
- more and more pollution is also caused by polycyclic aromatic hydrocarons (PAH) loadings from motor boats.

Invasive species (accidental and intentional introductions) (Nostra Project 2014; HELCOM 2010; Kronholm, Albertsson, & Laine 2005):

- invasive species have spread to the region with the ballast water of ocean-going ships: E.g. North American polychaete *Marenzelleria viridis*, sea walnut (*Mnemiopsis leidyi*) and the Arctic comb jelly *(Mertensia ovum)*;
- mink (*Neovison vison*) and muskrats (*Ondatra sibethicus*) are causing problems for the ecological balance in coastal ecosystems.

Climate change (HELCOM, 2010):

- a global phenomenon causing more and more problems even in the Quark ecosystems and their services.

The impacts of direct anthropogenic drivers on nature and its benefits to people, as well as status and trends of these in the future are described in table 3. These impact evaluations are based on expert evaluations, which have been conducted as part of the SeaGis. 2,0 – Interreg-project.

**Table 3: Some examples of anthropogenic pressures on the marine environment in the Quark area and their effect on the environment and benefits to people**

| Anthropogenic pressures | Effect on nature | Effect on nature's benefits to people | Links to good quality of life | Status and trends |
|---|---|---|---|---|
| Input of nutrients and organic matter | More frequent algae blooms | Recreational use of coastal waters less attractive | Reduced possibilities to swim, dive. Effects on health by toxic algaes | Slightly increasing |
| | Increased growth of aquatic plants and reed | Make fishing and boating more difficult. Effects on tourism | Reduced potential for recreational use | Slightly increasing |
| | Reduced secchi depth. Reduced habitat areas for macroalgae | Emotional response | Aesthetic effects | Slightly increasing |
| | Occurrence of anoxic bottoms especially in shallow enclosed bays and coastal lagoons during winter. Negative effects on benthic species and fish | Effects on the supply of fish species. Restricts the use of the water during winter | Reduced potential for recreational use. Negative effects on fishing | Unknown |
| Physical disturbance and loss | Loss of species diversity and habitat specially in shallow waters , loss of nursery habitats for fish and birds | Fish catches of commercial and recreational fishing affected negatively | Decreasing possibilities to fish on whitefish Fragmentation of the coastal landscape | Increasing |
| Input of hazardous substances from different sources | Affects health and recruitment in fish and bird populations | The use of some fish species like salmon and Baltic herring as human food is restricted | Reduced supply of a healthy food resource | No clear trend. Some substances decrease, other increase. |
| Input or spread of non-indigenous species | Disturbed balance in coastal ecosystems. Most known are the impact of mink and raccoon dog on bird populations | Partly unpredictable consequences. Reduced possibilities for observing and enjoying water birds. | Reduced potential for recreational use | Increasing |
| Climate change | Decreasing populations of marine species. Decreasing duration of ice cover. Increased land-runoff | The traditional use of ice-cover for transports to island during winter becomes restricted | Living conditions by the coast and in the archipelago are negatively affected | Unknown |

Note: Pressures according to Annex the Commission Directive amending Directive 2008/56/EC of the European Parliament and of the Council as regards the indicative lists of elements to be taken into account for the preparation of marine strategies. The effects of climate change are added.

### *3.6.2 Indirect drivers – urbanization and others*

The most essential indirect drivers for the Quark region are presented below. Many of them are common for both the Finnish and Swedish site, but some are not. The key indirect driver is urbanization: people are moving away from scattered settlements in the countryside towards growth centres (Vaasa region in Finland and Umeå region in Sweden). These indirect drivers have been analysed as part of the Nostra Project (Baseline study – Kvarken Strait) (Nostra Project, 2014). They have also been identified as part of implementing the EUs Water framework and Marine Strategy Framework Directives in Sweden and Finland. Identifying indirect drivers is also of key importance for the SeaGIS 2.0 project.

Urbanization:

- the growing trend of increasing distances between home and work;
- the amount of summer cottages along the coastline is heavily increasing;
- restructuring the seabed for pleasure boating and deepening of shore water outside summer cottages;
- as urbanization proceeds the traditional cultural landscapes get poorer and more scarce.

Economic development:

- the Quark is a strategically important area for maritime transport;
- the region is dominated by social services and manufacturing sectors, which contribute to the majority of employment. A very small portion of the population is employed in the agriculture and fishery sector.

Technological development:

- more intensive use of bioenergy and blue bioeconomy solutions;
- innovations to mitigate climate change are growing rapidly, including wind power, solar power, new technology solutions etc.

Demographic changes:

- as the population is growing the more pressure is put on building and improving the infrastructure (traffic routes, harbors etc.). The increasing population also is a driver for more and more summer cottages and leisure time fishing and boating.

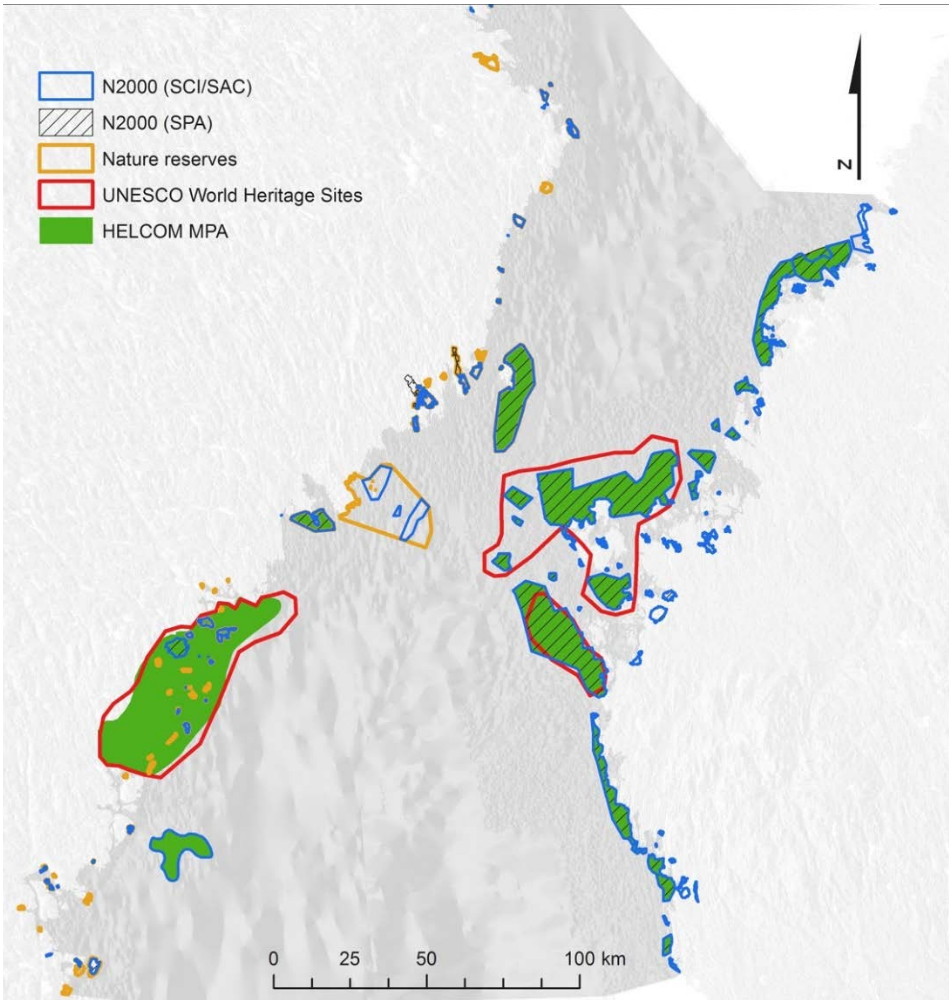
Increasing numbers of visitors to this UNESCO World Heritage region:

- as there is an increasing interest in visiting the Quark, which is promoting economic development, pressures on nature are expected to increase in the future.

Policies:

- the Habitat and Birds directives are widely implemented and reflected in the number of Natura 2000 protected areas;
- convention of the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention);
- cross-border initiatives and actions, and integrated management of biodiversity and natural environment: Many project have been and are being developed under the HELCOM convention and within the framework of regional development plans in the EU, such as European Grouping of Territorial Cooperation (EGTC) and EU INTERREG program, and the Kvarken Council (between Sweden and Finland).

**Figure 22: Map over protected areas in the Quark area, developed from SeaGIS 2.0**




The SeaGIS project (Interreg) deals with cooperation for ecosystem based planning of the marine environment using GIS. The overarching aim of SeaGIS is to produce an increased knowledge base and make it more accessible in order to increase knowledge base and make it more accessible in order to increase the possibilities of a coordination of ecosystem-based regional holistic planning of marine areas and create a common platform for knowledge storing, planning and future decision making in the Quark region. After the first phase of SeaGIS one has started to implement the second phase, SeaGIS 2.0 for which the activities are: Ecosystem services, Map data and participation, Establishing of the map service, Regional targets and blue growth, Cooperation for a better environment, Oil protection collaboration. (Please, find more information about the SeaGIS 2.0 in box 5 and fig. 30 on p. 98).

Activities: (Nostra Project, 2014; Finnish Ministry of Agriculture and Forestry, 2011):

- *physical restructuring of coastline for water management*: Land claim, canalization (e.g. coastal dams), coastal defence and flood protection, restructuring of seabed morphology (dredging);
- *extraction of non-living resources* (sand and gravel, water): The most significant potential damage comes from the direct removal of substrate and the associated fauna and flora that make their home there. Alteration of the seabed and increased turbidity can lead to short and long term changes in the composition and abundance of species in both benthic and fish communities. All this might have negative impact on bird and fish populations;
- *cultivation of living resources*: Marine aquaculture for instance;
- *production of energy*: Renewable energy production (e.g. rivers harnessed for hydro power) that obstructs fish migration and affect their populations. They also change the water temperature and the river's flow regime, which often harm native plants and animals in the river and on land;
- *extraction of living resources*: Fish and shellfish harvesting, commercial, artisanal and recreational fishing, hunting game and seabirds, marine plant harvesting;
- *transport*: The goods transported by shipping in expected to increase;
- *tourism and leisure*: Infrastructure for tourism and leisure (harbours, bridges), activities (passenger shipping);
- *urban and industrial uses*: Urban land use (e.g. seashore for living, industrial activity by seaside), waste treatment and disposal.

## 3.7 Governance of ecosystem services and influencing policies – national directives implemented regionally in the Quark

The challenge of maintaining vital ecosystem functions in marine areas such as these, has resulted in the development of several policies and legislations.

EU directives and strategies:

- EU MSFD 2008/56/EY. The goal is to reach good state of waters by 2020. Sustainable use of the marine resources is highlighted;
- EU WFD; Directive 2000/60/EC. The goal is to reach good ecological status by the year 2021;
- EU MSP 2014/89/EU. Since 2014 maritime spatial planning has been governed through the adoption of the Maritime Spatial Planning Directive, which recently have been implemented in Sweden and Finland. The ecosystem approach is highlighted;

- the habitats directive 92/43/EEC. The aim is to protect approximately 220 habitats and about 1000 species listed in the annexes. There are species and habitats that are considered to be of particular European interest. The directive asks Member States to take measures to maintain the conservation status of protected habitats and species;
- birds directive 2009/147/EEC. The aim is to protect all wild European birds and the habitats of species on the red list;
- EU BD strategy. Target 2: By 2020 ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems. Calls for the implementation of a mapping and assessment of the state and value of marine ecosystem services (MAES);
- CAP/EU (Common Agricultural Policy). Common European targets taking environmental protection in consideration;
- ICZM/EU (Integrated Coastal Zone Management). Defines the principles of sound coastal planning and management. (Integrated planning is highlighted);
- NCM: the Environmental program 2013 – 2018: Ecosystem services as an important field for conservation initiatives.

National legislation:

- *Sweden*:
  - Chapter 8 of the Swedish Environmental Code (SFS 1998:808) and the Species Protection Ordinance (SFS 2007:845), Nationally protected Nature Reserves are established by Chapter 7 of the Swedish Environmental Code (SFS 1998:808).
- *Finland*:
  - Water act (587/2011), Environmental Protection Decree (169/2000), Havsskyddslag (1415/1994), Nature Conservation Act (1096/1996), Land Use and Building Act (132/1999);
  - Finland/MSFD: Finland's national strategy covers Finland's territorial waters and the exclusive economic zone. The Ministry of the Environment in Finland has prepared the strategy in cooperation with other ministries. The Centres for Economic Development, Transport and the Environment (ELY-Centres) are responsible for drafting these strategies in their own regions.

Local and regional planning:

- the County Administrative Boards in Sweden implement national goals on nature protection. They also devise specific action plans for endangered species (ÅGP) when nature reserves and agri-environmental payment schemes are not sufficient. The Swedish Environmental Protection Agency is responsible for national coordination of the action plans for terrestrial species and birds, while the

Swedish Agency for Marine and Water Management, SwAM, coordinate action plans for marine and freshwater species. The Swedish Species Information Centre analyses which species are most in need of action plans for their conservation. SwAM is responsible for marine spatial planning in Sweden;
- the Regional Council of Ostrobothnia and other regional actors in Finland provide support for environmental initiatives. They are responsible for ensuring that environmental issues are taken in to consideration in land use planning. Regional Councils in Finland are responsible for marine spatial planning (according to the EU MSP directive) in cooperation with several other councils and regional actors.

Influencing policies:

- an ecosystem-based approach requires comprehensive integrated management of human activities, based on the best available scientific knowledge on ecosystems and their dynamics (HELCOM and OSPAR, 2003). The ecosystem approach is being used in the Quark area within nature conservation, sea planning and monitoring.

Intergovernmental Governance (Finland, Sweden):

- the Quark strait is governed through a number of programs run cooperatively between the regional authorities in the two countries, e.g. the creation of The Kvarken Council;
- the political cross-border dialogue platform, The Kvarken Council, is a cooperative association formed between the cities of Vaasa, Kokkola, Seinäjoki and Jakobstad in Finland, the three Regional Councils of Ostrobothnia in Finland, as well as the Regional Council of Västerbotten and the city of Örnsköldsvik in Sweden. The Kvarken Council, founded in 1972, is a non-profit bi-national organization with six board members from each country. The Council is one of the 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 circulates between the cities of Vaasa and Umeå in two year cycles;
- UNESCO World Heritage management issues are dealt with at the regional level by established bodies with representatives from authorities, municipalities and local stakeholders.

## 3.8 Insights from indigenous and local knowledge – From past to present

*Tero Mustonen*

### *3.8.1 Historical overview*

The Quark region has a rich biocultural past and present. The earliest inhabitants of the region were hunter-gatherers following the melting ice 10,000 years ago. Whether present day inhabitants of the Quark region can relate their ancestry to these early inhabitants remains largely unknown. There is evidence that Saami people inhabited the region for a long period, utilizing both in-land hunting/herding areas and the coastal seal hunting and fishing resources (Broadbent, 2010). Broadbent has documented numerous Saami dwellings and burial sites in the Quark-area that are characteristic of Saami cultures, including a ritual bear burial site. Around 700–1,000 years ago, the Scandinavian/Germanic-speaking sea and farming society expanded to the area, presumably cutting the Saami off from the coastal resource base.

Enterprising individuals and a unique natural environment have formed the characteristically opposed but cooperating forces of the last 1000 years of cultural history in the Quark. The High Coast's hilly scenery with high islands, steep shores, smooth cliffs, and deep inlets is a complete contrast to the Quark archipelago with its thousands of low-lying islands, shallow bays, moraine ridges and massive boulder fields. The land-uplift phenomenon has influenced everyday life, as shorelines have slowly changed and small water bodies have dried out. People in the archipelago have lived in balance with nature and this constantly changing landscape. The ethnic composition of villages on the coastal islands and coastal areas for the past centuries was Swedish and Finnish. The people of the Quark archipelago have always been reliant on the sea, which offers both food and a means for transportation (Sundfeldt & Johnson, 1964).

Agricultural land, buildings and open fields form the main components of the biocultural landscape in the Quark archipelago, reflecting the close relationship between man and nature. On the Finnish side of the Quark, the most distinctive features of the biocultural landscape are river valleys and agricultural plains, a contrast to the hilly forested 'wilderness' on the Swedish side. On the other hand, the landscape on the coast is somewhat different: towns at the estuaries and villages with small harbours give the area its specific character. The first houses were built in clusters on the riversides. As late as in the 1950s and 1960s, the rural community centres began to turn into more urban communities, as industrial facilities were built and new building styles appeared.

The economically important activities in the 1700s were seal hunting and fishing. Agriculture was, at that time and until the mid 20th century, at a small scale and for subsistence needs. Around the 1970s the rules of trading changed; the shipping and navigation industries expanded with the advent of motorised boats and ships. The seasonally used cabins (so-called "fiskebastu") in the outer archipelago started to lose their significance. Benefits from nature have always played a key role in livelihoods. Following industrialization, the balance between nature and society has changed, which has resulted in several pressures on biodiversity and ecosystem services. For example, modern day agricultural landscapes and river alterations affect coasts and biodiversity, whereas traditional agricultural practices preserved richness and variety of the natural environment. Current agricultural landscapes are going through rapid changes: A decrease in dairy farming and increase in underground drainage has created a more monotonous landscape. Old open farmland has been subjected to secondary succession, i.e. continuing bush encroachment. One of the most significant negative drivers that has altered the island habitats, is the replacement of primary forests with industrial forestry practices.

### *3.8.2 Some observations of biodiversity and ecosystem changes by nature photographers and fishermen*

Local citizens, fishermen, nature photographers and others have been following the changes in nature in the region. Below are some observations:

*Eero Murtomäki* (Mäkinen & Mustonen, 2004), a nationally well-known nature photographer in Finland gives an in depth analysis about the changes in species composition and biodiversity in nature he has noticed over a long period from early 1950s until today. He mentions the close relationship between nature and people in the preindustrial era, referring to the 1940s. He remembers the close relationship he had to the sea already as a child. Murtomäki writes about his interest for bird watching and his childhood observations. One observation from the Sundom wetland was the hen harrier (*Circus cyaneus*), which then disappeared due to the intensive drainage of wetland-habitats important for this bird. There are many observations on the changes in biodiversity of birds in his text. Dredging is noted as an important anthropogenic driver in the region, causing increased acidity, loss of spawning areas for the common bream (an important fish for the local community) and overall lowered water quality.

*Hans Hästbacka*, an experienced nature photographer and biologist in the Quark region working at the Finnish site, has recorded his observations about changes in the archipelago during the past 50 years. He mentions the very rich abundance of bird species, especially velvet scoter, tufted duck and common as well as red-breasted merganser. When visiting the forests, one would see grouses in good condition. The willow ptarmigan could be seen along the seaside, a habitat with a lot of berries and other suitable food to eat. Nowadays these kinds of habitats have declined and a lot of summer cottages have been built instead.

Murtomäki pays a lot of attention to the iconic white-tailed sea eagle. During the 1970s the eagle population consisted of only a few individuals. This was due to the presence of heavy metals, DDT and other organic pollutants in the food chain that affected its breeding success. As a result, a lot of conservation and assisted feeding action initiatives were undertaken and nowadays the population is strong and viable. These initatives were carried out by local citizens. A recent decrease in eider populations is, however, suggested to be a result of intensive predation by white-tailed sea eagle. Research is underway in attempts to clarify dynamics.

Murtomäki has followed the coastal ecosystem changes since the 1940s. According to him, land-uplift and drivers including agriculture and forestry with resultant increased nutrient flow, have resulted in many changes in species composition. Mountain hare (*Lepus timidus*), muskrat (*Ondatra zibethicus*), Siberian flying squirrel (*Pteromys volans*) and ringed seal (*Phoca hispida*) are among the most affected mammals, whereas grayling and whitefish are the most affected fish species. Birds including greater scaup (*Aythya marila*), velvet scoter (*Melanitta fusca*), lesser black-backed gull (*Larus fuscus*), black-headed gull (*Chroicocephalus ridibundus*), Caspian stern (*Hydroprogne caspia*) and ruddy turnstone (*Arenaria interpres*) have also been negatively affected.

According to Murtomäki, the ecosystem changes have favoured populations of some species including elk (*Alces alces*), white-tailed deer (*Odocoileus virginianus*), European roe deer (*Capreolus capreolus*), raccoon dog (*Nyctereutes procyonoides*), European hare (*Lepus europaeus*), and American mink (*Neovison vison*). The following fish species have also been mentioned to be more abundant in earlier years: Northern pike (*Esox Lucius*), zander (*Sander lucioperca*), vendace (*Coregonus albula*), and roach (*Rutilus rutilus*). Of birds the following species have increased: whooper swan (*Cygnus cygnus*), mute swan (*Cygnus olor*), the Canada goose (*Branta canadensis*), greylag goose (*Anser anser*), great cormorant (*Phalacrocorax carbo*), red-necked grebe (*Podiceps grisegena*), horned grebe (*Podiceps auritus*), and European herring gull (*Larus argentatus*). Hästbacka makes similar observations and they both pay quite a lot of attention to the reasons behind changes in abundance of bird populations. However, according to Murtomäki, the most severe disturbances can be seen on the seabed: eutrophication has led to rich blooms of algae spreading widely along the bottoms, thus the clear sand and rock bottoms are disappearing. This is however favouring bream and roach populations. Hästbacka regards the intense building of summer cottages and all the infrastructure connected to them as a significant driver of change.

Murtomäki (2017) also makes observations about the vegetation and noted the heavy spread of the common reed, which he considers to be one of the severest threats to Finnish coastal ecosystems. These overgrowths destroy habitats essential for species that are dependent on open coastal areas.

### *3.8.3 Observations by local fishermen at the Finnish side of the Quark archipelago*

As part of a mechanism to expand the ILK documentation of the Quark archipelago area, questionnaires were sent to pre-selected knowledge-holders, such as Evert Söderholm and Ove Kaarto, to invite them to contribute to the IPBES study. They responded with the following observations:

- waterbird populations are high in the Quark archipelago, particularly populations of tufted duck (*Aythya fuligula*) and guilllemots, mainly black guillemot and razorbill;
- when primary forests were intact on the bigger islands, hazel grouse was present in high numbers;
- whooper swan was quite rare in the post-WW2 era;
- one of the characteristic traditional land uses is berry picking over several weeks;
- seals can be observed at different parts of the year in the Quark archipelago. During proper ice winters, over 70 seals can be observed in one spot;
- eiders were plentiful and nesting just next to each other in the small islands;
- cormorants used to be very rare, but have now expanded in range and numbers.

One of the most remembered events was when the M/S Eira ship ran aground in autumn 1984. This caused 300 tonnes oil to leak into the Quark archipelago area. Several teams, even from the Finnish Army, were dispatched to clean the coastal and island shores (Mäkinen & Mustonen 2004). This provided an excellent mechanism for citizen science and ILK observations on the extent of the spill and its impacts on seabirds. It mostly affected eiders and mergansers, as well as some guillemots. Several birds had to be shot to prevent the proliferation of oil in the food chain. All in all, the oil cleanup lasted for a month, a stark warning for the 21st Century – could it happen again?

#### *3.8.4 Seal hunting (Tero Mustonen)*

One of the most iconic traditional occupations in the Quark archipelago in both countries is the seal hunt. There are signs of ancient seal hunting and fishing traditions all over the archipelago. The seal was an important and valuable catch. The blubber oil was sold or used by hunters, the meat and entrails were eaten, blood was used in cooking and the skin was used to make various goods. Seal hunting required great skills, which was passed from one generation to the next (Murtomäki, 2017).

This traditional seal hunt continued into the 1960s in the area. Sundfelt and Johnson (1964) provide us with an authentic description of the "long seal hunting trips" on the sea ice. They usually took place in late winter between March and May. Sundfelt and Johnson worked with tradition holders, such as Erik Granlund, travelling on the ice as a part of the traditional seal hunt. They published the classic book *Färdmän från Isarna* in 1964, and several academic and ethnographic studies regarding the seal hunt in the northern Baltic Sea have since been published (e.g. Edlund, 1989; Kihlström, 1993; Kvist, 1988; Nyström, 2000; Storå, 1990; Westerberg, 1988).

**Figure 23: Seal hunting journeys by Evald Geust of Replot, 1950s and 1960s. Evald Geust and Frans Geust 1959**

**Figure 24: Henry Sand and Frans Geust leaning against the boat (no year)**

**Figure 25: Sail and larger boat on the ice (no year)**

**Figure 26: Evald Geust with the sled and sail on ice (mid-1950s)**

**Figure 27: Dead seals next to the boat (1964)**

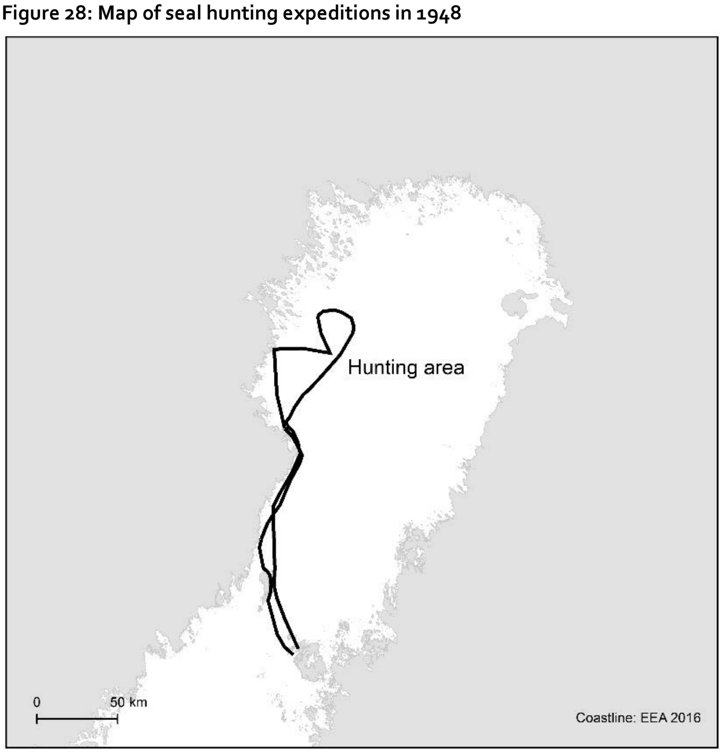
However, Sundfelt and Johnson recorded the seal hunt of the Bergö and other island hunters as a part of their seasonal round of the coastal communities. The ILK of the animals, categorisations of sea ice (as reflected in the sea ice terminologies see Mustonen & Mäkinen, 2004; Nyström, 2000), navigation, sea currents, winds, birds, traditional weather prediction and hunting techniques is comparable to the sophisticated seal hunting traditions of the Inuit in the Arctic area or the Suursaari Baltic Finnish seal hunters. One of the most profound messages Sundfelt and Johnson were able to convey from the hunts they participated in with Erik Granlund and his teams, was the sense of freedom inherent in the seal hunt. Life on the ice and the knowledge embedded in it contained what scholars later have defined as endemic values, place-based morals, ethics and ways of being that can only exist and be maintained through the traditional relationships with the sea, ice, seals and the weather.

Local innovations allowed hunters in the Quark archipelago to adapt to shifting sea ice conditions and adhere to long travels while hunting (cp. fig. 28–29). The Swedish Quark archipelago communities, as well as communities further up in the Bothnian Bay, developed a specific seal hunting boat that could be pulled over the ice and sailed on the open sea. Hunting camps could also be made from the overturned boats at sea, resting on an ice flow. From there, the hunters made shorter excursions using smaller boats. The hunters also had special skiis, as well as a range of other traditional storage and hunting equipment and clothing. Mäkinen and Mustonen (2004) continued the work of Sundfelt and Johnson by working directly with some of the traditional seal hunter families, concentrating on hunts from the village of Panike. They documented several long seal hunting trips taken by Evald Geust between 1939 and mid-1960s, which marked the end of the traditional hunt. Geust mastered the local sea ice terminology that was key to a successful hunt and central for survival on these trips that sometimes lasted over nine weeks. These hunts were long, unsupported and amidst the pack ice and the shifting North Baltic sea (see the attached seal hunt maps).

This exchange of knowledge between researchers and hunters is a good example of local monitoring of aquatic resources. It also demonstrates that hunters such as Erik Granlund and Evald Geust, had capacity to self-limit and govern their harvests. Both Granlund and Geust actively monitored the seal stocks during their hunts. They did not shoot seals with pups and had their own endemic approach to conservation. Professor Eero Helle has paid public respect to the intimate knowledge of the sealers. The sealers of Kvarken participated in research by conveying their observations of falling pup stocks due to PCB and DDT and other pollution-related issues in 1969. They passed on carcasses of ringed seals to researchers, who could detect the extent of these pollutants in the seals. From these samples, researchers were able to detect the impact these chemicals had on the uterus of the female seals. This allowed scientists to determine why seal stocks were falling even though hunting pressure had been significantly reduced after the war (Mäkinen & Mustonen, 2004).

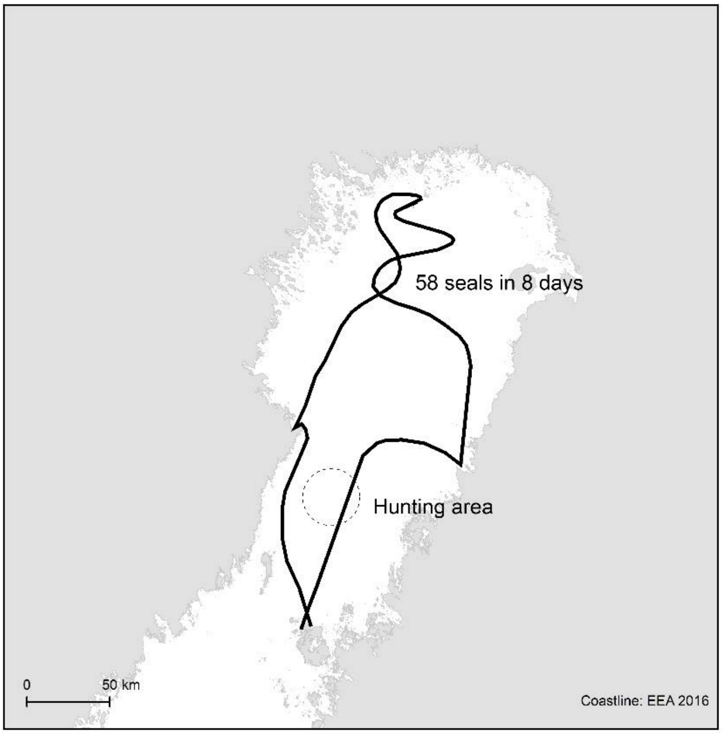
Seal hunters also worked with ice researchers, including the famous Erkki Palosuo, known as the "father of Baltic ice studies". After the second world war, they described and defined various ice formations and their characteristics to professor Palosuo. This undermines the unfortunate and stereotypical image that the seal hunt sometimes suffers from, where the animal is seen solely as the target of a bloody harvest.

**Figure 28: Map of seal hunting expeditions in 1948**




Source: Mustonen and Mäkinen, 2004.

**Figure 29: Map of seal hunting expeditions in 1964**




Source: Mustonen and Mäkinen, 2004.

The seal hunt in the Quark archipelago should therefore be approached as one of the iconic traditional activities that combines oral histories and unique material technology with ways and morals of being with the sea and seals. In more recent times, a controlled seal hunt has been re-opened to control the high number of grey seals.

In summary, the Quark seal hunt was a very traditional subsistence and small-scale economic hunt that began in pre-historic times. Originally, it may have been practiced by the Saami who lived in the area. The seal hunting journeys of the 1900s involved staying out on the Bothnian ice for weeks. Their ILK system is comparable to the Inuit sea ice and hunting traditions in their scale, detail and diversity. Sealers were amongst the first to detect the impact of persistent organic pollutants and other ecological challenges on Baltic seals back in the 1960s. Today, most of the hunting culture has been discontinued and the few seals that are hunted, are shot from motorboats mostly on open water. In 2015 the EU adopted Regulation (EC) No 1007/2009 banning the trade of seal products within the European Union.

## 3.9 References


Ask, J., Rowe O., Brugel, S., Strömberg, M., Byström, P., & Andersson A. (2016). Importance of coastal primary production in the northern Baltic Sea. *Ambio 45*(6), 635–648. http://dx.doi.org/10.1007/s13280-016-0778-5

Broadbent, N. (2010). *Lapps and Labyrinths: Saami Prehistory, Colonization, and Cultural Resilience*. Washington D.C.: Smithsonian Institution.

Edlund, A.-C. (1989). *Sjökatt och svarttjäder – Studier över säljägares noaord för säl inom det bottniska området och Östersjöområdet*. Umeå: Center for Arctic Cultural Research, Umeå University. Research reports, nr 15.

Gundersen, H., Bryan, T., Chen, W., Moy, F.E., Sandman, A.N., Sundblad, G., Schneider, S. *et al*. (2017). *Ecosystem services in the coastal zone of Nordic countries*. Nordic Council of Ministers. TemaNord 2016:552. https://doi.org/10.6027/TN2016-552

HELCOM. (2010). *Ecosystem Health of the Baltic Sea 2003-2007: HELCOM Initial Holistic Assessment. Balt*. Sea Environ. Proc. No 122, Helsinki. http://www.helcom.fi/Lists/Publications/BSEP122.pdf

Hietikko-Hautala,T. (Ed.) 2012. *The Kvarken archipelago, World Heritage Site – Echoes of the Ice Age*. Vaasa: Centre for Economic Development, Transport and the Environment for South Ostrobothnia. 154 p.

High Coast/ Kvarken Archipelago World National Heritage – website: www.kvarkenworldheritage.fi

Jensen, H. & Alanärä, A. (2006). *Provfiske efter lekmogen harr vid kusten i Kvarkenregionen.*Sveriges lantbruksuniversitet, Vattenbruksinstitutionen Rapport 46. Umeå.

Kihlström, J. E. (1993). Sälar och säljakt i norr, *Norrbottenakademiens årsskrif*t, pp. 51–58.

Kronholm, M., Albertsson, J & Laine, A. (Eds.) 2005. *Bottenviken Life*. http://www.lansstyrelsen.se/norrbotten/SiteCollectionDocuments/Sv/publikationer/miljo%20och%20klimat/Tillst%C3%A5ndet%20i%20milj%C3%B6n/1_2005%20Bottenviken%20Life%20-%20Handlingsprogram%20f%C3%B6r%20Bottenviken/1_2005_Bottenviken_life_inledning.pdf

Kvist, R. (1988). Sälfångstsätten i Österbotten, Västerbotten och Norrbotten 1551–1570, *Oknytt*, *1–2*, 4–14.

Lundberg, C., Jakobsson, B.-M., & Bonsdorf, E. (2009). The spreading of eutrophication in the eastern coast of the Gulf of Bothnia, northern Baltic Sea – An analysis in time and space. *Estuarine, Coastal and Shelf Science 82*, 152–160. https://www.abo.fi/fakultet/media/16577/lundbergetal2009_ecss82.pdf

Mäkinen, A., & Mustonen, T. (2004). *Pitkät hylkeenpyyntimatkat sekä muita kertomuksia hylkeenpyynnistä* – Raippaluoto, Merikarvia, Kotka, Islanti. Tampereen ammattikorkeakoulu.

Ministry of agriculture and Forestry. Ministry of the Environment. (2011). *Guidelines for mitigating the adverse effects of acid sulphate soils in Finland until 2020*. http://mmm.fi/documents/1410837/1720912/2_2011_mmm_hapsu-eng-WEB.pdf/9fa91ff2-6c93-41cb-996a-12c05af2a586 (REF 9)

Murtomäki, E. (2017). *Merenkurkun saaristossa vain muutos on pysyvää*. Snowchange Cooperative Discussion Paper, #14. http://www.snowchange.org/pages/wp-content/uploads/2017/01/snowchange-dp-14.pdf

Mustonen, T., & Mustonen, K. (2013). *Eastern Sámi Atlas*. Snowchange Cooperative.

Nostra Project. (2017). *Baseline study. Kvarken strait*. Nostra website: http://www.nostraproject.eu/

Nuuja, I. (ed). (2016). *Merikotkien puolesta – WWF:n merikotkaryhmän vuosikymmenten taival*. Helsinki: WWF. https://wwf.fi/mediabank/9316.pdf

Nyström, L. (2000). *Alg, pytare och skridstång – Sälfångstens och säljaktens terminologi i finlandssvenska folkmål*. Helsinki: Svenska litteratursällskapet i Finland.

OCEANA. Baltic Sea Project (2014). http://oceana.org/sites/default/files/euo/OCEANA_The_Quark_6.pdf

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S. *et al*. (2007). Marine Ecoregions of the world: A Bioregionalization of Coastal and Shelf Areas. *BioScience*, *57*, 573–583.

Storå, N. (1990). Sälrodd, bräddlöpning och långfärd, *Aktuellt om historia,* pp. 227–247.

Sundfeldt, J., & Johnson, T. (1964). *Hylkeenpyytäjät*. Helsinki: Weilin-Göös.

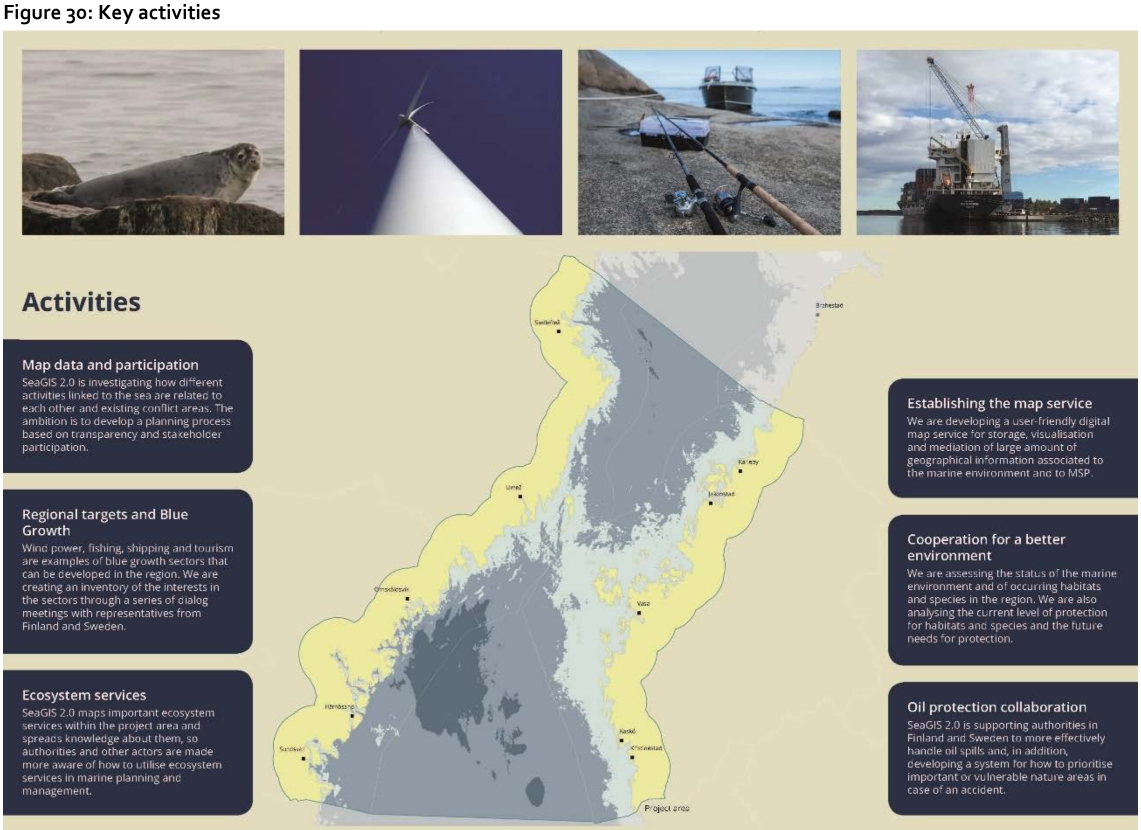
UNEP WCMC. United Nation's Environment Programme. World Conservation Monitoring Centre. World Heritage Sites. High Coast/Kvarken Archipelago. Sweden/Finland: http://ec.europa.eu/ourcoast/download.cfm?fileID=841

Westerberg, J. O. (1988). *Säljaktens redskap. En studie av bevarade redskap från Norrbotten och Västerbotten*. Umeå: Center for Arctic Cultural Research, Umeå University. Research reports, nr 7.

## 3.10 Annex: SeaGIS 2.0 Interreg-project

The key activities can be found in the illustrative picture below.

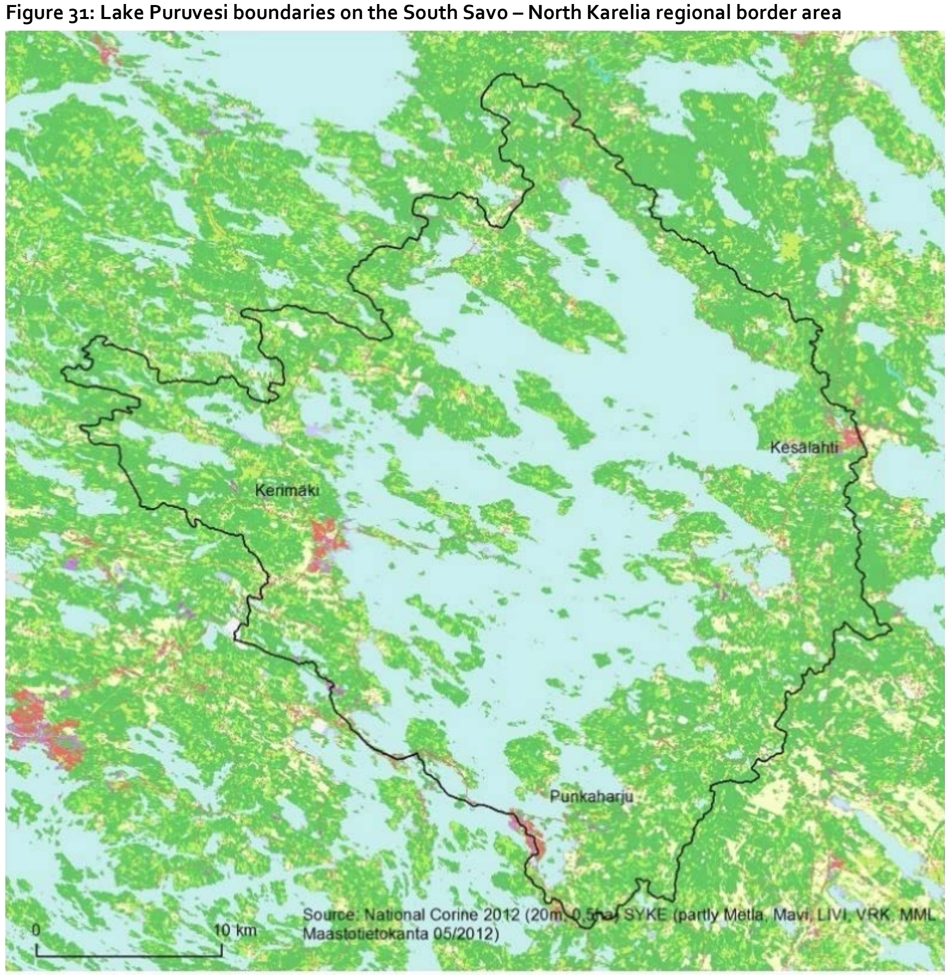
**Figure 30: Key activities**



# 4. Lake Puruvesi, North Karelia and South Savo, Finland – Representing the Ecoregion: Saimaa

*Tero Mustonen*

**Figure 31: Lake Puruvesi boundaries on the South Savo – North Karelia regional border area**




Source: National Corine 2012.

## 4.1 Setting the scene

### 4.1.1 *Area*

Lake Puruvesi belongs to the Vuoksi water system in the provinces of North-Karelia and South-Savo in eastern Finland. The main towns in the provinces are Kitee and Savonlinna respectively. The area of the lake is approximately 416 $km^2$ making it the 11th largest lake in Finland by total area. The mean depth is 8.8 meters and the maximum depth 61 meters. The total area of the watershed is 1,017 $km^2$, of which water covers 35 percent. The largest sub-catchment area is river Kuonanjoki which covers 73 $km^2$. Water residency time is approximately 12 years in Puruvesi.

**Figure 32: Winter seining on lake Puruvesi is an age old tradition**

Note: The seining crew led by late Esa Rahunen harvesting vendace on the ice.

Photo: Snowchange, 2017.

### 4.1.2 *Main sources of income in the area*

The main sources of income in the Kitee region are education, public services, trade, forestry, agriculture (including fishing) and industry. In the Savonlinna region these include industry, trade and services. The number of inhabitants in the Kitee region is 10,712 of which 6,000 are in the municipal center, and in Savonlinna the number of inhabitants is 35,229 (Pennanen 1979; Mustonen 2009). Tourism also plays a role in the regional economy.

**Figure 33: Risto Ketolainen empties vendace (*Coregonus albula*) into the transport container on the ice of Puruvesi after success in seining**

Source: Snowchange, 2017.

## 4.2 Key Ecosystem Services

### 4.2.1 *Cultural Services*

The traditional communal seining (pulling) net fishing culture is an essential part of historical Finnish livelihoods and is under consideration as a national cultural heritage within the UNESCO Convention for the safeguarding of the intangible cultural heritage due to its rich oral content. The communal aspect of this activity has been lost in most of the other fishing regions and communities in Finland, but the tradition has been maintained in the Puruvesi area (Pennanen, 1979, 1986; Mustonen, 2009, 2014). This special cultural fishing practice has also received a special distinction in the EU. The EU has provided a Geographical Indicator to the vendace fish (*Coregonus albula*) from Puruvesi, recognizing both the biological qualities of the fish, as well as how it is harvested, i.e. traditional seining. Seining as a practice is seal friendly, providing an example of successful co-existence with the extremely endangered Saimaa ringed seal (*Pusa hispida saimensis*).

A distinctive Eastern Finnish local dialect is spoken in the area (Mustonen, 2009). The fishermen of Puruvesi have specific terms for fishing activities and events in the surrounding environment that reflect and communicate conditions and changes in Puruvesi area (for example concerning weather, seasons and lake ice).

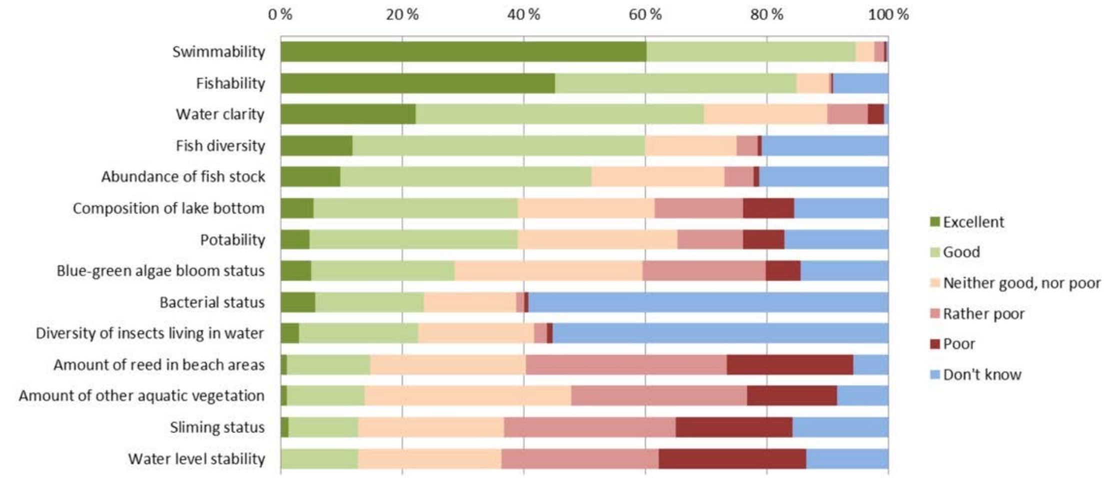
The region around Lake Puruvesi is mostly rural, with a distinct eastern Finnish village culture. In Hummovaara village, a traditional rune singing heritage site, which is connected to the known "Kalevala" singing that refers to the national epic of Finns and Karelians, as well as prehistoric monuments (i.e. Court session / *ting* stones in Käräjäkallio area) can be found in the region (Mustonen 2009, 2014). Hummovaara was home to the most famous rune singer from Finland, Juhana Kainulainen, who sang hundreds of lines of oral poetry to Elias Lönnrot, a compilator from Kalevala. Seining features in these songs.

Seasonal fishing tourism (lake salmon, *Salmo salar*, and trout, *Salmo trutta*, as the main catch species) plays a role in the local economy of the area. A traditional trolling competition in early July brings hundreds of sports fishermen to the community of Kesälahti every year.

**Figure 34: School children seining in March 2016**

Source: Snowchange.

**Figure 35: The quality of Lake Puruvesi perceived by recreationists**




Source: Tienhaara, A. & Pouta, E. 2016. Survey data on water recreation of Lake Puruvesi. Unpublished data. Natural Resources Institute Finland.

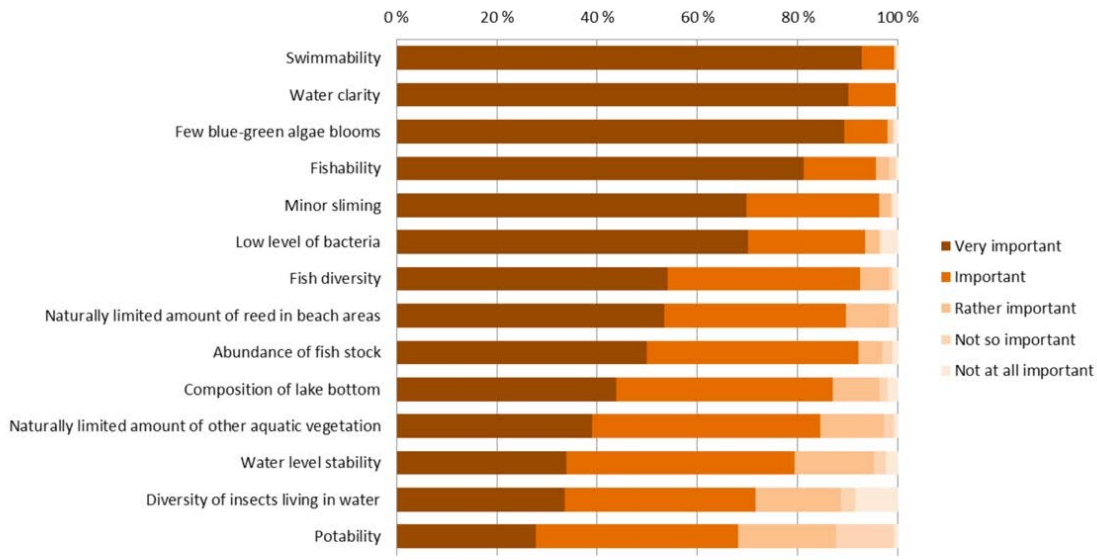
### 4.2.2 *Provisioning Services:*

The professional fishermen in the Puruvesi area mainly fish for vendace (*Coregonus albula*) and the majority of the catch is caught in the winter seining. In the summer months, both fish traps and seining can be used. Since Lake Puruvesi is a potential future nesting area for land-locked Saimaa ringed seal (*Phoca hispida saimensis*), it is worth noting that both of these fishing methods are seal-friendly. The seal is an iconic species of the area.

Lake Puruvesi is an oligotrophic lake and the water is drinkable, indicating a relatively clean status. However, loading from the catchment area has started to impact bay areas with occasional algae blooms. Seining removes up to 400 tonnes of vendace from the lake annually, assisting in controlling biomass and drivers of euthrophication. Vendace are a very clean local fish with low content of pollutions that have the potential to provide for local food security. As vendance features prominently in local culture, it is thought to have formed a central resource that has attracted people to the Puruvesi area for centuries.

The lake area also has recreational uses. In the summertime, the whole Saimaa lake system is a popular place for boating and scuba diving (many of the Finnish lakes have naturally dark water and Lake Puruvesi is exceptionally clear). There is also a number of seasonal summer residents in the area. The winter season is much quieter in the region, with only skiing and snowmobile routes, along with ice roads and tracks being in use.

**Figure 36: The importance of quality attributes perceived by recreationists at Lake Puruvesi**




Source: Tienhaara, A. & Pouta, E. 2016. Survey data on water recreation of Lake Puruvesi. Unpublished data. Natural Resources Institute Finland.

### *4.2.3 Regulating services*

Lake Puruvesi is a major migratory bird resting and staging area. Large areas of the watershed (340 $km^2$) belong to the EU Natura 2000 network.

## 4.3 Biodiversity and ecosystem characteristics

### *4.3.1 Habitats*

Puruvesi is part of the larger Saimaa Lake system and consists of many open water areas with smaller islands and partially drowned eskers that form numerous coves and small bays (cp. map p. 99 in the introduction). The area is exceptionally barren. The landscape is open due to the vastness of water areas and shallow shores. The quality of water is excellent. Puruvesi is ultra-oligotrophic lake where nutrient and humus content is very low. Lakewater transparency in Lake Puruvesi is exceptional, in parts down to 12–15 meters. Vegetation on islands and shores is typical for esker areas. Forests are dominantly dry and barren pine forests and shore vegetation is very sparse. Forest areas around Puruvesi are for the most part converted to economic pine plantations subject to industrial timber production. Water residency is 12 years.

### 4.3.2 *Key Species*

The key species in Lake Puruvesi area are vendace, freshwater salmon, perch and grayling (*Thymallus thymallus*), along with a number of bird species including red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica*) and little gull (*Larus minutus*) and the sedge *Carex ericetorum*.

### 4.3.3 *Significant structural features*

The Puruvesi landscape consists of large sea-like and open lake formations, with barren esker sand soils and shallow shores. The Lake Puruvesi is relatively deep and stands alone and partly apart from the larger Saimaa system, which has darker waters. The ecological productivity of plankton is high due to high water visibility.

### 4.3.4 *Ecosystem functions*

The transparency and excellent quality of water are trademarks of Lake Puruvesi, known as the "crystal waters of Puruvesi". There is a low nutrient content in the water and a good plankton production, which maintains a viable vendace population in the lake. The Puruvesi vendace is a special case amongst other vendace in Finland, it has very high content of vitamin D and its bones are softer. It has been designated a Geographical Indicator from the EU.

There is a possibility that, in the future, Saimaa seal will begin breeding in the area again. Currently the seal visits Puruvesi annually. Puruvesi is also the natural habitat of the critically endangered freshwater salmon (landlocked salmon, *Salmo salar*).

## 4.4 Drivers and pressures

### 4.4.1 *Direct*

Visible changes have been detected in the Puruvesi landscape. In the summer season, algae blooms now occur in some parts of the lake due to increased organic matter flow. On the Savo side of the lake, peat production has resulted in an accumulation of organic matter in the sediment. Forest industry is intensive in the area. It is a known cause of discharges of organic matter and nutrients. Scattered rural settlement and summer residence around Lake Puruvesi also create potential sporadic loading into the lake. Farming nutrients constitute impacts in the bay areas of Ristilahti, Mehtolanlahti and Savonlahti. Following the large algae blooms of 2010, several theories and analyses of the root causes of the outbreaks was assessed. Clear water visibility combined with the "new" summers of extreme temperatures in the region (up to 37 °C in July 2010) may have triggered the nutrient and organic materials in the sediments to activate and release the algae cycle.

A large EU LIFE-funded project "Freshabit" operates in the area. Together with landowners, the NGO Pro Puruvesi, forest companies and regional authorities, the project works to maintain the Lake's quality. One of the goals of the project, is to minimise point loading and leaching of nutrients from industrial forestry sites, along with agricultural farms and fields. While the open water areas of Lake Puruvesi are still relatively clean, the bays suffer from decades of accumulated run-off from the catchment area and are in need of water protection measures. This mainly top-down led project has excluded, for example, the ILK from professional lake fishermen and its effectiveness is thus questioned.

### 4.4.2 *Indirect*

Climate change has had a direct impact on the winter fishing season. The lake ice is more unpredictable, arrives later and melts earlier, resulting in a shortened fishing season. According to the observations by local professional fishermen, winds have changed and gotten stronger (Mustonen, 2009, 2014). The summer 2010 marked a significant change, with temperatures reaching up to 37 °C in July. In the following September, algal blooms affected the lake even at the open areas. Being an ultra-oligotrophic lake, even small amounts of nutrients in the water can have substantially larger impacts in comparison to impacts on eutrophic lakes. The combined impacts of climate change, both in the summer months (extreme temperatures, strong winds, torrential rains in the catchment areas) and winter months (warm spells, diminishing ice cover in January–April and rain), combined with accumulated changes from nutrient and organic loading, have the potential to constitute a system wide risk for Puruvesi and the socio-ecological system it maintains. This is especially relevant due to the long water residency time (12 years).

### 4.4.3 *Activities*

There has been a lot of discussion about the potential for trawling in the area. However, the threats to the cultural and small-scale fishing traditions in Lake Puruvesi, as well as the threats to the fish itself, provide arguments against trawling initiatives. Presently viable and stable vendace populations might collapse as a result of introducing such efficient ways of fishing in the lake system. This has happened in other lakes in Finland where trawling was introduced.

Soil and sand extraction occurs close to the Puruvesi shores. It is an activity with possible negative impacts on the lake. Point loading from the wastewater plant in the Kerimäki settlement has been stopped following the closing of the facility. Positive results can be expected from directing the wastewaters through a larger and more efficient wastewater management facility.

## 4.5 Governance of ecosystem services and influencing policies

### *4.5.1 International / EU*

EU Life Project "Freshabit", EU Natura 2000 sites and relevant Water Framework Directive and other related directives are in place in the watershed.

### *4.5.2 National*

The southern part of Lake Puruvesi belongs to the national shore protection programme. Lake Puruvesi is classified as one of the watersheds in need of special protection. Initiatives are enabled through the Nature Protection Act and Water Act.

### *4.5.3 Regional / Local*

In the regional plan, Puruvesi has the status of a valuable watershed area. Regional planning and zoning (i.e. locations for summer holiday homes) and management of fish and fishing have regional and local relevance. Renewal of the Metsähallitus Act from 2016 may, potentially, promote industrial soil extraction from the lake and increase the construction of summer cabins and other facilities along the lake shore. In order to reduce organic loading from forestry, regional plans for the management of timber resources was introduced in 2017. Given the land ownership structure resting mostly on private capacity, the effectiveness of this plan is uncertain.

### *4.5.4 Policy conflicts*

There are several possible sources of conflict in the area. For example, if trawling is allowed in Lake Puruvesi, it will have implications on the fish and other fishing methods on the lake. Saimaa ringed seal is a source of conflict in itself in Finland. It is the most endangered seal species in the world – the Saimaa Lake system being its only habitat. It has proven to be a difficult task to combine conservation efforts with non-professional fishing rights of the residents and to certain extent, general recreational use in the area. Regulation affecting private industrial forestry in the name of watershed improvement measures, may have potential to trigger negative stakeholder responses. ILK groups, such as those that carry out the traditional winter seiners, do not get their ILK officially recognised in the conversations regarding the lake.

Future demands on freshwater for export, extraction of gravel and other resources may provide yet another arena for future conflict if not managed well. Mustonen (2009) proposes that the Puruvesi area, due to its traditional winter seining livelihood and outstanding ecological value, should constitute a "territory of traditional nature use" that could form a new legal-social tool for protection and preservation of the lake.

## 4.6 Insights from indigenous and local knowledge

Puruvesi is an exceptional socio-ecological basin. It is the home of the most famous rune singers of the Kalevala national epic, including Juhana Kainulainen from the early 1800s (Mustonen 2009, 2014). It is also the home of the most iconic inland traditional fishing culture – the winter seining. Summer seining also takes place in the area (Pennanen 1976). Central to the winter seining, is the communal role the families involved in the trade have, that has been recorded since the beginning of the 1300s (Pennanen 1979, 1986). The ILK of the fishermen has been recognised in the EU decision making process regarding the geographical indicator for the vendace and its harvest.

Monographs and science peer-reviewed articles have recently been produced about the ILK system of the winter seining. Central to this system is the time-space of *apaja*, a location and a time of pulling the nets under the ice (Mustonen 2014, 2015). Some *apajas* can be used weekly, others every other day, others only once a winter. Their variation and diversity can only be achieved through learning on the ice, embedded in the oral transfer of knowledge and practice. The oral histories, toponymic place names and on-going practice of using over 130 *apaja* sites across the lake form the core of this ILK system. In November 2017, this ILK system was included into the the national registry of intangible culture and is shortlisted for inclusion into the international UNESCO list of immaterial culture. In June 2017, a documentary film the "Winter Seiners of Puruvesi" featuring practices in the past and present, was released to international audiences.

**Figure 37: Seining on Puruvesi in 1960s. A video still from the film "Winter Seiners of Puruvesi", OPOE, 2017**

In conclusion, the knowledge of the fishermen could be applied more wholly in the monitoring of the ice, water quality and fish stocks in the lake. The management and decisions regarding Puruvesi are still, for the most part, embedded in the science-management structure of the state. Continued seining removes up to 400 tonnes of vendace from this ultra-oligotrophic lake annually. This practice is thus helping to address the nutrient and organic flows into the lake. Larger cooperation between managers and fishermen is urgently needed to address the future health of the lake.

## 4.7 References

Mustonen, T. (2009). *Karhun väen ajast-aikojen avartuva avara – Kolmen luontaistalousyhteisön paikallinen tieto pohjoisen ilmastonmuutoksen kehyksessä*. Tieteellinen väitöskirja, Joensuun yliopisto.

Mustonen, T. (2014). Endemic time-spaces of Finland: Aquatic regimes. *Fennia 192*: 2.

Mustonen, T. (2015). Ice Fishing Cultures of North Karelia. Case of Winter Seiners of Puruvesi. In S. Böhm, Z. Barucha, & J. Pretty (Eds.), *Ecocultures: Blueprints for Sustainable Communities* (pp. 45–61). Abingdon, Oxon: Routledge.

Pennanen, J. (1976). Puruveden kesänuottakalastuksesta. Teoksessa. In A. Turunen (Ed.). *Kalevala-seuran vuosikirja 56 – Veden viljaa*. Helsinki: WSOY. ISBN 951-0-078581-7.

Pennanen, J. (1979). *Muikkuapajilla*. Jyväskylä: Kansatieteen arkisto. ISBN 951-9056-35-1.

Pennanen, J. (1986). *Talviapajilla. Ammattimaisen talvinuottauksen sata vuotta*. Helsinki: SKS. Suomen kirjallisuuden seuran toimituksia 445. ISBN 951-717-456-X.

# 5. Lumparn

*Susanne Vävare and Maija Häggblom*[5]

## 5.1 Setting the scene

### *5.1.1 Representing the Ecoregion: Baltic Sea*

#### Åland archipelago

Åland is an automous area of Finland with guaranteed demilitarisation and Swedish is the official language. The Åland islands are situated in the Baltic Sea between Sweden, Finland and the Bothnian Sea, Baltic Proper, Åland Sea and the Archipelago Sea sub-basins. Åland consists of nearly 6,500 islands (ranging in size from 0.25–5 ha, and one greater than 50,000 ha), 20,000 smaller islets and reefs (less than 0.25 ha) and a shoreline of several thousand kilometers in length. Åland consists of 16 municipalities; a number that may be reduced in the future to cut costs. The local community is strongly influenced by the distinctive geography of the islands, and remains closely tied to the current status of the Baltic Sea.

The mosaic-like archipelago consists of shallow waters with depths below 30 meters, with deeper areas located in the southwestern part of the archipelago with depths up to 290 meters. Åland has areas with high biodiversity, including small islands, long narrow inlets, flads and gloes. The zone between the beach and the sea are important from a biodiversity perspective because it consists many different small biotopes. Åland is continuously rising from the sea at a rate of approximately 0.3–0.4 meters every 100 years.

### *5.1.2 The study area: The Bay of Lumparn – the inner archipelago*

#### Area and depth

The Bay of Lumparn is considered to be a separate body of water in the inner Åland archipelago. It consists of bays within the archipelago that are divided into a number of different water bodies in accordance with EUs Water Framework Directive. Figure 38 shows the Lumparn catchment and its lakes, which covers 301.1 km$^2$. The total surface area of all water bodies within the catchment, Lumparn and its inner bays, is 429.9 km$^2$.

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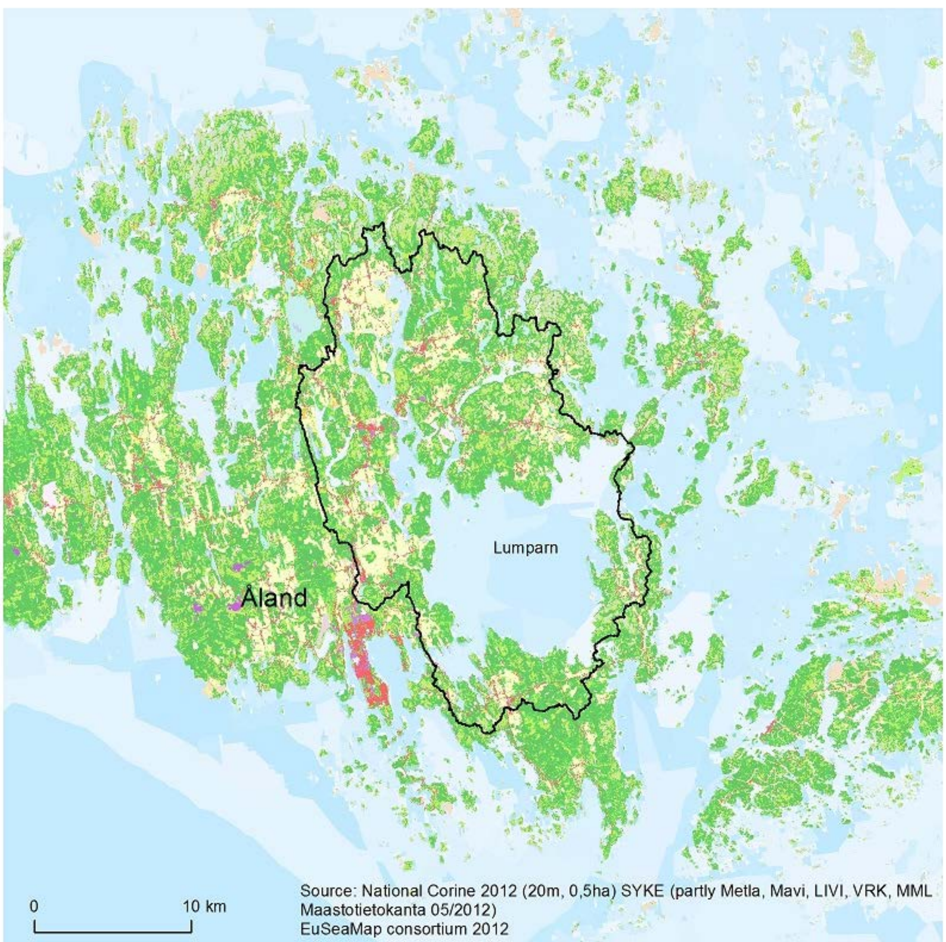
[5] S.V. has written most of the text. M.H. has contributed with text about Nature Care Legislations, Natura 2000-areas in Lumparn and parts on the legislative framework and policy documents.

Lumparn is an oval bay about 10 kilometers long and wide, with three openings – one to the open sea, one in the south and one in the east. The Bay was formed by a meteorite impact roughly 1,000 million years ago.

Lumparn Bay reaches a maximum depth of 35 metres near the island Trollskär in the eastern part of the bay. The average depth is 20 metres. The bottom is flat and composed of ionic sandstone and Baltic Sea limestone. The basin has a number of inner bays that extend in different directions. The northern inner bays are long and narrow with underwater sills, and run from north to south. Among these is the Slottssundet, which is 4 kilometers long and extends to Kastelholm and the inlet Färjsundet. In Lumparn there are a few islets.

**Figure 38: The catchment area of Lumparn**




Source: National Corine 2012.

## Population, habitants, visitors

Åland has a population of 29,214 people (Ålands Statistik- och utredningsbyrå ÅSUB, December 2016). Approximately 8,000 people live in the four municipalities in the Lumparn area. There are around 2,500 summer cottages in these municipalities.

### Main source of income

Åland is a small society with a relatively closed economy, but is still dependent on trade with neighbouring regions. The Islands' location half way between two expanding economic centres, southern Finland and the Stockholm region, is a major advantage. However, this also makes Åland sensitive to economic fluctuations occurring in its two neighbouring markets.

Åland has a large number of businesses and a long entrepreneurial tradition. There are currently about 2,100 businesses, of which about 143 are agricultural enterprises. Approximately 20 companies, mainly shipping firms, banks and insurance companies, have more than 50 employees. More than 90% of companies on the Islands have less than 10 employees, and many are one-man businesses. Shipping, with 20.8% of Åland's GDP, as well as banks and insurance companies with 18.8% of Åland's GDP (2014) are the most important businesses for the economy (Åsub http://www.asub.ax/en/publications/aland-figures 28/3/2018). Today, the primary sector only contributes 2.4% to the GDP, but still constitutes an important base for the Åland food industry. Shipping is an important part of the tourism industry, since a majority of all tourists arrive by ferry from Finland and Sweden. The tourism industry drives much of society in Åland, although it is only indirectly included in economic statistics. Åland has changed into a service society during the past decades.

Fishing, hunting, tourism and recreation are important for those who live in the Lumparn area, but some still engage in agriculture and forestry.

### History and tourism

The Lumparn area is a historically interesting area on Åland, with buildings such as Kastelholm Castle and the fortress of Bomarsund. Kastelholm Castle is a well-preserved castle ruin with interesting historical significance. One Swedish noble family in particular, the House of Vasa, showed great interest in the castle since it at the time was situated in the middle of the Swedish kingdom. A Swedish king Erik XIV was imprisoned there by his brother John, the Duke of Finland, and later king John III, in the struggle for the throne. The castle, which originially was the only medieval fortress on Åland, was constructed in the late 1300s. Today, the area around Kastelholm Castle is popular for visitors. They are also attracted to the museum that features twenty Jan Karls farmhouses, relocated to this area from various parts of Åland. Together the castle and museum give the visitor great insight into Åland building and housing culture, and showcase historical working and living environments. Since the 1940s, the area has raised a midsummer pole here on Midsummer's Eve and every first weekend of December, Ålands largest Christmas market occurs here. Smakbyn is a nearby investment in to food culture based on local food items.

The fortress of Bomarsund was once the most magnificent structure on the Åland islands. The fortress was originally constructed by the Russian military as an important outpost to the west, but was destroyed during the Crimean War in 1854. Following the end of the Crimean War, the Åland islands were demilitarised in 1856. As a consequence, the fortress was never rebuilt. Today the area is a historical monument, covering some 870 hectares and easily accessible for visitors.

## 5.2 Key ecosystem services

Ecosystem services in Lumparn are important for social welfare in the region. Both commercial and recreational fishing are dependent on a high diversity of fish species, and a good condition and functioning of the ecosystems producing these services. Fishery, tourism and recreational activities play a key role in people's quality of life and are of significant importance for health.

### *5.2.1 Cultural services*

The Åland archipelago with red rapakivi granite, blue water and green landscape with high biodiversity has been a source of inspiration for many painters and writers. Åland also has strong maritime traditions, including well-preserved shipbuilding traditions still used to build the wooden vessels used today.

Sport fishing, recreational fishing, boating and bathing are very important for tourism. Cultural activities including the Åland Harvest Festival in September, along with the Åland Sea Days, attract many tourists from Sweden, Finland and other European countries.

### *5.2.2 Provisioning services*

Subsistence fishing and hunting are important in the Lumparn area, not only for livelihoods and food security, but also for the maintenance of culture. Pike perch (*Sander lucioperca*) is one of the Baltic Sea's main pelagic predators, with high recreational value (Veneranta *et al*., 2011) and of great economic importance. Local food and farming products in Lumparn are also very important for the livelihoods of local producers. The products are also very popular among tourists.

### *5.2.3 Regulating and supporting services*

The shallow and sheltered bays offer suitable habitats for many species of fish and vascular plants. The bays also have exceptional recreational value, spurring the potential for conflicts of interest. Seagrass meadows are threatened throughout the Baltic Sea due to human activities leading to eutrophication. They are a good indicator of water quality (Selig *et al*., 2007). Seagrass meadows help to filter runoff from coastal areas, they make the water clearer and some species can be linked directly to good spawning and nursery areas for fish. The rich and dense vegetation creates a forest-like, three-dimensional structure and provides food and shelter for a large number of groups of organisms (Hansen, 2012), including fish, mussels, insects and birds.

Predatory fish provide biological control. They are an important part of the food web and can help to counter eutrophication due to cascading trophic effects. In Lumparn, predatory fish eat stickleback, reducing pressure on fish larvae and grazing organisms, which in turn reduces the growth of filamentous algae.

## 5.3 Biodiversity and ecosystems characteristics

During the summer of 2016, a study was performed to create a complete picture of the state and trends of biodiversity and ecosystem services in the Lumparn area (Maarse, 2017). The gathered data included waters parameters, catches from test fishing, vegetation cover and indices of benthic fauna. In some parts of the bay, water circulation is poor because of underwater thresholds, which leads to increased nutrient concentrations, particularly in deep water. In some bays oxygen free bottoms occur. The main impacts are those resulting from agriculture, settlements and small-scale industry.

The salinity decreases as one moves from the bay of Lumparn inwards from its inlets. In 1994, the salinity was 7.47 ppm in the middle of Lumparn at a depth of 18 m, while at Slottsundet, salinity measured 3.90 ppm at 0–7 m. Salt concentrations have decreased since then. The average salinity was around 5.5 to 5.99 ppm in the middle of Lumparn in the years 2003–2008.

### 5.3.1 *Important and key species and habitats*

*Benthic fauna* forms a large part of the biodiversity in Lumparn. It is an important food source for fish and other animals and plays an important role in the decomposition of organic matter. The composition of benthic fauna is a good indicator of changes in water quality as most species are relatively stationary and long-lived, and are thus able to reflect the state of the environment.

Bladderwrack, blue mussel colony, eelgrass beds, seagrass meadows, vascular plant communities and red algae are found throughout the Baltic Sea (Raunio *et al.*, 2008). Vascular plants need much sunlight, which limit their depth extension. Light dependent plants in shallow bays are especially sensitive to eutrophication.

*Blue mussel colonies* with varying shell size create habitats for many species and contribute to increased biodiversity. The blue mussel is considered durable, but like most other organisms, disappears from areas of very poor water quality such as that resulting from increased sedimentation due to dredging. The blue mussel is highly valued in conservation, not only because it creates a habitat and is a food source for many fish and bird species, but also because of its ability to filter water. *The Baltic mussel* (*Macoma Balthica*) is also very important in the ecosystem, especially as food for fish. Interestingly, the mussel is able to survive ingestion by fish and is still alive when excreted. Its high population numbers in the Baltic indicates high nutrient levels.

*Macrophytes* maintain species diversity by creating habitats and are thus vital for invertebrates, fish and birds. The environmental factors that control species composition are light, nutrients, bottom structure and exposure (Nyström, 2009). Åland has its own classification methodology developed for macrophytes, as Åland is different from the Swedish and Finnish environmental conditions.

*Pike perch* is one of the Baltic Sea's main pelagic predators and of great importance economically and recreationally (Veneranta *et al.* 2011). Pike perch propagation is governed by water temperature and turbidity, and it benefits of muddy water and sandy bottoms. Spawning takes place in shallow (1–3 m) bays in May and June (Koli 1990; Lehtonen *et al.*, 1996). In 2013, the potential spawning grounds of pike perch, including the Lumparn folding system, were mapped (Gripenberg, 2013).

### Natura 2000-areas in Lumparn

The Nature Care Act for Åland includes a number of coastal habitats and marine habitats. The Nature Directive, Bird Directive and Natura-2000 programme for Åland are implemented under this act. Most of Åland's protected areas are protected through the Nature Care Act, but some forest habitats are protected through the Forest Care Act. If land use is changed for these forests, their protection status may lapse.

Three of the islands in the Lumparn Bay fall within two protected areas: the Lillnäs-Tingön nature conservation area and the Fjärdskär and Harrgrund nature conservation area, which also are a part pf the Natura-2000 programme. Tingön is the biggest of these islands, which is rocky and has coniferous dales. Fjärdskär has a small coniferous grove, while there are only a few trees on Harrgrund. These islands are traditionally important breeding areas for seabirds. For example, the Fjärdskär-Harrgrund area is known as an important place for the breeding population of eider in Lumparn.

**Figure 39: Åland archipelago, Sea holly (*Eryngium maritima*). NANNUT-project 2010–2012**

Photo: Suvi Kiviluoto, The Government of Åland.

### 5.3.2 *Status and trends in Lumparn and its bays*

#### Vegetation – macrophytes

The composition of vegetation differs between the main Lumparn basin and its inner bays. The inner bays contain species that require more protected environments, while the opposite is true in the basin of Lumparn (Kauppi, 2012; Maarse, 2017). In the bays, plants including Eurasian water milfoil (*Myriophyllum spicatum*), reeds (*Phragmites australis*), hornworts (*Chara* spp.) and *Ranunculus baudotii* occur, while in the basin of Lumparn, brown algae (*Pylaiella littoralis* and *Fucus vesciculosus*) and eelgrass (*Zostera marina*) dominate.

Stonewort (*Chara* spp.) and bladderwrack (*Fucus vesiculosus*) have been observed at relatively shallow depths, which is normal in moderate water quality conditions (Ruuskanen, 2014). Eelgras (*Zostera marina*) species require good water quality (Hemminga & Duarte, 2000; Short & Wyllie-Echeverria, 1996). The increase in the eelgrass populations in eastern Lumparn from 2004 to 2016, suggest that water quality is improving. This is supported by Mustamäki *et al.* (2014), who show that chlorophyll-a concentrations in Lumparn have fallen during the period 2000–2009. The occurrence of *Chara horrida* in Mellanviken suggests that the water quality in bays around Önningebyfjärden is good, as the species has high demands on water quality (Kauppi, 2012; Maarse, 2017).

#### Birds

The bird fauna of the archipelago reflects both the physical environment, e.g. vegetation, as well as the availability of nesting places and food. The bird fauna of the outer archipelago is different from the inner archipelago, which is often dominated by ducks and grebes. The municipality of Lumparland has been surveyed for seabirds in 2000, 2001 and 2004. Recorded species include eider (*Somateria molissima*), velvet scoter (*Melanitta fusca*), tufted duck (*Aythya fuligula*), goldeneye (*Bucephala clangula*), breasted merganser (*Mergus serrator*), mallard (*Anas platyrhynchos*), greylag goose (*Anser anser*) and mute swan (*Cygnus olor*).

**Table 4: Compilation of inventories from a small area located within the Lumparn basin area, Lumparland, Lumparby reference area**

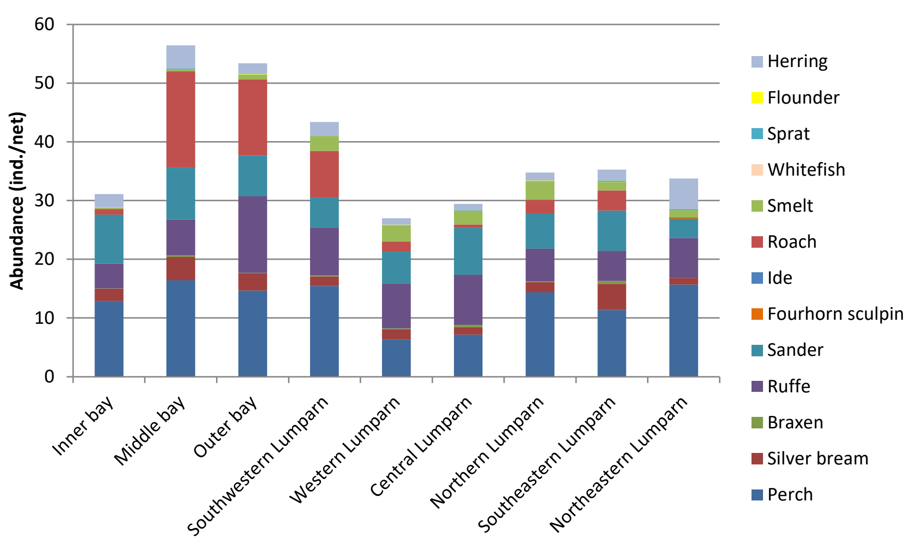
| Inventory | Year | 2000 | 2001 | 2004 |
|---|---|---|---|---|
| 1 | Eider duck ( *Somateria mollissima*) | 61 | 84 | 58 |
| 2 | Velvet scoter (*Melanitta fusca*) | 8 | 9 | 3 |
| 2 | Tufted duck (*Aythya fuligula*) | 6 | 9 | 5 |
| 1 | Goldeneye (*Bucephala clangula*) | 25 | 11 | 14 |
| 1 | Breasted merganser (*Mergus merganser*) | 24 | 20 | 10 |
| 2 | Red breasted merganser (*Mergus serrator*) | 8 | 3 | 3 |
| 1 | Mallard (*Anas platyrhynchos*) | 1 | 8 | 2 |
| 1 | Greylag goose (*Anser anser*) | | | |
| 1 | Mute swan (*Cygnus olor*) | 1 | 2 | 2 |

Recent scientific studies showed that the Baltic Sea / Wadden Sea population of eiders increased steadily between 1940 and 1990. Among other explanations for the rise of the tribe is a reduced hunting pressure and a low predation pressure as well as an increasing biomass in the Baltic Sea due to eutrophication (Christensen 2008; Desholm *et al.*, 2002; Ottvall 2012). However, the development since has been negative. The number of wintering eider in the population was 1.2 million birds in 1990 and the breeding population was estimated to close to 0.5 million in 1991. In 2000, the corresponding number was there estimated about 760,000 wintering birds and around 560,000 breeding pairs. In 2009, the wintering stock was estimated at 976 000 birds and the breeding stock to almost 290,000 pairs (Ekroos *et al.*, 2012). It is estimated that Finland's catching stock has decreased by about 44–62% in the 2000s, and in Sweden by around 50–70% in the same period (BirdLife International, 2015). Several explanations to this rapid decline have been presented, but one explanation that is collecting more and more evidence is the occurrence of a widespread thiamine deficiency among seabirds in the Baltic Sea resulting in high mortality of the pulli a few days after hatching (Mörner *et al.*, 2017).

## Fish

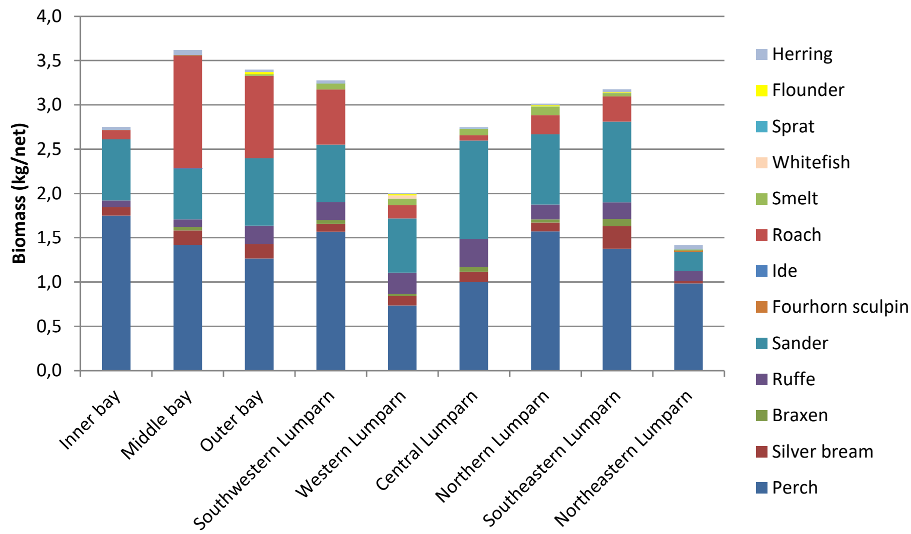
Previous studies have shown that the number of large individuals of pike perch (*Sander lucioperca*) has decreased in Lumparn during the 2000s (Maarse, 2017). Studies have also shown that there are greater numbers of herring (*Clupea harengus*) in the northeastern part of Lumparn than in the rest of the basin, suggesting that this area has more exchange with the surrounding seas. In the middle and outer parts of the bays, there are larger numbers of roach (*Rutilius rutilius*) than in the inner parts, which may indicate a higher degree of eutrophication in peripheral bay areas (Eveleens Maarse, 2017; Husörapport No. 146). A large number of roaches is an indicator of eutrophication and high primary production (Person *et al.*, 1991; Bonsdorff *et al.*, 1997; Ådjers *et al.*, 1999, 2006).

**Figure 40: The average catch (number of individuals per net), per region during 2010–2015**




Source: Fiskeribyrån 2015 in Eveleens Maarse, 2017.

**Figure 41: The average catch (kg per net), per region during 2010–2015**




Source: Fiskeribyrån 2015 in Eveleens Maarse, 2017.

Since 1999 the Fisheries Agency (ÅLR) has conducted survey fishing of pike perch in Lumparn. The following is a summary of their findings for the period 1999–2010:

- rough pike perch has significantly decreased over time during the period 1999–2010. Also, its average length has decreased. This is a classic sign of overfishing, but also of increased pressure from predators;
- over the past five years, there are no significant changes in pike perch stock;
- the strength of the year class determines the basis of population size. It has ranged significantly between years. Year classes of 2011 and 2012 were worse than normal, but holdings during the period 2016–2017 are still expected to be as high as normal. The 2014 year class is good, which should be reflected in a larger stock available for fishing from year 2018;
- the sensitivity of pike perch stocks to variations in the strength of the year class, in combination with heavy fishing pressure and pressure from predators, makes regulatory measures necessary;
- the mortality of pike perch is high, even for young fish. This is an obstacle to maintaining viable stocks.

In 1981, populations of pike perch were in good condition in one of the Lumparland foldings. Moreover, there were also a high number of perch and reproductive Baltic herring.

Pike perch is a lean fish species, both fished and eaten widely in Åland. It is a local species that both reproduces and lives in Åland, and consequently, the levels of pollutants reflect the local conditions in Åland. In an analysis of toxins in pike perch from Lumparn carried out by the Government of Åland, they were found not to have particularly high levels of environmental toxins. However, some uncertainty remains regarding contamination from brominated flame retardants and for perfluorooctanesulfonic acid (PFOS). The assessment has taken the EU standards for sale and environmental quality in to consideration.

### Benthic fauna

Benthic fauna surveys have been conducted in the Åland waters since 1980s. A significant increase in benthic biomass in the archipelago has been reported by Bonsdorff *et al*. (1997) between 1976 and 1994. An increase in biomass has been linked with increased eutrophication (Cederwall & Elmgren, 1980; Bonsdorff *et al*., 1997; Kotta *et al*., 2007).

During the summer of 2013, the Government of Åland, in cooperation with Husö biological station, conducted a follow-up study of the benthic fauna of the archipelago (Cederberg, Björkholm, & Weigel, 2015). The total number of identified species and groups of benthic fauna rose from 37 species in 2006 to 41 in 2013. In 2007, the Baltic mussel (*Macoma balthica*) and *Marenzellerina* spp. (*Polychaete*) were the most widespread species (Nygård, 2007). However, a low density of Baltic mussel was found in the internal bays north of Lumparn, which may indicate prolonged disturbance and low oxygen levels in bottom waters. Baltic mussels are relatively durable and can occasionally tolerate low oxygen levels in bottom waters, but not when the temperature exceeds 5 °C (Dries & Theede, 1974) as it did in year 2013. Recruitment success at some stations in or adjacent to Lumparn was very low in 2013 compared with 2006. In addition, several length classes were almost completely missing in 2013, which may indicate that the conditions have been poor for a long time. The ecological status of the various bays north of Lumparn has been classified as either moderate, poor or bad. The inner bays north of Lumparn are highly eutrophic, but in the south the conditions are much better.

**Table 5: Ecological status for benthic fauna in 2013, according to The Water Framework Directive**

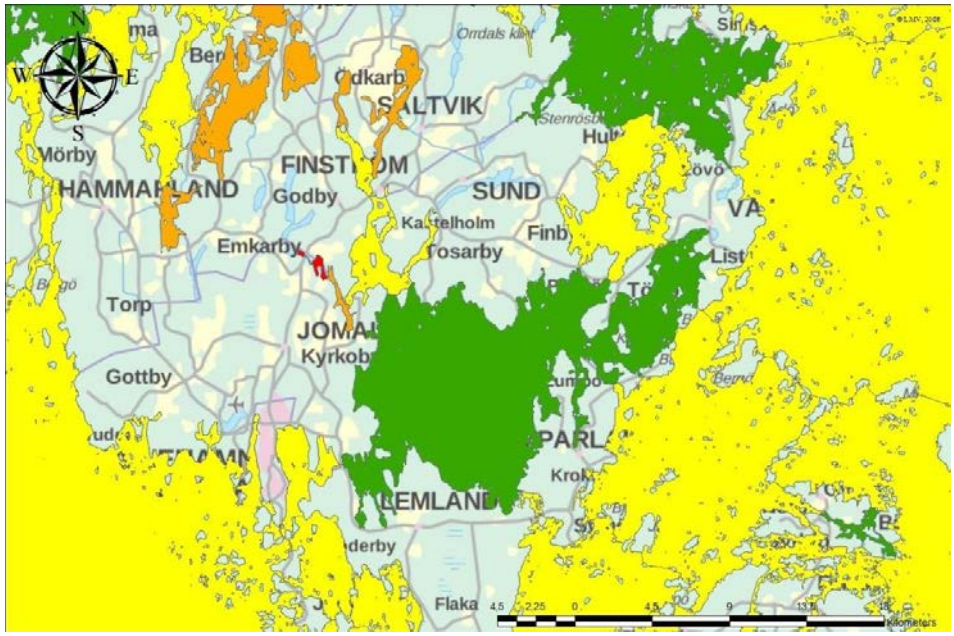
| | L-22 | Hjortösund | Ål-Lumparn | Tingö | Slotts-sundet | Kuggsund | Bruksviken yttre | Prästö |
|---|---|---|---|---|---|---|---|---|
| Ecological status 2013 | Good | Moderate | Good | High | Good | Poor | Bad | High |

Source: Cederberg *et al.*, 2015; Eveleens Maarse, 2017.

### Status – Water Framework Directive (WFD) classification

Based on the WFD classification, the ecological status of the Lumparn waterbody is good, but several of the smaller bays and inlets that connect to Lumparn basin have moderate status or worse (2006–2012). In a long-term study of benthic communities (Husö report No. 140, 2015) several monitoring stations surrounding the Lumparn Bay show signs of long-term disturbance, which are thought to be a result of disruptive or failing recruitment.

**Figure 42: The WFD classification 2006–2012 for Lumparn and adjoining bays, also categorised as water bodies**




Note: The colours illustrate classes as follows: blue high status, green good, yellow moderate, orange poor and red bad status.

Source: The Government of Åland, 2015.

### General conclusions about the status of hydrography, fish, aquatic plants and benthic fauna

Hydrographic parameters and data on fish populations, vegetation and the benthic community show that there are differences in water quality between the Lumparn basin and the bays around Lumparn. Water quality in the inner parts of bays is worst, especially in Ämnäsviken and Kaldersfjärden, but is better closer to the basin. The main challenges to achieving good water quality in the Lumparn area overall, include eutrophication and overfishing.

## 5.4 Drivers of change

### *5.4.1 Drivers in The Baltic Sea*

There have been significant structural changes in the Baltic Sea ecosystem during the past decades. Eutrophication, pollution, fishing and hunting, along with changes in salinity and temperature, are the main factors that affect the food chain in the Baltic Sea.

### 5.4.2 Drivers – Lumparn

Direct drivers:

- eutrophication as a result of dredging, agricultural nutrient load, along with loading from settlements;
- habitat degradation;
- overfishing;
- invasive species;
- climate change;
- legislation.

Indirect drivers:

- climate;
- internal load.

Activities:

- fishing, hunting, tourism, boating, small harbours, households, dredging, agriculture, forestry and small-scale industry.

### 5.4.3 Direct drivers

#### Eutrophication

The whole area is highly sensitive to point loading as water circulation is limited in the inner archipelago. The area is considered to have water circulation class 3, which means that the average water exchange time is more than 40 days. The largest land-based sources of loading in the Lumparn area are agriculture, settlements, private sewers and forestry to a lesser extent. Municipal treatment plants in the Finström, Saltvik and Sund municipalities have added to this load, but as all treatment plants are now connected to Lotsbroverket in Mariehamn, this impact has decreased. However, the overflow points at pumping stations are occasionally overloaded or shut down due to power failure, resulting in point loading. Fish are strongly affected by eutrophication, in a number of, at time contradictory, ways. Perch are disadvantaged by eutrophication, whereas, for example, pike perch benefit (Bergström *et al*., 2013).

#### Boating

Studies have shown that intensive boating, which is thought to increase turbidity, can have negative impacts on macrophytes and benthic organisms. Small boats and ferry services outside the entrances to sensitive bays leads to back flow, currents and increased water circulation, which in turn contributes to sediment being stirred up from the seabed resulting in reduced visibility. This high turbidity adversely affects macrophytes and other organisms as benthic fauna.

### Dredging and dumping

Dredging and dumping in the water can lead to increased turbidity, erosion or covering of vegetation on the seabed. Dredging can also cause the release of nutrients and toxic substances from the sediments.

It is paramount that dredging and disposal of dredged material does not take place in areas where rare or endangered species exist, particularly if it increases the risk of their habitats being destroyed.

### Habitat degradation, overfishing and other problems that counteract the sustainability of fish stocks

Maintaining sustainable fish stocks requires the fish have access to good habitats with protected spawning areas. Eutrophication should, in general, be limited and overfishing should be controlled. A variety of fisheries management measures should be implemented to boost stocks.

It is the lack of habitat that limits the stocks in the Lumparn basin. For perch, pikeperch and northern pike, lacking access to spawning and nursery areas has large impacts on adult stocks (Bergström *et al.*, 2013). Shallow and sheltered bays are important for aquatic plants, which provide both food and shelter for fish and other organisms. In some areas, rivers and creeks that flow into coastal waters are vital spawning grounds. However, large-scale drainage for agriculture and forestry has had negative impacts. Restoration of wetlands can be a good fish conservation measure (Bergström *et al.*, 2013).

With higher population density, increased pressure to build on coastal lands results in the exploitation of important spawning areas for fish. When planning for population growth, it is very important to protect coastal spawning and nursery areas. In these areas, natural production is high: 1 hectare can produce 10,000 perch or 2,000 pike perch 2,000 or 1,000 pike (Bergström *et al.*, ppt presentation, 2016).

### Invasive species

*Marenzellerina* ssp. (*Polychaete*) is very tolerant of low oxygen levels. Albeit an invasive species, one positive impact of *Marenzellarina* populations, is their ability to eat through sediment and create deep tunnels in the sea floor more effectively than indigenous species. The stirring of sediments counteracts the lack of oxygen arising from eutrophication, but also releases toxins that are buried in the sediment.

### Climate change

The most significant changes expected in the Åland climate include warming, sea level rise, increased precipitation and the following additional pressures on the Baltic Sea: Climate change will affect the composition of species and ecosystems due to the low salt content, changes in pH and increased runoff leading to increased eutrophication, increased algal blooms and increased low-oxygen sediments (Ålands landskapsregering, 2015).

### Institutional drivers

Åland has no formal protection of shore lines. The homestead right regulates who can buy houses along the coast.

The conservation of coasts is governed through Åland legislation, as well as international agreements and directives.

### *5.4.4 Indirect drivers*

The nutrient load in Åland waters is carried by streams, carrying point loading from the catchment area. Internal loading and atmospheric deposition. Part of the fallout descended from the ship traffic that passes Åland. The ongoing eutrophication from all countries around the Baltic Sea, pollution and climate change affect the Åland coastal community negatively. Deterioration is for instance seen in the form of increased algal blooms, oxygen-free sediments and changes in fish stocks.

### *5.4.5 Drivers affect on nature's benefits to people and good quality of life*

Around the Lumparn area, the negative effects of eutrophication on underwater communities are visible. Fishery may change, as some species disappear while others are favoured. Some ecosystem services risk being eliminated.

When water quality decreases, it reduces recreational value and quality of life. In Lumparn, the occurrence of algae blooms in summer months is increasing. Recreative practices are disrupted. Climate change is expected to cause challenges to ecosystems, particularly in flood risk areas, with further implications for ground and surface water. Water quality is expected to decrease, with further impacts for the tourism industry. Fish stocks are diminishing due to overfishing and habitat degradation in coastal waters.

Preventive measures to reduce nutrient loads and curb eutrophication, along with efforts to mitigate and adapt to climate change need to be implemented. Overfishing needs to be tackled. International cooperation is needed to solve large-scale problems that are linked to the Baltic Sea.

## 5.5 Knowledge gaps and recommendations for policy makers

- Knowledge of the environment under the water surface is still very limited despite the fact that the Baltic Sea has been subject to a series of studies in recent decades. There are many scientific articles, but the collected data have often stayed at an academic level, leaving local decision-makers unaware of the consequences landuse planning has on different habitat types. Tools to obtain information on underwater environments for landuse planning are generally lacking (Kiviluoto, 2013). Important underwater habitats, such as spawning areas, need special attention.

- We need to take advantage of local knowledge and local commitment to make sustainable decisions. Application of ILK measures to curb eutrophication should be prioritised.
- We need better information about fish stocks and fishing. Knowledge dissemination, such as that through eco-mapping, needs to be improved.
- There is a need for a holistic approach in land use planning.
- There is a need for better inventories of potential pollution sources, such as private sewers and overflow points.

To fill these knowledge gaps, synergies between science and ILK need to be made. All stakeholders need to be involved, in accordance with the IPBES concept.

### *5.5.1 Åland – national and regional legislation*

Several EU Directives are of significance for the environmental work carried out in Åland. Among the most important are the Water Framework Directive (2000/60 / EG), the Marine Strategy (2008/56 / EG), the Floods Directive (2007/60 / EG), the Habitats Directive (1992/43 / EG), the Birds Directive (1979/409 / EEC) and Nitrates Directive (91/676 / EEC). The Common Fisheries Policy (CFP) and the Common Agricultural Policy CAP (Common Agricultural Policy) also have significant influence on the marine environment. In addition, the Emission Ceilings Directive for air emissions (2001/81 / EG) and the REACH chemicals legislation are also important to reduce the presence of toxic chemicals. The EU Commission has also proposed a framework for marine spatial planning (MSP) and integrated coastal zone management (ICZM), based on the two previous Commission Communications on marine planning in the EU.

Åland is a self-governed (autonomous) part of the Republic of Finland with its own legislative powers, including for the water area. The Åland Government is responsible for developing a management and action plan for the Åland waters, which constitutes one river basin district according to the Water Framework Directive. Reporting on the progress of the Water Framework Directive to the EU is performed by Finland in cooperation with the Government of Åland.

#### Water management in Åland and legislation

The Government of Åland and its Environment Agency at the Department of Social Affairs, Health and Environment prepare the management cycles within the Water Framework Directive (WFD) for Åland. The WFD is implemented in the Åland legislation, mainly through the Water Act (1996: 61) and Water Regulation (2010: 93). The Water Act is currently undergoing an audit to, among other things, be adapted to the new requirements from the EU (Weser judgment).

### Environmental aspects and sustainability in Åland

The objective of water management is to monitor water quality and promote sustainable use of the aquatic environment and reduce pollution and harmful effects, thereby preserving and improving water quality in seas, lakes and groundwater. The work also includes international cooperation to improve water quality in the Baltic Sea.

### Government Programs for a sustainable Åland

According to the Government of Åland government program of 25th November 2015, the provincial government works for a viable Åland in a number of ways. Sustainability initiatives strive for economical, social- and environmental sustainability. A sustainable Åland presupposes equality and accessibility, by being based on equal opportunities to participate in community-building. Åland's sustainability work builds on Agenda 21, the UN global action plan for environmental sustainability adopted by the UN in 1992, the project A green Åland in a blue Baltic Sea and the Åland Parliament and the Åland Government's decision in 2014 to move towards a fully sustainable Åland by 2051. Over the last year, a lot of strategic sustainability work has been carried out.

The Agenda for Development and Sustainability for Åland has the following motto "Everyone can flourish in a viable society on the Islands of Peace".

As it is written in the Agenda:

> "Åland is an island society with pristine nature and a unique history; rich and diverse with many different habitats in a small area. We make use of the landscape, the entrepreneurial spirit, the traditions, the business sector and new technology to facilitate for all who wish to live and work here. We create a society where the sea, as in the time before private car-ownership, is a connector, creating new possibilities for prosperity and viability"

The four sustainability principles of the global environment network The Natural Step are included in the Agenda, e.g. in a sustainable society, nature is not subject to systematically increasing:

- concentrations of substances extracted from the Earth's crust;
- concentrations of substances produced by society;
- degradations by physical means; and
- in that society people are not subject to structures that systematically undermine their capacity to meet their needs, including health, influence, skills development, impartiality and creation of meaning.

From this, seven strategic development goals have been formulated:

1. The well-being of people whose innate resources grow.
2. Everyone feels trust and have real opportunities to participate in society.
3. All water is of good quality.
4. Ecosystems in balance and biodiversity values maintained.

5. Attractive for residents, visitors and businesses.
6. Significantly higher proportion of the energy is taken from renewable resources, as well as increased energy efficiency.
7. Sustainable and mindful patterns of consumption and production patterns.

Due to the Sustainability Agenda there are several ongoing processes. For example, in the agricultural sector, a new Strategy for Sustainable Food Production produced mainly by local stakeholders, aims for Åland to become the climate-friendly and sustainable gastronic island in the Baltic Sea. The Strategy is a roadmap describing how the goal can be reached. Central aspects in the strategy are industrial collaborations around circulating nutrients, circular blue economy, better soil health and healthy biodiversity.

There is also ongoing work reforming the Planning and Building Act, which includes ineffective protection measures for coastal areas. There is no general plan for Åland, leaving each municipality to have their own practices and recommendations for coastal planning. The Development and Sustainability Agenda needs to be better integrated in to planning for land and water use in to the future. Physical substructures (green and blue infrastructure, buildings, transport and technical structure) shall serve as grounding for land and water use, with comprehensive sustainable guidelines by 2030.

### The Operational Programme under the European Maritime and Fisheries Fund

The Operational Programme under the European Maritime and Fisheries Fund covers the years 2014–2020. It supports the implementation of the EU Common Fisheries Policy and to some extent, the International Marine Products policy. The European Commission approved the new program peropd in the spring of 2015, and the first grant applicants will be taken in to consideration in the fall of 2015. An analysis of the major challenges in the fishing industry has been undertaken, needs have been identified and targets have been set. The overall objective is for Åland's fishing industry to be viable, economically profitable and ecologically and socially sustainable. The fish stocks and ecosystems that are utilised by the industry, should be protected and cared for into the future, to allow the continued production of raw materials and food of high quality. It is important that the fishing industry does not have uncontrolled negative impact on fish stocks, water quality and ecosystem function.

Other important documents related to fish and aquaculture are the Aquaculture Strategy (2014–2020) and a Consultation Report for fish farms from 2009.

### Agriculture and Forestry – political priorities

The Rural Development Program for Åland includes measures that focus on improving management of water quality, fertilisers, pesticides, soil erosion and healthy soil These measures are particularly in the Lumparn Bay, which is surrounded by arable lands. The potential to invest in hydro techniques to reduce water use, as well to recirculate water from ditches and trenches, is being determined. The Program also focuses on sustainable local products, including their marketing. It considers issues such as animal health and risk management in agriculture. Measures that aim to conserve ecosystems in agricultural and forestry landscapes are also considered under the Rural Development Program.

A new Program for Sustainable Forestry on Åland is about to be adopted. The Program describes the impact of forestry on the aquatic environment, including leaching of nitrogen, phosphorous and other nutrients. Leaching of nitrogen leads to acidification of the soil, which in turn can lead to the release of heavy metals such as aluminium and cadmium into groundwater, lakes and streams. However, the lime-rich soil on Åland may buffer against acidification. Calculations based on drainage from the forest area in Åland in 2014–2015, show leaching of 0.4–0.5 kg of nitrogen and 0.01–0.02 kg of total phosphorus per hectare per year, which corresponds to studies from Sweden showing that the leaching of nitrogen and phosphorus is low in most of the forests.

Forestry and nature care legislation in Åland, along with forest certification, has always taken account of water conservation. For example, the legislation has defined protected zones for beaches and streams, wetlands must be preserved and peatlands must not be trenched. In order to receive support for the protection or rehabilitation of dredges or roads, water protection measures must be reported. The use of pesticides in the forestry industry is limited to treatments against the large pine weevil (*Hylobus abietis*) in forest nurseries. In the field, stubs are treated for *Heterobasidion*-fungi with biological pesticides (*Phlebiopsis gigantea*) and the use of chemical pesticides and fertilizers are regulated in groundwater.

### *5.5.2 Mainstreaming biodiversity and ecosystem services across sectors in the Nordic region: the water governance example*

#### Policy integration

The EU Water Framework Directive has increased the awareness on Åland of the need to nurture and protect our water resources in a sustainable way. Many stakeholders have been involved in preparing the River Basin Management Plan (RBMP), which requires updating every six years.

### *5.5.3 EU's impact*

#### A concrete example of how cooperation between different activities –water conservation and agriculture – can be developed through the EU's positions and actions

The changes to the Rural Development Program introduced by the Agricultural Agency, aim to grant investment aid to reduce water use by utilising nutritional traps that bring nutrient-rich water back to the farmland. Another goal is to use irrigation to raise the competitiveness of the agricultural industry. The EU supported the coordination efforts through the WFD. The Commission required detailed knowledge on the Åland RBMP and implementation of the WFD, thus supporting cooperative initatives.

### 5.5.4 *Policy coherence – conflicts*

**EU Common Fisheries Policy**

Total allowable catch (TAC), or fishing opportunity, defines a catch limit defined using fish stocks of high commercial value. Proposals are based on scientific advice from the advisory body ICES (International Council for the Exploration of the Sea) and STECF (Scientific, Technical and Economic Committee for Fisheries). Fisheries Ministers of the Council determine annual quotas for most stocks. For those stocks that are shared and jointly managed with third countries, quotas are determined with them or with groups of countries. The TACs are distributed among EU countries in terms of national quotas, which can be shared and replaced between countries.

Countries must use clear and objective criteria when allocating national quotas for fishermen. They are required to ensure that quotas are not exceeded. When the quota for one species is exhausted, the country must close the fishery for that species. In December 2016, negotiations relating to fishing quotas were underway between Åland and Finland. No agreement has been reached yet.

**Policy coherence and conflicts – Åland aquaculture**

Fish farms in the Baltic Sea cause negative environmental impacts, but simultaneaously constitute an important source of income for the Åland archipelago, employing 3% of the archipelago's population (ÅSUB 2015). Moreover, it has been estimated that about as many are indirectly involved. A closing of fish farming operations would have major social and economic consequences. People will lose jobs and tax revenues will be lower for that municipality.

The Åland coastal waters status is predominantly moderate and needs improvement to good status according to the Water Framework Directive guidelines. A reduction of excessive nutrients is needed to prevent eutrophication.

As traditional aquaculture results in the discharge of nutrients into the aquatic environment, the business need environment permits. The development of the aquaculture industry must comply with the requirements for the improvement of water quality in accordance with the Water Framework Directive (Directive 2000/60/EG), HELCOMs Baltic Sea Actions Plan and recommendations and the Åland marine strategy (Directive 2008/56/EG).

The most sustainable long-term measures for the expansion of aquaculture appears to be land-based recirculating systems or the new semi-closed or closed cultivation systems, where production materials consist of eco-friendly products (IMTA, Vattenbrukscentrum Väst, 2015).

**Modification of the Åland Water Act**

The Water Act is currently being updated following consequences of the Weser Judgement and Schwarze Slum under article 4 of the WFD. These state that fishery projects that may cause deterioration of the ecological status of a water body be shut down – known as the "stop-paragraph". This "stop-paragraph" halted the establishment of new fish farms in coastal waters around Åland. Following a case on fish farming in the High Coast in Sweden in March 2017, a proposal suggested that compensatory measures be implemented in accordance with WFD requirements.

**Figure 43: Diving in the Åland archipelago. NANNUT-project 2010–2012**

Photo: Suvi Kiviluota, The Government of Åland.

### *5.5.5 Concluding remarks*

The Lumparn area is a coastal area of major importance to Åland, both historically and in to the future. Harvesting of local biological resources through fishing, hunting, farming and forestry are still of importance for the local people. Local products are appreciated by both local residents and tourists. The relatively high density of people living in the area make Lumparn an area sensitive to environmental change, including climate change. It is of utmost importance to try to prevent any negative developments. There is a need for more local participation in order to direct efforts to the right areas. There is also a need to construct and preserve wetlands in order to reduce nutrients and sediments from reaching the sea, and improving the conditions for predatory fish In order to achieve sustainable development and create transparent and fair regulations, the planning stages need to include all parts of society.

## 5.6 References


Bergström, U., Olsson, J., Casini, M., Eriksson, Bk., Fredriksson, R., Wennhage, H., & Appelberg M. (2015). Stickleback increase in the Baltic Sea: a thorny issue for coastal predatory fish. *Estuarine Coastal and Shelf Science, 163*, 134–142. https://doi.org/10.1016/j.ecss.2015.06.017

Bergström, U., Sundblad, G., Downie, A-L., Snickars, M., Boström, C., & Lindegarth, M. (2013). Evaluating eutrophication management scenarios in the Baltic Sea using species distribution modelling. *Journal of Applied Ecology*, *50*, 680–690.

BirdLife International. (2015). *European Red List of Birds*. Luxembourg: Office for Official Publications of the European Communities.

Bonsdorff, E., Blomqvist, E.M., Mattila, J., & Norkko, A. (1997). Long-term changes and coastal eutrophication. Examples from the Aland Islands and the Archipelago Sea, northern Baltic Sea. *Oceanol. Acta*, *20*, 319–329.

Cederberg, T., Björkholm, C., & Weigel, B. (2015). *Bottenfaunan i Ålands skärgård 2013*. Forskn. rapp. Husö biol. stat. No 140, 32 p.

Cederwall, H. & Elmgren, R. (1980). Biomass increase of benthic macrofauna demonstrates eutrophication of the Baltic Sea. *Ophelia*, no. 1 (suppl.), 287–304

Christensen, T.K. (2008). *Factors affecting population size of Baltic Common Eiders* Somateria mollissima. PhD thesis. Dept. of Wildlife Ecology and Biodiversity, NERI. National Environmental Research Institute, University of Aarhus, Denmark. 204 pp.

Desholm, M., Christensen, T. K., Scheiffarth, G., Hario, M., Andersson, Å., Ens, B., Camphuisen, C. J., Nilsson, L., Watlho, C. M., Lorentsen, S-H., Kuresoo, A., Kats, R. K. H., Fleet, D. M., & Fox, A. D. (2002). Status of the Baltic/Wadden Sea population of the Common Eider *Somateria m. mollissima*. *Wild-fowl 53*, 167–203.

Dries, R.R. & Theede, H. (1974). Sauerstoffmangelresistenz mariner Bodenvertebraten aus der westlichen Ostsee. *Mar. Biol.*, *25*, 327–333.

Ekroos, J., Fox, A.D., Christensen, T.K., Petersen, I.K., Kilpi, M., Jónsson, J.E., Green, M., Laursen, K., Cervencl, A., Boerm P., Nilsson, L., Meissner, W., Garthe, S., & Öst, M. (2012). Declines amongst breeding Eider *Somateria mollissima* numbers in the Baltic/Wadden Sea flyway, *Ornis Fennica 89*, 81–90.

Eveleens Maarse, F.K.J. (2017*). Helhetsbild av Lumparn-området.* Forskn. rapp. från Husö biol. stat. No 146, 30 p.

Gripenberg, F. (2013). *En fältkartering av potentiella yngelområden för gös (Sander lucioperca L.) – mätningar av grumlighet och andra miljöparametrar*. Forskn. rapp. Husö biol. stat. No 133, 31 p.

Hansen, J.P. (2012). *Benthic vegetation in shallow inlets of the Baltic Sea. Analysis of human influences and proposal of a method for assessement of ecological status*. Plant Ecology 2012/12. Botaniska institutionen, Stockholms universitet, 37 p.

Holgersson, E. (2013). *Kartering av makrofyter, framtagandet av en klassificeringsmetod för att kunna beräkna ekologisk status för Ålands skärgård och skapandet av ett miljöövervakningsprogram*. Forskn. rapp. Husö biol. stat. No 134, 41 p.

Kauppi, L. (2011). *Kartering av undervattensvegetation i kustområden i NV och SÖ Åland*. Forskn. rapp. Husö biol. stat. No 130, 58 p.

Kiviluoto, S. (2013). *Kartering och klassificering av undervattensmiljöer samt tillämpning av information på den regionala planeringen. NANNUT-projektet på Åland 2010-2012*. Forskn. rapp. Husö biol. stat. No 135, 56 p.

Lehtonen, H., Hansson, S., & Winkler H. (1996). Biology and exploitation of pikeperch, *Stizostedion lucioperca* (L.), in the Baltic Sea. *Annales Zoologici Fennici 33*, 525–535.

Mörner, T., Hansson, T., Carlsson, L., Berg, A.-L., Ruiz Muñoz, Y., Gustavsson, H., Mattsson, R., & Balk, L. (2017). Thiamine deficiency impairs common eider (*Somateria mollissima*) reproduction in the field. *Scientific Reports 7*, 14451. https://doi.org/10.1038/s41598-017-13884-1

Nygård, H. (2007). *Bottenfaunan och hydrografin i den åländska ytterskärgården sommaren 2006*. Forskn. rapp. från Husö biol. stat. No 117, 23 p.

Nyström, J. (2009). *Basinventering av bottenvegetationen i grunda havsvikar med potentiell förekomst av kransalger i Saltvik, Sund och Föglö, Åland*. Forskn. rapp. från Husö biol. stat. No 124, 60 p.

Ottvall, R. (2012). *Ejderns och andra musselätande dykänders minskning i Östersjön*. Rapport från Miljöforskningsberedningen. Statens offentliga utredningar, Stockholm.

Perus, J., Liljekvist, J. & Bonsdorff, E. (2001). *Långtidsstudie av bottenfaunans utveckling iden Åländska skärgården – en jämförelse mellan åren 1973, 1989 och 2000*. (A long-term study of changes in the zoobenthos in the Åland archipelago – a comparison between 1973, 1989 and 2000). Forskn. rapp. Husö biol. stat. No103.

Selig, U., Eggert, A., Schories, D., Schubert, M., Blumel, C., & Schubert, H. (2007). Ecological classification of macroalgae and angiosperm communities of inner coastal waters in the southern Baltic Sea. *Ecological indicators 7*: 665–679.

Vattenbrukscentrum Väst. (2015). *Marin fiskodling på den svenska västkusten – Tekniska lösningar*. Rapport från Vattenbrukscentrum Väst, Göteborgs universitet. No 4, 98 p.

Veneranta, L., Urho, L., Lappalainen, A., & Kallasvuo, M. (2011). Turbidity characterises the reproduction areas of pikeperch (*Sander lucioperca* (L.)) in the northern Baltic Sea. Estuarine. *Coastal and Shelf Science 95*: 199–206.

Ålands landskapsregering (1998) Ålands Natura 2000 – program.

Ålands Landskapsregering. (2015). Förvaltningsplan för avrinningsdistriktet Åland, år 2016–2021.

Ålands landskapsregering (2014, revised 2017) Finland-Rural Development Programme (Regional). Åland

### *5.6.1 Links*

http://www.regeringen.ax/miljo-natur/fiske-fiskar

http://www.regeringen.ax/miljo-natur/fredad-natur

http://www.regeringen.ax/miljo-natur/vatten-skargard/klassificering-vatten

http://www.regeringen.ax/miljo-natur/vatten-skargard/vattenovervakning

http://www.regeringen.ax/naringsliv-foretagande/lantbruk/landsbygdsutvecklings-programmet

http://www.regeringen.ax/sites/www.regeringen.ax/files/attachments/page/klimatforandringar-pa-aland.pdf

http://www.regeringen.ax/alandsk-lagstiftning/alands-lagsamling

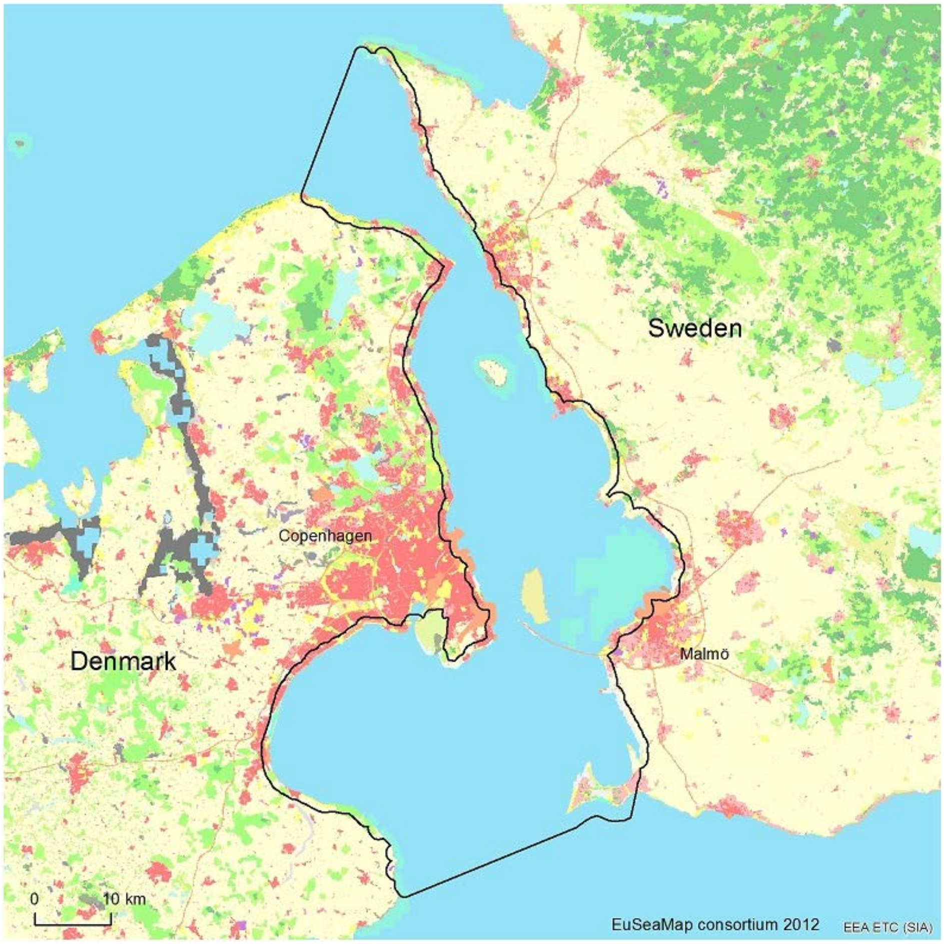
# 6. The Sound: Biodiversity and ecosystem services in a densely populated and heavily exploited area

*Anders Højgård Petersen, Preben Clausen, Lars Gamfeldt, Jørgen L.S. Hansen, Pia Norling, Eva Roth, Henrik Svedäng, and Håkan Tunón*

## 6.1 Setting the scene

The Sound (local names "Øresund" in Danish and "Öresund" in Swedish) is a strait located between Denmark and Sweden. It is one of the three straits/belts (Great Belt, Little Belt and the Sound) connecting the Baltic Sea to the Atlantic. The Sound defines the border between Denmark and Sweden. It is often claimed that no other areas in the Baltic Sea area has played an equally important role in geopolitics for more than a thousand years. As a major route for maritime trade and traffic to the Baltic Sea, the Sound and the narrow northern part between the cities Elsinore (Helsingør) and Helsingborg, have served as "gate" controlled and enforced by Danish kings. Here, ships had to pay toll to pass for more than 400 hundred years, which contributed significantly to the Danish national budget. The Sound has also provided vital ecosystem services; in particular, the rich herring fishery is historically important. Herring migrate through the Sound on their way to feeding areas in the Kattegat and the spawning grounds in the western Baltic Sea. The aggregation of herring in the Sound may have been the main reason and motivation for the first settlements around the Sound, and herring fishery has since become a central part of the cultural heritage of the area. The historian Saxo Grammaticus (1160–1208) already described this fishery back in the early Middle Ages, and the richness of this ecosystem service was emphasised with anecdotal descriptions of how people caught herring with their bare hands. The nutritious herring, preserved by salting, sustained food security both locally and regionally, through export to the Baltic Sea region in all seasons. The Danish kings moved their residence from its old location in Roskilde to the shores of the Sound in Copenhagen in 1443. Already at that time the area was an emerging metropole and centre of trade and politics (the name Copenhagen refers to "Harbour of trade"), which it continues to be to this day.

**Figure 44: Map over the Sound study area**




Source: EuSeaMap consortium 2012.

Due to extensive urbanization, the Sound region is now the most densely populated area in Scandinavia with about 2 million inhabitants in the coastal municipalities. The high density potentially results in corresponding pressures on the environment, such as through sewage discharge. Recently (2000), Denmark and Sweden constructed a bridge and a tunnel across the Sound, which has also involved construction of the fourth artificial island (Peberholm) in the Sound. This infrastructure, together with wind farms, harbours, etc. take up space. At the same time, the Sound is one of the most trafficked places in the world oceans. Thus, the Sound is a hotspot of almost all kinds of human activities: Commercial, household and sports fisheries, as well as navigation, yachting, bathing, diving, sand and gravel extraction, windfarming, sewage discharge, urban and coastal development, land transport, aviation, recreational activities on land, large scale tourism and even agriculture, industry and forestry. The associated environmental pressure could potentially have heavy impacts on biodiversity and ecosystem function and services. Improved sewage treatment during the 1980s and 90s has mitigated some typical eutrophication effects and restored water quality, so even bathing is now possible in the harbours of Copenhagen and in Malmö. A trawling-ban that was initiated for navigational safety reasons alone, resulted in unexpected benefits for seafloor fauna, vegetation and fish stocks. The construction of a fixed link across the Sound (bridge and tunnel) exemplifies another benchmark for its precautionary approach to both local and regional environmental concerns. However, as opposed to the marine habitats, terrestrial habitats are generally diminished by the expansion of urban areas and intensively cultivated farmlands. Only few terrestrial habitats with substantial natural values still exist, including about 20 km$^2$ of semi-natural grassland providing recreational value close to Copenhagen. The island of Saltholm is also outstanding, with virtually no infrastructure and 16 km$^2$ of protected salt marshes, which together with grassland and salt marshes along the Swedish coast, are vital for breeding and migratory water birds.

**Figure 45: Wood cut illustrating the herring fishery in the Sound during the Middle Ages**

Source: From Olaus Magnus, 1555.

## 6.2 Key Ecosystem Services

### *6.2.1 Fisheries*

The Sound has viable local fisheries that harvest cod, flatfish, herring and migratory stocks of garfish (*Belone belone*) and lumpsucker (*Cyclopterus lumpus*). Historically, the Sound has been regarded as a rich fishing ground, especially for herring. Today, cod is among the most targeted species for both the professional and recreational fishermen. This shift is partly context-bound; both the Kattegat and the western Baltic are severely depleted of predatory fish and the Sound is hence an important area for cod.

Apart from being a provisioning ecosystem service, fishing and its cultural heritage can be seen as a cultural ecosystem service that is culturally, socially and economically important for the society. Therefore, even if the number of traditional fishing harbours decline, they still play an important role in tourism, as well as for the local cultural context.

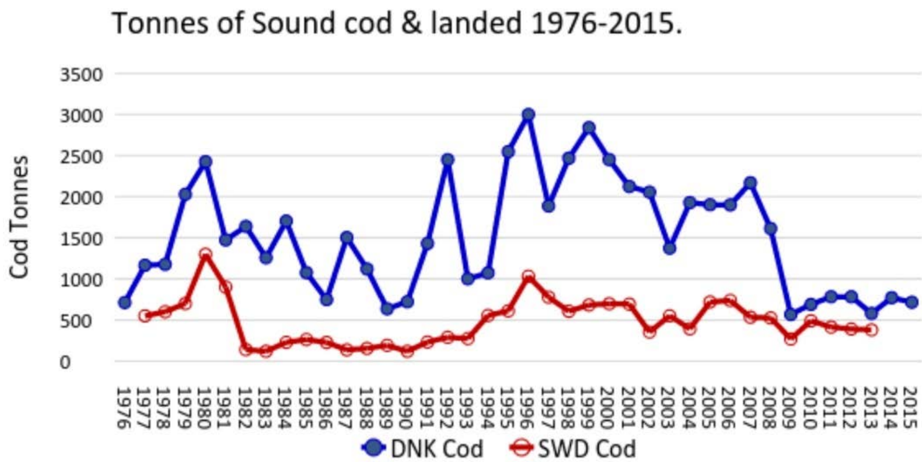
### *6.2.2 Cod Fishery*

The Sound cod is renowned for a relatively high abundance of, in particular, larger individuals and moderate or at least sustainable exploitation rates (Svedäng *et al*., 2010a; Lindegren *et al*., 2013; Sundelöf *et al*., 2013).

This situation is partly due to the resident behaviour of this stock (Svedäng *et al*., 2010a), and, partly because of a ban on trawling initiatied already 1932 (Anonymous, 1932), i.e. gillnetters take the major catch. Trawling is still allowed in the northern area adjacent to the Kattegat, albeit with restrictions since 2009 (e.g. ICES, 2012). The Sound cod is managed together with stocks in the western Baltic Sea off Bornholm and the Belt Sea under the so-called western Baltic cod stock. This management does not include any considerations of the local Öresund cod (ICES Subdivision 23), as biological information as well as cath quotas are aggregated for the entire area (ICES sub-division 22–24). Therefore, set quotas unlikely have sufficient limitations on fishing activities in the Sound. However, the local trawl ban has seemingly provided a sufficient restriction on fishing. Thus even though the trawl ban was not implemented for protection of the fish stocks, this technical regulation has enabled a viable cod stock, supported a substantial local gill-net fishery, as well as an economically important recreational cod fishery in the area (Svedäng *et al*., 2004; Svedäng *et al*., 2010b). The Swedish landings have stagnated around 500 tons per year. Danish catches have, however, been about four times as high until 2009, when they dropped to the same level as the Swedish one (fig. 46) due to the restrictions on the trawl fishery in the northernmost part of the Sound (ICES, 2012), where spawning cod aggregate during spring.

This productive cod stock presents a lucrative fishing opportunity, proving particularly profitable for Sweden in 2009 when the reported commercial revenue for Sound cod was noted at 839 tonnes and valued at EUR 1.1 million (Lindegren *et al.*, 2013). In 2014, Denmark landed 771 tonnes of cod, which when valued at 25.75 DKK/kg, the revenue was estimated at EUR 2.7 million (EUR 1 = DKK 7.46). Furthermore, fishermen in the area benefit from having their fishing ground at a close distance and in sheltered waters, meaning lower fuel costs and better safety. Thus, there is potential for greater profit margins for the fishermen in the Sound. Furthermore, this fishery has a limited carbon footprint. All of these factors in combination can be considered to contribute to positive human well-being.

Figure 46: Danish and Swedish landings of cod in the Sound




Source: Data from ICES, 2015.

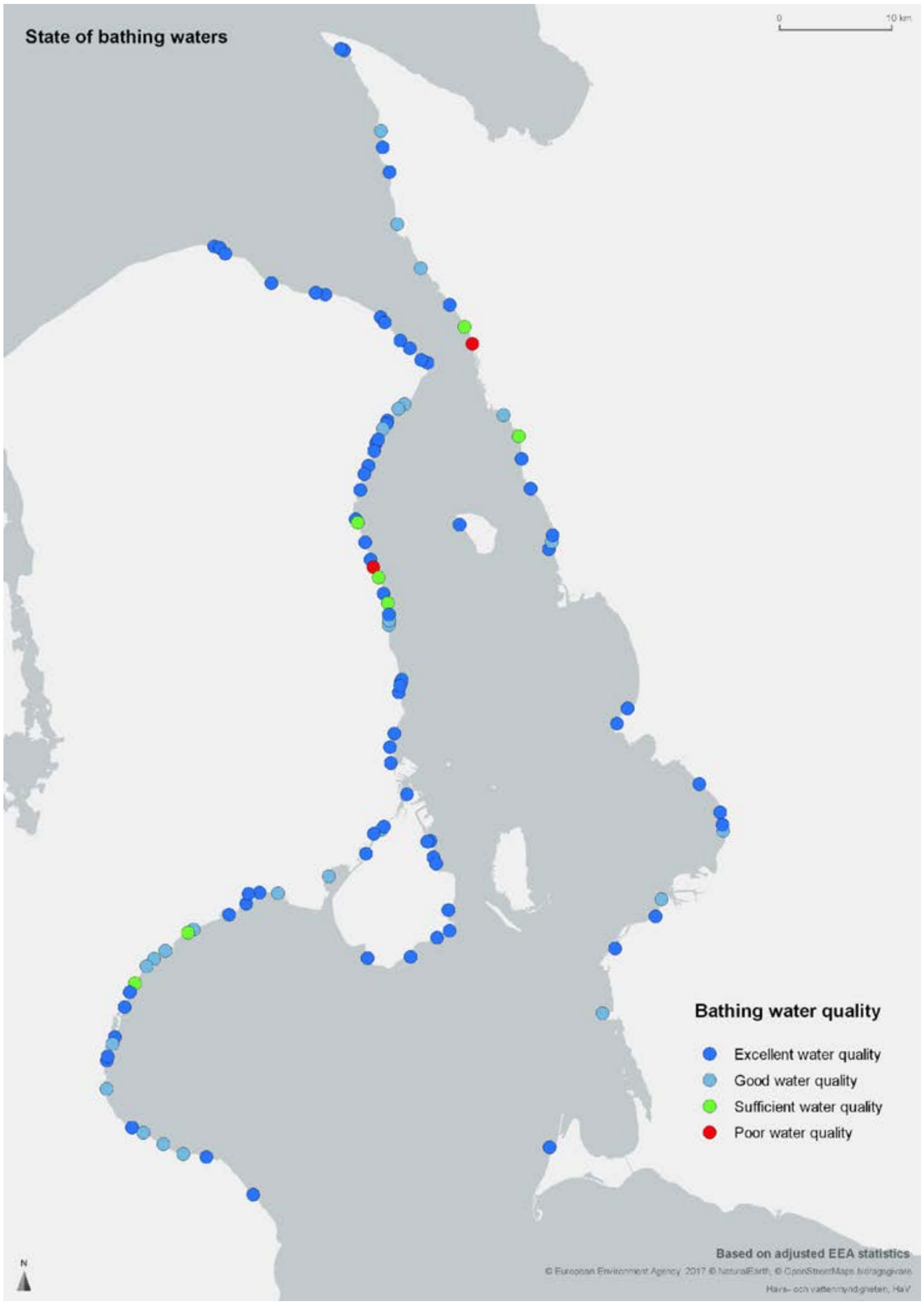
### *6.2.3 Herring fishery*

Today, only a fraction of the Danish Baltic Sea herring catch comes from the Sound (ICES, 2016). The herring fishery still played an important role for the Danish fishing industry in the second half of the 20th century and it was, next to cod, the second largest species caught by biomass. However, the catches in all fisheries have declined in recent years (Zeller *et al.*, 2011) including in the Sound. Presently, the stock is fished at unsustainable levels, meaning that the population will decrease or eventually collapse in the years to come (ICES, 2016), with related negative effects on ecosystem function and services.

### *6.2.4 Recreational bathing, boating and diving.*

Recreational facilities in the coastal areas of the Sound are very well developed and continuously monitored. The recreational value and its capitalization depend on the quality of bathing waters, state of the beaches and build up facilities. According to the European Environment Agency, the water quality was "excellent" in 55 places around the Sound. In fact, out of 77 monitored locations along the Danish coastline (including Copenhagen harbour) 72 were in either "good or excellent condition" (European Environment Agency, 2016) (fig. 47).

Figure 47: State of bathing water quality in the Sound




Note: The quality of bathing water is mostly good to excellent.

Source: Data from the European Environment Agency for 2016.

The high quality of bathing water and beaches is also reflected in the high number of beaches signposted with a blue flag, particularly in northern parts. The blue flag certificate needs to comply with specific criteria and yearly application for renewal is part of blue flag standards. These are places where the municipality has decided to put extra effort in to protecting the environment, including by raising the standard of the beach water quality.

Public beaches are often managed by the local municipality, as are public facilities linked to beach areas. These include wooden piers, lifeguards, handicap facilities, access by public transport, parking, toilets etc. The most favoured facilities in or close to Copenhagen are the Bellevue beach 10 km north of the city center, the outdoor harbour bath at Islands Brygge in the city centre and the artificial beach of Amager Beachpark few kilometers from the centre. 500,000 visitors are recorded at Bellevue Beach each year, 90,000 at Islands Brygge (www.kk.dk 2014) and a spectacular single day record of 30,000 visitors to Amager Strandpark on July 10th 2010 (www.politiken.dk 2010). On the Swedish side of the Sound, large public beaches are found in the central area of Helsingborg and Malmö. There are also many long sand beaches along the coast between these cities with excellent water quality (Figure 6.2.3). One example is Mölle, which has been a famous public beach since the 1800s and has given the community much of its cultural value.

A total of 48 marinas are located along the coast of the Sound. The large recreational value of boating in the Sound is illustrated by the fact that the 23 Danish marinas alone, hold a total of around 10,000 berths. Each of these represent an annual rent typically ranging from hundreds to thousands of Euro. Almost all marinas have waiting lists and several have plans for expansion (Source: Individual home pages for the harbours in question). It may be questioned whether boating per se, can be regarded as an ecosystem service. It is certainly an important aspect of the whole array of recreational services provided by the Sound. The Sound also offers a wide range of diving experiences, including wreck diving. More than 50 Danish and 11 Swedish dive clubs near the Sound are registered in the national Sports Diver Federations. Dive shops in both countries arrange tours to the strait for both locals and tourists. Diver's interests for a particular location tends to increase with increasing biodiversity. Particularly the presence of larger visible animals such as crustaceans, fish and marine mammals, increase the perceived value of a location for most divers (Schoeman *et al*., 2016).

### *6.2.5 Recreational fishery*

Recreational fishing is an important ecosystem service in the Sound area. Sporadic social and economic studies have been made covering all the Nordic Countries around year 2000 (Toivonen *et al*., 2000) and Denmark in 2010 (Fødevareministeriet, 2010). The first study used a "willingness-to-pay" measure to establish the social and economic benefit, whereas the latter used a choice analysis. The latest willingness-to–pay elicited an average of DKK 736 (about EUR 100) above the actual costs (licence, tackle, transport etc.) of average DKK 4,000 per recreational fisherman (Fødevareministeriet, 2010). The data does not permit a detailed geographical delimitation of the Sound. Thousands of people are engaged in recreational fishing, but no reliable numbers have been reported. In 2015 a total of 226,710 recreational fishing days in the Sound area were recorded in Swedish statistics, 159,233 of which were from boats (Havs- och vattenmyndigheten, 2017).

### *6.2.6 Bird watching*

Birdwatching is another important cultural ecosystem service in the Sound area. Many bird-watchers enjoy the richness of waterbirds in and around the shallow bays along the coasts of both Sweden and Denmark. The vast numbers of migrating terrestrial birds passing through the Sound during winter and autumn is also very important in this respect, although the migration is not linked to the Sound ecosystems as such. Falsterbo in the Southern part of the Sound coastline, represents one of Sweden's top localities for all kinds of migrating birds. According to statistics from Artportalen (the Swedish Species Observation System, www.artportalen.se), 3,399 individual bird watchers have reported observations from this coastal location during the period 2007–2016, and together they have visited the area more than 107,000 times. An annual average of 1,060 individual bird watchers report observations to the database. However, as far from all bird watchers report to Artportalen, the actual number of bird watchers is presumed much higher. During 2016, approximately 364 bird species were reported from the area.

### *6.2.7 Water cleaning by blue mussels*

Filter feeding animals can have a significant positive influence on water quality and transparency. In particular, blue mussel beds have been shown to have high capacity to filter water, which enables them to filter the entire water column above them several times per day. Thereby they counteract the effects of eutrophication, control pelagic production, and increase water clarity. There has been a study on the effects of blue mussel filter feeding on phytoplankton in the Sound. The study showed significant removal of large-sized phytoplankton species in the community, which favoured smaller fast-growing species (Norén *et al.* 1999). In the study, the filtering capacity of dense mussel beds in the Sound was 4.0 $m^3/m^2$/hour for a mean abundance of 24,100 individuals/$m^2$. There has been no explicit study on the influence of blue mussels on water quality in the Sound. However, the filtering capacity above and the fact that mussel beds occupy more than 100 square kilometres (see fig. 48) suggests a significant positive effect on water clarity and thereby on the depth limits of macrobenthic vegetation; the latter being an indicator of ecological quality under the Water Framework Directive.

### *6.2.8 Eelgrass beds: fish production and uptake of carbon and nitrogen*

As described in Chapter 3 (Belgrano (Ed.), 2018), seagrasses provide a range of ecosystem services. For example, eelgrass beds have positive effects on carbon sequestration and thereby on mitigation of climate change. In particular, the rhizomes of seagrass beds facilitate accumulation of organic carbon over centuries (Duarte *et al*., 2005). Such carbon storage plays an important role in global carbon budgets. Seagrass beds are also of importance for stabilizing the sediment and reducing and counteracting the effects of wave erosion, which is a problem in this area. However, seagrass beds are threatened by human activities worldwide (Waycott *et al*., 2009). Thus, the well-preserved eelgrass beds in the Sound (see section 6.3.2) provide ecosystem services locally and exemplify how such services can be sustained in a densely populated area.

It has been estimated that, over a 20 year period, one hectare of eelgrass on the northern west coast of Sweden produces an additional 626 kg of cod and 7500 wrasse individuals compared to unvegetated habitats. It also sequesters about 100 extra tonnes of carbon and 460 kilograms of nitrogen. Given the area covered by eelgrass in the Sound (see 6.3.2), losing e.g. 10% of the eelgrass meadows, could lead to a net loss of about 1,900 tonnes of cod, 294,000 tonnes of potential carbon sequestration, and 1,400 tonnes of potential nitrogen sequestration over 20 years. For potential carbon sequestration it could lead to a net loss of 294,000 tonnes over 50 years (Cole & Mosnes, 2016).

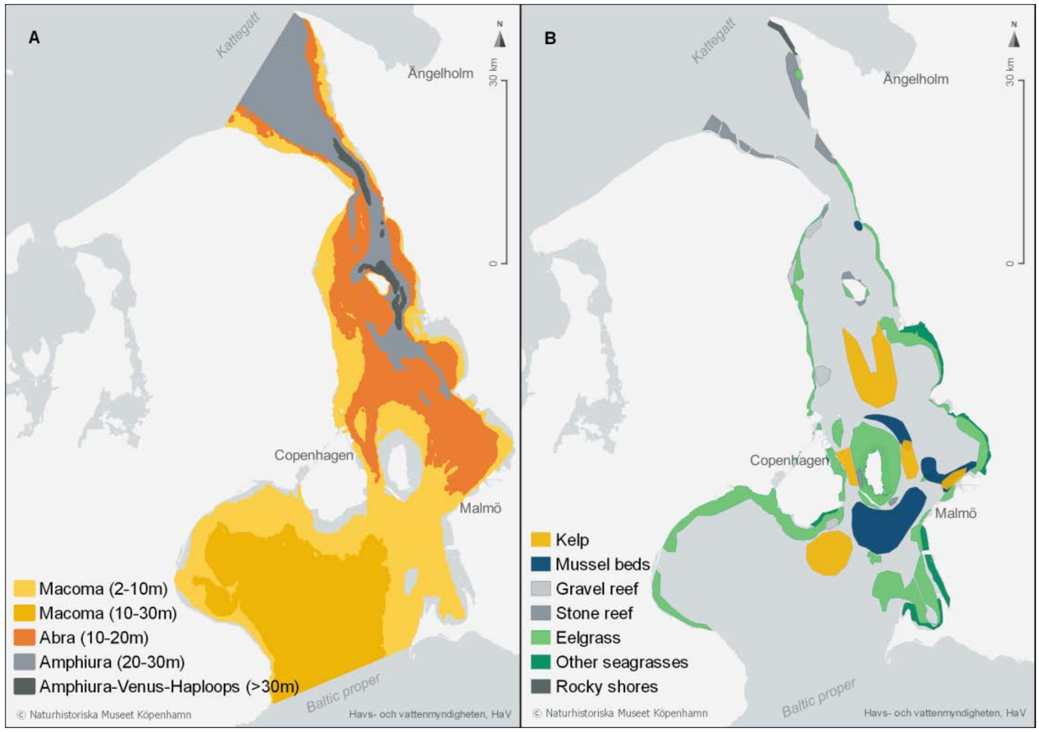
## 6.3 Biodiversity and Ecosystem Characteristics

The hydrographic conditions (distribution of salt, temperature and water movement) determine the structure of the marine ecosystem in the Sound and divides it into different habitats. It is a very dynamic area characterised by strong currents. Although highly variable, the hydrography can be described as part of a typical estuarine circulation pattern with a surface layer of outflowing (northward direction) brackish Baltic Sea water and a deep counter-current of high saline bottom water. A persistent and strong halocline at about 10–15 m separates these two water masses and limits ventilation of the bottom water. Ventilation is additionally limited due to the "Drogden" sill in the southern Sound that blocks the passage of bottom water, which therefore is only renewed when the sill is overflown during events such as storm surges. Long periods of stagnation in the bottom water can become critical for the fauna due to declining bottom water oxygen, mostly manifesting in late summer and autumn (Hansen & Bendtsen, 2013; Jonasson *et al*., 2012). Salinity differences across the halocline divide the biota into distinct communities with differing diversity. Biodiversity declines with salinity in the Sound, with higher diversity of benthos occurring in high saline bottom layers. Primary production by phytoplankton and benthic vegetation (seagrasses and macroalgae) is largely restricted to the surface layer and illuminated bottoms above the halocline. The vegetated bottoms provide key ecological functions, including habitat provision for fish and other organisms, uptake of carbon and nutrients and sediment stabilization. The bottom layer and bottoms below the halocline depth are largely aphotic and heterotrophic. Here, food webs are based on sedimentation of organic matter from the productive surface layer. Primary production of phytoplankton in the Sound (about 120–150 g/m$^2$/year) resembles the levels observed in adjacent marine areas. Primary production in areas with vegetation is higher, but unknown. There is no indication (but explicit studies are few) of locally enhanced production (Carstensen *et al*., 2016) or pelagic respiration (Hansen & Bendtsen, in prep.). Swans graze some of the production of sea grasses; otherwise, marine primary production is processed in the marine food web. Phytoplankton production sustains the higher pelagic food webs through zooplankton grazing to fish production. The benthic food web also takes up phytoplankton, either directly by filtration of the water such as by the large blue mussel beds, or later when it sinks to the bottom and deposit-feeding animals process it. The Sound is an open ecosystem where transport by currents or migration between adjacent sea areas affect all trophic levels. Therefore, individual ecosystem components and the biodiversity in general in the Sound, are not necessarily linked to local drivers.

### *6.3.1 Benthic fauna*

The Danish straits and the Kattegat, including the Sound, are characterised by naturally diverse and rich invertebrate macrofauna communities, which play central roles in the marine food webs and ecosystem services. Some of the species, such as the Norwegian lobster (*Nephrophs norwegica*), are also commercially important. The benthic fauna can be divided into hard bottom communities found on hard substrates, and soft bottom communities (infauna) in sedimentary bottoms. This assessment focuses on the soft bottom communities, for which by far most data exists, and where monitoring goes back more than 100 years (Petersen, 1913). However, although the communities are different, assessment of the ecological quality based on soft bottom communities is to some extent applicable to both bottom fauna types. In general, the benthic fauna communities in the Sound resemble communities found in similar habitats in the Kattegat, the Belt Seas and the western Baltic Sea. The most abundant community is the "Macoma"-community (named by C.G.J. Petersen in the beginning of the 20th century) extending down to about 10 m in areas with fine sediments. Blue mussel beds, particularly in the southern parts where strong currents particularly favor these filter feeders, dominate harder substrates in the same depth range (fig. 48). The *Abra*-community dominate around and just beneath the halocline, and further down on the deepest bottoms, the *Amphiura*-community dominates. The *Amphiura*-community is, however, restricted to areas with high salinity north of the Drogden sill, whereas the "Macoma"-community, dominates at similar depth ranges on the southern side. Of special interest are communities of the small tube living crustacean *Haploos* found on deep mud bottoms north of the island Veen (Göransson, 2010). This species used to dominate large areas of the southern Kattegat in the beginning of the 20th century, but is now a red list candidate (HELCOM, 1998). Another threatened (OSPAR, 2003) and habitat-forming species, the horse mussel (*Modiolus modiolus*), is found in the same area. Possibly, the trawl ban can partly explain why both species still thrive in the Sound, as they have traits vulnerable to physical disturbance. As previously mentioned, extensive blue mussel (*Mytilus* spp.) beds are present, which support a high diversity of associated species (Norling & Kautsky 2007).

**Figure 48: Benthic fauna and vegetation in the Sound**

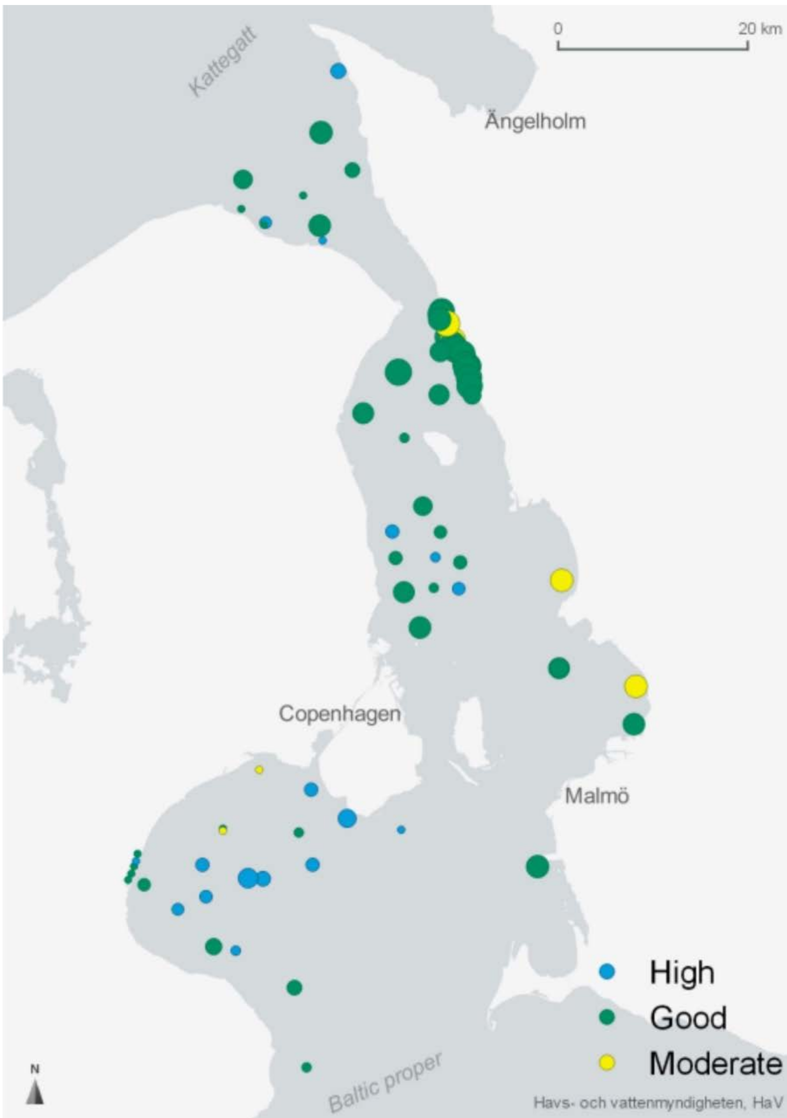



Note: Left: Distribution of benthic fauna communities named after the dominating macro-zoobenthic species. Right: Distribution of dominating biogenic habitats.

Source: Distributions based on maps from "The Sound Water Cooperation".

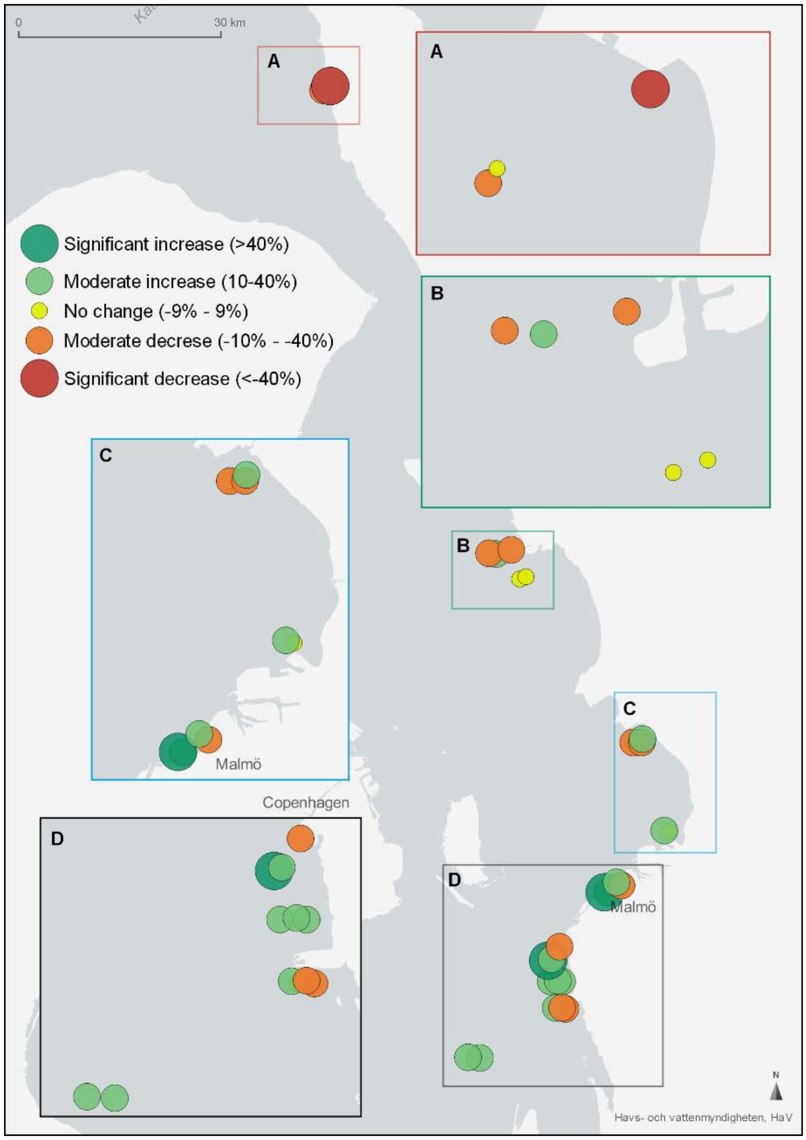
Macrofauna communities respond to environmental changes, and there is a long tradition of using macrofauna to assess the status of marine ecosystems. The organisms are generally sessile and long-lived, and the overall community composition therefore integrates long-term (> one year) environmental conditions. Environmental disturbances typically result in shifts in the community composition, favouring species that are tolerant to specific sources of disturbance, which may also be accompanied by a decline in the species diversity. Thus, whereas changes in the species composition sometimes indicates the specific nature of the environmental change, such conclusions are seldom apparent, because diversity measures are overarching and may describe cumulative pressures on the fauna community. Denmark and Sweden use multi-metric indices, DKI and BQI respectively, to assess the ecological status of benthic communities. Although calculation methods are different, both indices use diversity together with community sensitivity measures (Josefson *et al.*, 2009) to describe the ecological status. Furthermore, DKI normals diversity measures in relation to the maximal diversity at a given salinity. We analysed DKI for all available fauna data from 1) local Swedish and Danish authorities, 2) National Danish and Swedish monitoring and 3) fauna data collected during construction of the fixed link (bridge and tunnel). DKI values per station were averaged over all samples in all years and depicted using colour codes (fig. 49). Ecological status is generally above the threshold defining good ecological status according to the EU-Water Framework Directive. Note that the calculation method used here is slightly different from the EU-WFD-calculation due to heterogeneous data formats. Thus, even though fauna diversity is relative low in the surface water, both communities are more or less in good condition.

**Figure 49: Classification of ecosystem quality based on benthic fauna**




Note: Fauna samples are from 1996–2015 and originate from the national Danish and Swedish monitoring programs, Danish and Swedish local monitoring programs and from the monitoring program of the fixed link (a bridge, a tunnel, an artificial island and a peninsula). Symbol size is scaled to data abundance, and colours of the fauna stations correspond to classification under the Water Frame Directive (note that different calculations and thresholds are used due to heterogenous data).

Figure 50: Classification of ecosystem quality based on eelgrass




Note: Eelgrass monitoring occurred at 29 stations monitored by the Swedish county administrative board in Skåne, from 1994 to 2015.

### 6.3.2 Benthic vegetation

Eelgrass, *Zostera marina*, is a common species in the Sound area, covering an area of around 29,800 hectares in the region (fig. 48). Other marine angiosperms are also present, but eelgrass is the most abundant species. Eelgrass meadows in the Sound are home to a high diversity of associated organisms. These include a number of crustaceans, such as amphipods (e.g. *Gammarus* spp.) and isopods (e.g. *Idotea* spp.). These species thrive among the eelgrass leaves, where they feed on dead and live plant material. There are also many species of mollusks, where the blue mussel (*Mytilus* spp.)

is the most abundant. Fish, such as sand goby (*Pomatoschistus minutus*), garfish (*Belone belone*) and lumpsucker (*Cyclopterus lumpus*), find protection and spawning ground in eelgrass beds (Olsson, 2016). Due to the species' role in carbon sequestration and provision of nursery areas for cod, the loss of eelgrass would thus result in serious economic consequences (Cole & Moksnes, 2016).

Although no general assessments of the conservation status of eelgrass in the region have been made, available reports and monitoring data indicate relatively good condition of the species. There is, however, large variation among localities, with both local increases and decreases, as shown by regional monitoring programs on the Swedish side of the Sound. Figure 50 presents 29 sampling stations that have been monitored over time. Some stations have been followed over 22 years (1994 to 2015), others for only a few years. The median eelgrass cover of these stations is 60%, with no overall trend in population growth.

In order to evaluate the ecological status according to the Water Framework Directive, some stations have been monitored for depth distribution of eelgrass. Since eelgrass is sensitive to bad water quality in terms of turbidity and light penetration, the maximum depth distribution of the plants can be used as indicator of water quality. Stations monitored by the Swedish county administrative board indicate an average good status, although some water districts only report moderate ecological status (Toxicon AB, 2017), indicating needs for management actions. This is in strong contrast to the status of eelgrass off the northern part of the Swedish west coast, where large areas of seagrass have disappeared over the last few decades (Moksnes *et al*., 2016). Local losses are as high as 60–100% (Baden *et al*., 2003).

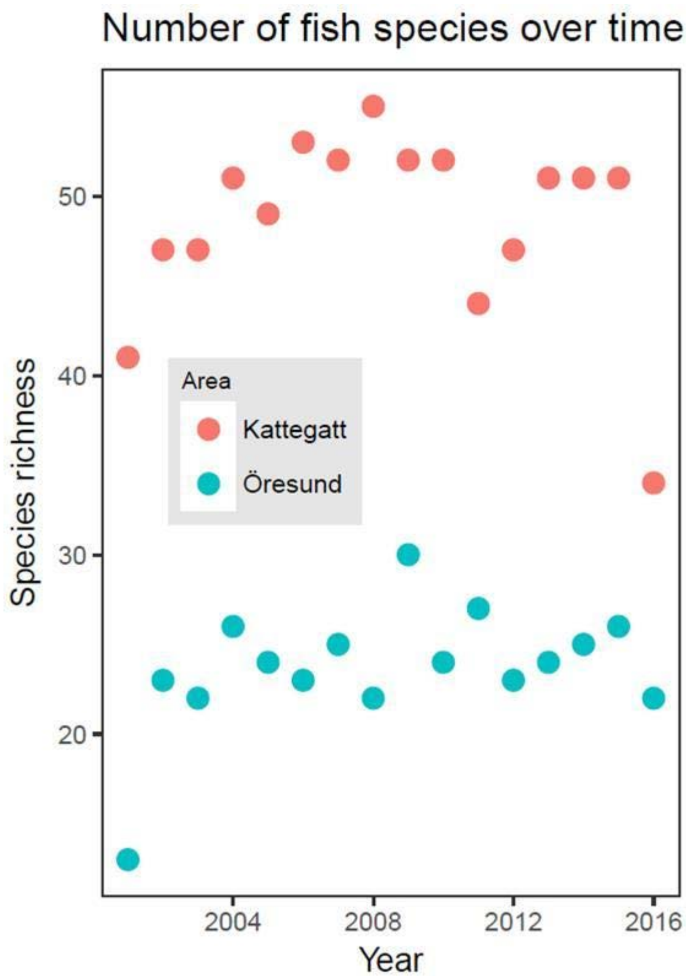
### *6.3.3 Fish*

The Sound is an important migratory route for many fish species. For instance, the herring stock of the western Baltic Sea migrates throughout the year and large numbers of herring pass through the Sound in spring and autumn. In the summer, the population feeds in the Kattegat, Skagerrak and Eastern Atlantic. To reproduce and overwinter, the stock moves south towards the German island of Rügen. In spring the juvenile and adult herring return to their feeding grounds. (Ulrich *et al*., 2012). Due to environmental variability in the Sound – large vertical variation in salinity, strong currents, extensive shallow areas dominated by eelgrass meadows, littoral parts with freshwater plant species, and deeper parts of soft as well as hard bottoms areas – the fish fauna is rather diverse, including both marine and freshwater species. The regular monitoring of the fish fauna is rather scattered, consisting of few stations and conducted partly in soft littoral areas with fyke nets (Lagenfelt & Svedäng, 1999 and references therein), and partly on deep soft bottoms open for trawling (ICES, 2013). These two methods are not directly comparable. In addition, due to the movements of fish, especially by pelagic species such as herring and mackerel (*Scomber scombrus*), biomass of fish varies naturally between seasons.

Beam trawling on littoral bottoms in Lundåkrabukten at 0.5 to 1.5 m depth on the Swedish side of the Sound, have shown large inter-annual variation in the density of juvenile plaice, i.e. between close to zero and 20 per 1,000 trawled $m^2$ (Andersson *et al.*, 1999). The abundance of juvenile eel is high in the Sound compared to the density in the adjacent Baltic Sea.

The fish species community in the Sound is similar to that in the Kattegat (Lagenfelt & Svedäng, 1999). However, species number is lower: the number of species found in fyke net motoring fishing in the Sound, is about half of that found in the northern part of the Kattegat. Concordantly, the trawl surveys indicate about twice as many species in the Kattegat as in the Sound (fig. 50), however it should be noted that the number of trawling stations is much higher in the Kattegat. The community biomass is dominated by a relatively small number of species, which include flatfishes, primarily plaice (*Pleuronectes platessa*), flounder (*Platichthys flesus*), dab (*Limanda limanda*), sole (*Solea solea*), turbot (*Psetta maxima*), cod, haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and pelagic fishes, e.g., herring and sprat (*Sprattus sprattus*). Starry ray (*Amblyraja radiate*) is frequently encountered in the trawl survey. Among the littoral species, wrasses, black goby (*Gobius niger*), and pipefish are common, as are freshwater species such as roach (*Rutilus rutilus*) and ide (*Leuciscus idus*). A number of migrant species are found in the Sound during the summer, including mackerel, garfish and lumpsucker. Diversity indices of fish, as revealed from trawl surveys, show a higher degree of stability over time in the Sound compared to the Kattegat.

**Figure 51: Comparison of the number of fish species caught in trawl surveys between the Sound and Kattegat**




Source: Data from www.ices.dk

Fish encountered in the Sound and the Kattegat may not belong to the same stock, because the Sound and Kattegat areas serve as both nursery and feeding grounds for fish in the Skagerrak/North Sea and Baltic Sea, as well as for local resident stocks. Knowledge about the number of stocks, along with their distributions and movements, is vital for fisheries management. Spatially separate stocks need individual, spatially sensitive management, or at least recognition, monitoring and a lowering of the general exploitation rate to levels where the survival of the least productive stock elements are secured (Stephenson, 1999).

Cod spawning activity has been observed in the middle of the Sound and in the southeastern part of the Kattegat, as well as at the border between the Sound and the Kattegat (Bagge *et al*., 1994; Vitale *et al*., 2008; Börjesson *et al*., 2013). Studies using tagging, genetics and otolith chemistry have revealed that cod in the Sound are behaviorally separate from spawning cod in the Kattegat (Svedäng *et al*., 2010a), but this stock differentiation has, however, not been confirmed by genetic surveys. The tagging study suggested that separate spawning groups show some degree of homing behaviour, i.e. a tendency to return toward their natal spawning grounds. Svedäng *et al.* (2010a) found, in a subset of the tagged individuals selected for analysis of otolith trace elements, a clear signal of separation between different spawning aggregations in the central and northern part of the Sound and the Kattegat.

### *6.3.4 Birds*

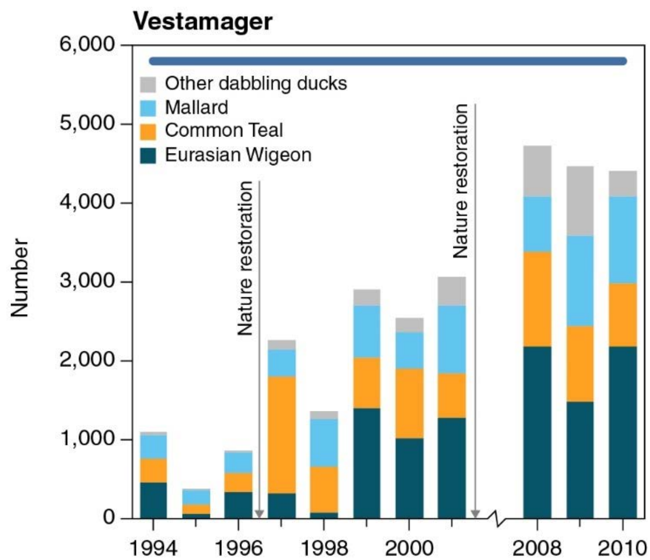
The importance of the Sound for staging, moulting and wintering waterbirds was recognd when the first comprehensive national surveys of waterbirds were launched in both Denmark and Sweden in the mid 1960s (Joensen, 1974; Nilsson, 1975). The area has been regularly, albeit not annually, surveyed during the last 50 years both from the Danish and Swedish side, and occasionally in full surveys covering the entire Sound from aircraft or by combined land- and air-based surveys.

The combination of very shallow waters and mixed *Ruppia* spp.-*Potamogeton pectinatus* dominated plant communities, replaced by *Zostera marina* below 1 meter of depth, and even deeper areas with *Macoma*-dominated infauna communities in the Sound, is a perfect match for a typical wintering community of waterbirds in the Baltic Sea.

The seagrass beds are a year-round home to several thousands of mute swans *Cygnus olor*, which can be found in any shallow area with seagrasses, but occurr in highest numbers around Saltholm in the Danish part of the sound and in Lundåkrabukten, Lommabukten, Foteviken and in Höllviken, i.e. the four shallower bays on the Scanian coast of Sweden (Andersen-Harild, 1991). This distribution mirrors the location of the largest shallow areas with seagrasses (see fig. 48). During moult in July–August, when non-breeding swans shed their flight feathers, they are intolerant to disturbance (e.g. Clausen *et al.*, 1996). The largest numbers therefore aggregate around Saltholm, where up to 3,800 birds have been counted during summer months (Andersen-Harild 1991). The attraction of the island is the combination of plenty of food and remoteness from beaches and populated areas with their associated human recreational activities. After moult, the birds spread out and are more evenly distributed in the Sound, where they often are joined by up to 8,500 coots (*Fulica atra*), with whom they feed (Andersen-Harild, 1991; Nilsson, 2005). The third group of birds associated with the shallow seagrasses is dabbling ducks, with wigeon (*Anas penelope*) and teal (*Anas crecca*) being the most numerous during autumn, and mallard (*Anas platyrhynchos*) during winter. The establishment of a shooting free reserve around Saltholm in 1993, along with a major nature restoration project on Vestamager near Copenhagen, has caused a significant increase in numbers of dabbling ducks using both sites, with up to 22,000 dabbling ducks observed on Saltholm and 5,000 at Vestamager – a three to five-fold increase at both sites (Clausen *et al.*, 2014) (fig. 7). This is in stark contrast to the early 1990s, when most dabbling ducks were found on the Scanian coast in autumn (Andersen-Harild, 1991). It is unknown if the increase in Denmark is accompanied by a decrease in Sweden, because the national autumn *Anas* spp.

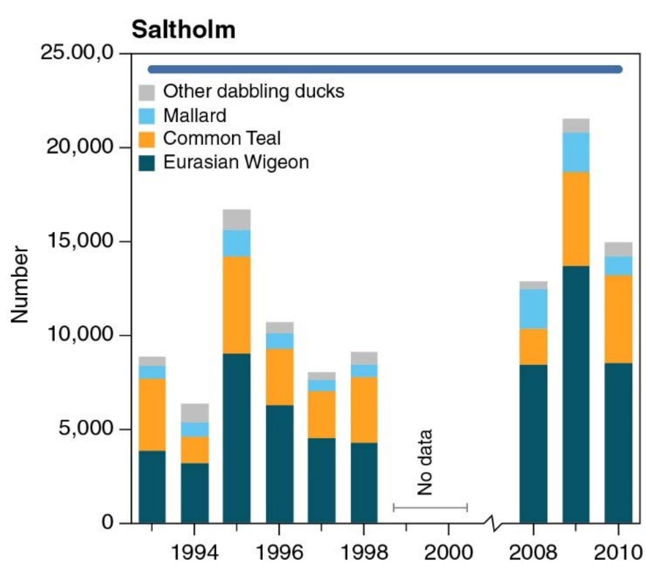
monitoring programs are temporarily segregated, with Swedish counts taking place in September and Danish counts in October.

**Figure 52: Autumn maximum abundance of dabbling ducks during 1993 to 2010 at Vestamager**




Source: Figures from Clausen *et al.*, 2014.

**Figure 53: Autumn maximum abundance of dabbling ducks during 1993 to 2010 at Saltholm**




Source: Figures from Clausen *et al.*, 2014.

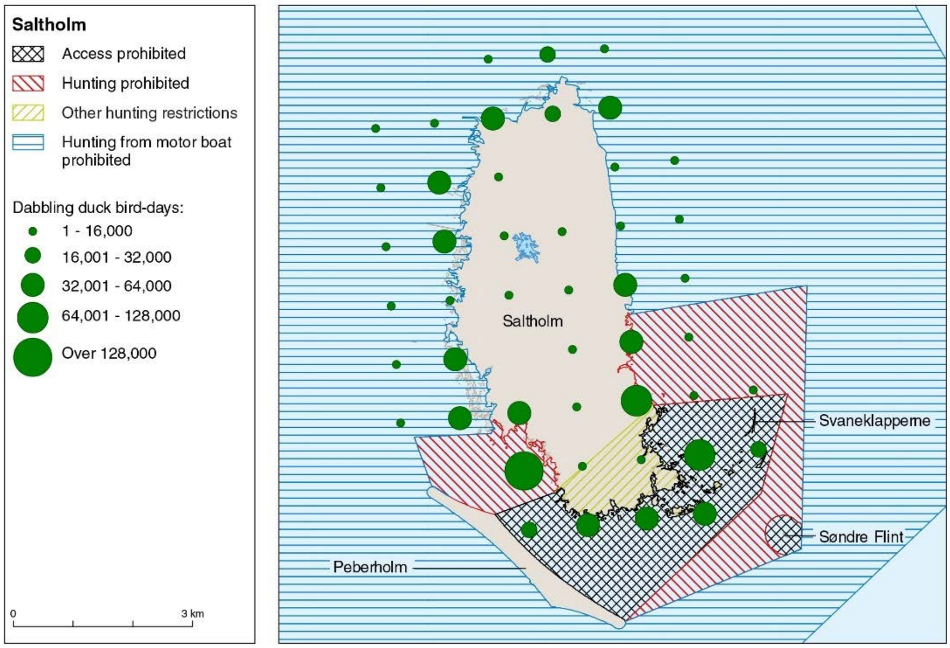
The Sound is also a feeding ground for diving ducks and the area is of international significance for at least two species, common eider (*Somateria mollissima*) and tufted duck (*Aythya fuligula*). Their use of the Sound is distinctly different, with eiders breeding in the area, whereas tufted ducks winter here.

Saltholm holds the largest breeding colony of eiders in Denmark, with 4,500 breeding pairs in 2010, whereas numbers breeding elsewhere in the Sound are small (Christensen & Bregnballe, 2011). The eiders arrive shortly before breeding and spend some weeks feeding, mostly in the shallows around Saltholm, until the females lay and incubate eggs. Immediately after hatch in mid-May, the females and their ducklings spread out over the entire Sound, where the ducklings feed in so called creches in shallow nursery areas. In 1993–94, 70% of the birds went to Sweden and 30% stayed in Denmark (Noer *et al*., 1994). After the ducklings fledge, the majority of the eiders fly northwest to moult and later winter in Kattegat.

Tufted ducks arrive from Fennoscandian and Russian breeding areas to winter in late October and depart during March, with peak numbers usually being present in December-February. Numbers are weather dependent, with highest numbers (up to 50,000 birds) recorded in cold winters (Christensen & Noer, 1994). The tufted ducks daytime roost at undisturbed lakes and harbour basins, mostly near Copenhagen, but also around Malmö (Andersen-Harild, 1991). From the daytime roosts, the birds fly out at dusk to feed on mussels around Saltholm, in Køge Bugt and Lommabukten (Christensen & Noer, 1994; Andersen-Harild, 1991).

The potential environmental impacts of the construction of the fixed link (a bridge and tunnel) between Copenhagen and Malmö were subject to heavy debate in the early 1990s, also regarding the effects on birds. Therefore, intensive monitoring and research activities were applied during 1993–1999; pre-, during and post-construction of the link. Breeding eiders, moulting greylag geese and moulting and wintering mute swans were selected as focal species for intensive studies of ecology, nutrition and behavioral responses to human disturbance, whereas other waterbirds were just counted. The overall conclusion from the studies was that although the construction of the tunnel and bridge might have caused a replacement of some birds in the areas around Saltholm, only a few species had been numerically affected, signalling that food supplies were plentiful around the island (e.g. Fox *et al*., 2000). In the cases where numbers did decline, factors affecting populations during their time spent outside the Sound may have had a more significant impact (e.g. Fox *et al*., 2000). In the years after the construction works have finished, some of the highest numbers of mute swans and dabbling ducks have been recorded around Saltholm (Clausen *et al*., 2014), so no long-term impacts on these species are expected.

**Figure 54: Distribution of dabbling ducks around the island Saltholm during 2008–2010 in UTM grid cells**




Note: Symbol size scales with abundance quantified as average number of bird days per km². Admittance and hunting regulation zones from 2014 marked with 1) blue horizontal lines (hunting from motor boats prohibited) 2) diagonal red lines (hunting prohibited) 3) black crosses (Admittance prohibited).

Source: Figure from Clausen *et al.*, 2014.

## 6.4 Drivers and Pressures

Human activities affect the ecosystems in and around the Sound directly and indirectly. This includes losses, physical damage and changes to terrestrial and marine habitats due to land used for infrastructure and offshore constructions. The marine environment is also affected by new near-shore constructions and coastal exploitation. Other drivers include fishery, which potentially effects ecosystem structure and biodiversity. Abrasion of the seafloor by fishing gear is another driver of change. Besides pollution coming from the intense maritime traffic, the Sound is particularly vulnerable to eutrophication due to its stratified water column, with potential further amplification due to climate warming. Each of these drivers are, to a varying extent, manageable on a local or regional scale. Climate change mitigation initiatives are, although ambitious, certainly of miniscule local effect.

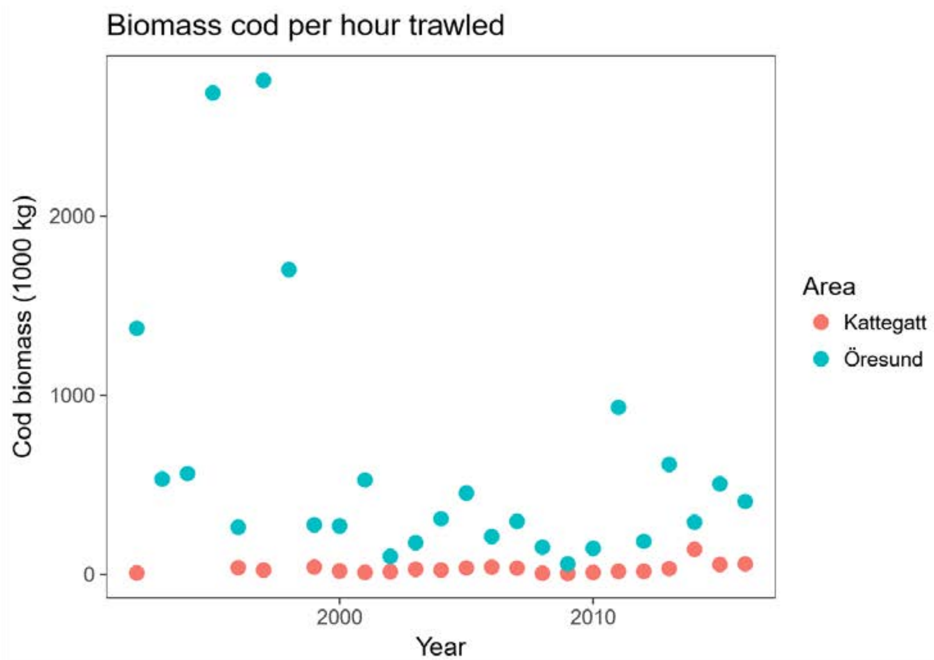
### *6.4.1 Physical disturbance*

Marine habitats are lost, damaged or changed due to offshore constructions, such as the Fixed Link across the Sound (built in 1996–2000). The construction itself occupies space from original habitats, excavations may have altered benthic habitats locally by siltation or by changes to seafloor substrates, and the reduced water exchange through the Sound may have had potential Baltic Sea-wide effects on hydrography. Whereas habitat losses were described (and accepted) during the project approval procedures, the extent of habitat change and damage was assumed manageable. Here, new standards were set as construction activities had to comply with specific environmental thresholds and standards. Otherwise, they were discontinued or revised (Dynesen, 1999; Øresundskonsortiet, 2000a). Physical disturbance from constructions of wind farms and extraction of raw materials on the Danish side, affects the ecosystem in a similar way. Wind turbines take up an insignificant area, but most concern focuses on potential long-term habitat change, along with the disturbance of migratory birds and fish (Pedersen & Malm, 2006). Extraction of raw materials (sand and gravel) is confined to minor designated areas. It is conclusive that marine biota will re-establish once the activity stops, but most likely, this new habitat will house different benthic communities. The risks that original habitat types become endangered by such changes are often handled at a local scale in environmental impact assessments, as exemplified in the Sound (Øresundskonsortiet, 1995). However, there is a need to consider potential cumulative effects at a regional scale, as they may arise for similar activities in larger sea areas (Pedersen & Malm, 2006). Furthermore, as the Sound defines the border of polyhaline (18–30) soft bottom habitats toward the Baltic Sea, the benthos may depend on population exchange and thereby healthy habitats in connecting seas (Josefson & Hansen, 2004; Bendtsen & Hansen, 2013). As a habitat with polyhaline mud bottoms, the Sound is unique for the absence of chronic physical disturbances of the sea floor due to the trawl ban. The historic trawl ban decision represents an indirect driver that may partially explain the relatively high diversity of the benthic fauna (Hansen & Blomqvist, in prep.). Exactly how much this ban has contributed to the benthic diversity in the Sound is still uncertain, as the Sound may not function to serve as a reference for the nearby and continually trawled Kattegat (Pommer *et al.*, 2016).

### *6.4.2 Fishing intensity and selectivity*

The cod stock in the Sound has a wider size distribution and is considered much more productive than adjacent cod stocks (Svedäng *et al.*, 2010a & 2010b; Lindegren *et al.*, 2013; Sundelöf *et al.*, 2013; ICES, 2015). The Sound cod stock shows no significant temporal changes in catch-per-unit-effort, however the abundance of cod is much higher in the Sound than in the Kattegat (fig. 55). As opposed to the development of the eastern and western Baltic cod stocks, the size-distribution of the Sound cod is becoming neither wider nor more truncated (Svedäng & Hornborg, 2017). The Sound differs in exploitation patterns from the Kattegat and the western and eastern Baltic, particulary in terms of the selection of gear. In the Sound fishery is based on gill nets instead of trawl, which is a plausible explanation for the difference in productivity between the Sound and the Baltic or the Kattegat cod stocks. The bell-shaped type of selectivity in gill net fishing compared to trawl fishing, where selectivity curves show saturation with a steep increase on the left-hand side and a flat curve on the right side (Harley & Myers, 2001), has in fact also been suggested to stabilise population dynamics in earlier studies (Hutchings, 2009).

**Figure 55: Cod abundance in the Kattegat and the Sound (Öresund) over time: Catch per unit effort (kg cod per trawling hour)**

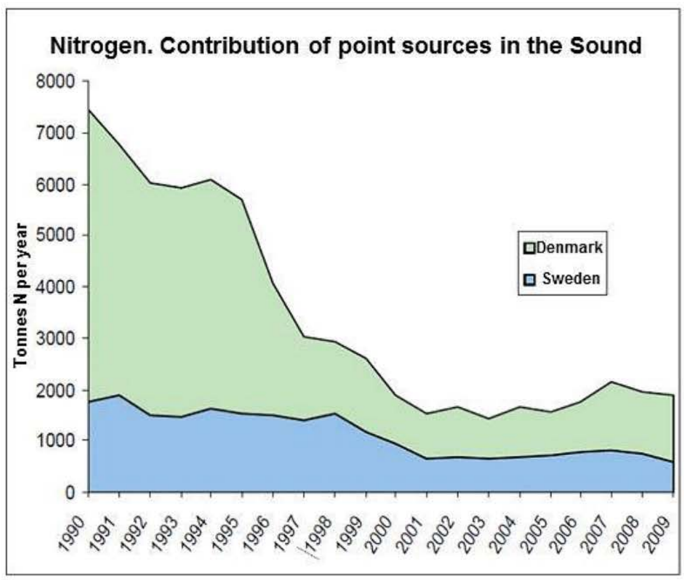



Source: Data from www.ices.dk

### 6.4.3 *Eutrophication*

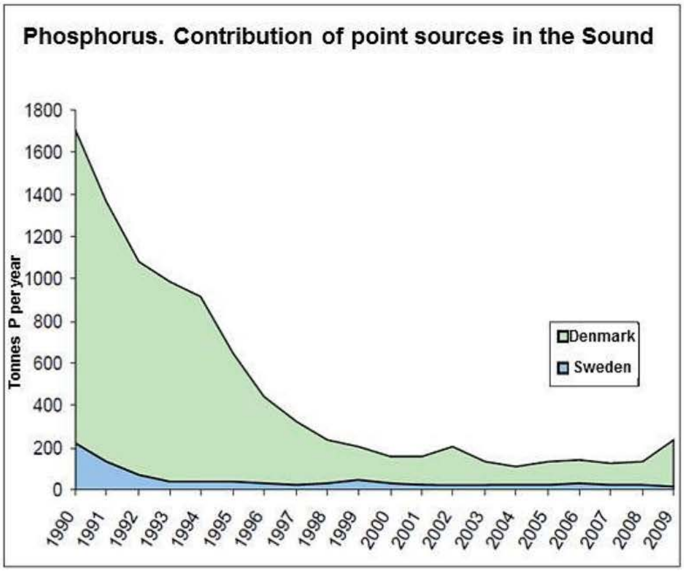
Eutrophication describes the phenomenon where one or more trophic levels in an ecosystem become enriched. For aquatic ecosystems, this is a direct driver linked to dense human populations, intensive agriculture or industrial production and is caused by loading of organic matter or inorganic nutrients into the ecosystem. The typical nuisances of eutrophication are algae blooms and poor water quality. This may further lead to hypoxia in bottom water, which is a growing problem causing mortality in benthic ecosystems worldwide (Diaz & Rosenberg, 2008). The eutrophication level in the Sound is impacted by both regional eutrophication levels in the Baltic Sea region, along with local point sources such as sewage treatment plants. Therefore, eutrophication status in the Sound depends on both Baltic Sea-wide nutrient management and local management by Swedish and Danish municipalities. Previously, most of the phosphorous loads came from urban point sources, both regionally and locally. Local point sources also contributed significantly to the nitrogen loads, but regionally, washout of fertilizers from farmlands was by far the main source. Nutrient concentrations in the Sound have decreased in the past decades. First, the phosphorous concentrations declined due to improved sewage treatment in the 1980s and 1990s (fig. 10). While this also reduced the local nitrogen load (fig. 56), the main reductions of nitrogen concentrations in open water occurred somewhat later following, with delay, the management of agricultural uses of fertilizers (Carstensen *et al.*, 2006). Presently, there is no significant indication of locally enhanced nutrient concentrations as would be expected if local nutrient loads were significant. Although the Sound may be sensitive to hypoxia due to its hydrography, no severe oxygen depletion events have occurred since 2002–2003.

**Figure 56: Loads of nitrogen to the Sound from point sources on the Danish (green) and Swedish (blue) side from 1990 to 2009**




Source: Data compiled by The Sound Water Cooperation http://www.oresundsvand.dk/english/html/reports.html

**Figure 57: Loads of phosphorous to the Sound from point sources on the Danish (green) and Swedish (blue) side from 1990 to 2009**




Source: Data compiled by The Sound Water Cooperation http://www.oresundsvand.dk/english/html/reports.html

### *6.4.4 Climate change*

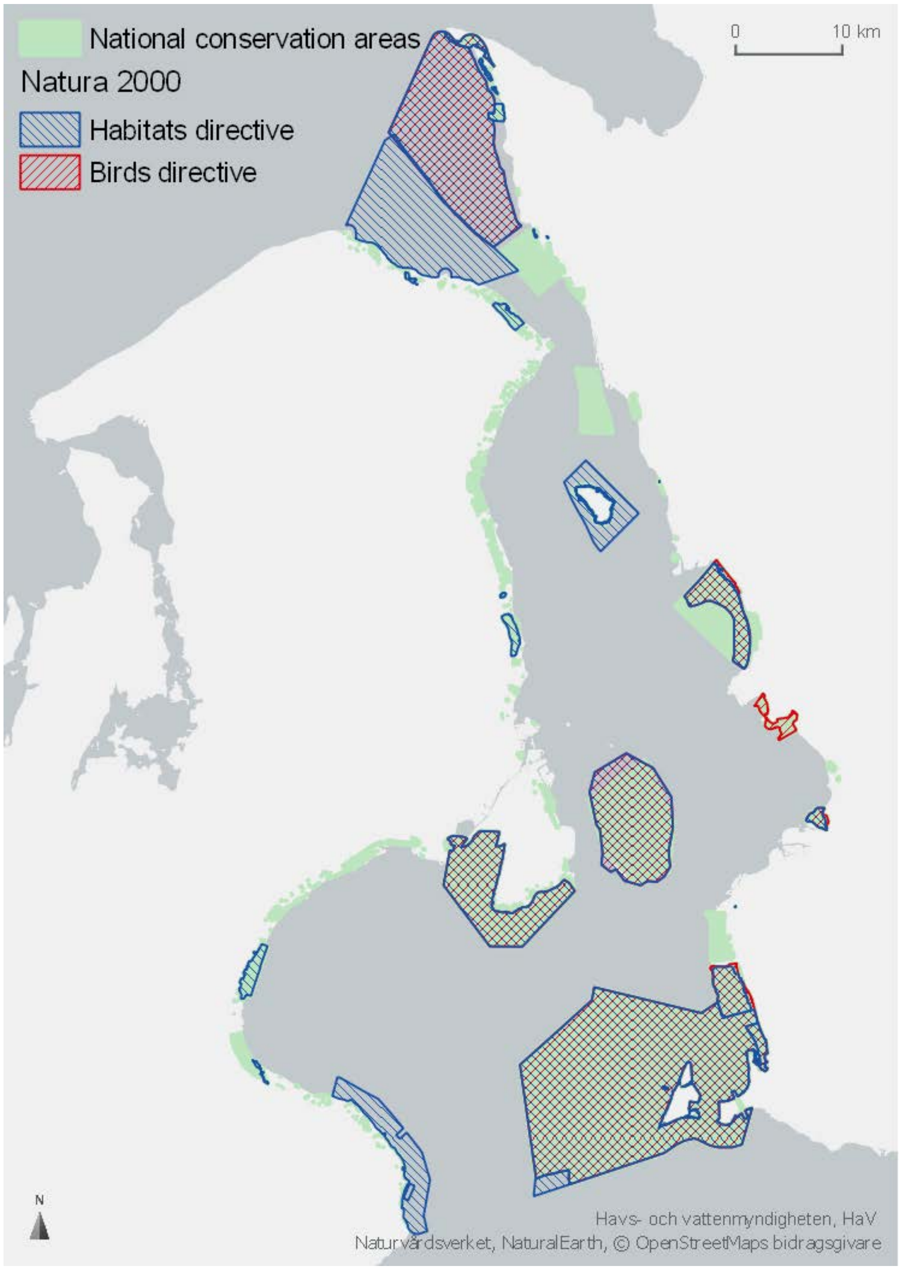
Climate warming arising from global human $CO_2$ emissions is a general driver that affects biodiversity, ecosystems function and services across all scales, and its potential effects on hydrography and water chemistry are multiple. The water temperature has already increased 1–2 °C over the last decades and further increase is likely to follow in the forthcoming century (IPCC, 2007; BACC, 2008). The marine ecosystem in the Sound will mostly be affected through climate-related changes in the hydrography, driven by changes in temperature or precipitation over the Baltic catchment area, wind regimes, etc. Temperature itself may affect biodiversity, but as salinity presently is the strongest regulating factor for biodiversity patterns in the Sound, climate driven changes in salinity (e.g. changes in precipitation) may be even more important for marine biodiversity in the future. Climate warming may also amplify eutrophication effects, and thus mitigation may require more ambitious management targets (e.g. further nutrient reductions). For example, rising temperatures generally causes reduction in bottom water oxygen (Hansen & Bendtsen, 2014), and a recent estimate shows that it would take a 30% further reduction in the eutrophication level to compensate for the expected temperature increases by the end of the 21th century (Bendtsen & Hansen, 2013). Climate warming could also favor blooms of blue-green algae in the central Baltic Sea, which depend on warm and calm summer periods combined with high phosphorous concentrations. Sometimes, easterly winds transport these blooms into the Sound and can prevent bathing at the coasts.

## 6.5 Governance of ecosystem services and influencing policies

### *6.5.1 Nature conservation and protected areas*

Through history, urban and agricultural development has fundamentally impacted the nature around the Sound. However, in recent decades, restrictive spatial planning regulations have substantially slowed down this development and now almost all remaining natural or semi-natural terrestrial habitats are protected in accordance with EU-legislation and/or national legislation (fig. 58). Natura2000 sites and national reserves are found in both countries. In Sweden, a number of municipal reserves also exist. In Denmark all open land natural areas larger than 0.25 ha are subject to protection. The management of the protected areas varies. Natura2000 area specific management plans are mandatory. Generally, most terrestrial areas are subject to some kind of active management, including maintenance of e.g. grassland habitats. Furthermore, most areas important to breeding water birds are subject to access restrictions, at least during the breeding season. Several reserves, including Natura2000 sites, stretch across the coastline, comprising both terrestrial and marine areas. Presently, about 690 $km^2$ of sea and 90 $km^2$ of land are protected in the coastal zone of the Sound. This corresponds to around 30% of the sea and 23% of the land within a 1 km inland zone, but with some additional areas around Copenhagen and on the island of Saltholm (cf. fig. 58).

**Figure 58: Protected areas in the Sound coastal zone**




Note: Natura2000 areas are established according to EU-directives as indicated. In Sweden, national conservation areas include nature reserves, whereas in Denmark they encompass protected terrestrial habitat types, nature and wildlife reserves and other areas of conservation. Protected areas up to 1 km inland from the coastline are shown.

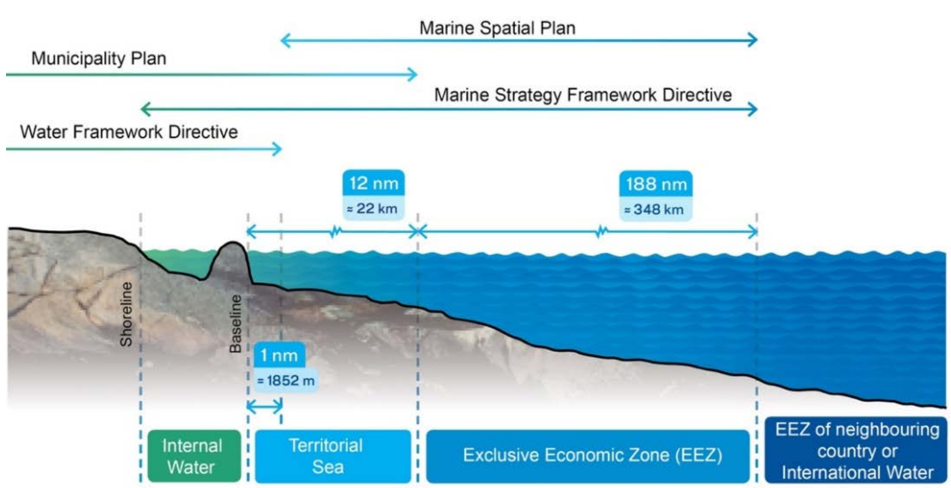
Source: Naturvårdsverket, NaturalEarth.

### *6.5.2 Management of marine ecosystems and ecosystem services*

In general, the marine environment is protected according to the EU Water Framework Directive (WFD) which covers the coastal zone, and the Marine Strategy Framework Directive (MSFD) which covers the open waters. However, the Swedish part of the central Sound is managed under the WFD whereas the Danish part is managed under both directives. In principle, these directives are ambitious and call for strict regulations to achieve defined targets. However, the related management plans are only in place for the WFD, whereas the final interpretation and definitions of "good environmental status" (GEnS) under MSFD is still pending and subject to scientific analyses.

Recreational fishery in Denmark and Sweden is well regulated. The regulations cover both sports fishing (anglers with rod and line) and subsistence fishing (fishing with a restricted number of fishing tackles, nets, traps etc). To protect migratory fish species and to promote "fair gaming", both angling and fishing with standing fishing gear is prohibited in several parts of the Sound, notably river mouths and around harbours. As of 1st of January 2017 a "bag limit" of cod (5 per fisherman, 3 per fishermen in February and March) for all recreational fisheries has been established as part of the "Cod Recovery Plan". This is an unusual regulatory measure in the sea fishery in the Baltic.

**Figure 59: How the Water Framework Directive and the Marine Strategy Framework Directive meet in Swedish policy practice**




Source: Swedish Agency for Marine and Water Management.

Recreational fishery has benefitted from environmental regulations. For example, the outer harbour areas of Copenhagen are now open to sports fishing.

Small boat traffic and surfing etc. is a significant recreational coastal activity in the Sound. This is regulated in sensitive bird areas. However, disturbances are still reported. Particularly the use of jet skis is heavily debated both in relation to nature protection and to other recreational activities.

There is a long tradition of cooperation between the environmental authorities across the Sound. "The Sound Water Cooperation" is an agreement between Danish and Swedish municipalities and counties surrounding the Sound. The objective is to act for a healthy marine environment in the Sound. Among the tasks are to describe the state of the marine environment and factors that affect it, to formulate environmental targets for the marine environment of the Sound, and to disseminate knowledge and promote exchange of experiences regarding protection of the water environment and management techniques. The agreement was reached in 1995, but cooperation on these matters reaches more than 50 years back (http://www.oresundsvand.dk).

Some remarkable examples of governance described in the box below, illustrate that the marine environment and its ecosystem services in the Sound are, in some cases, placed very high on the political agenda.

**Box 7: Special cases of governance in the Sound**

*The Öresund Fixed Link*

In the years 1995–2000 a 16 km motorway and rail link was constructed across the Sound (Öresund) between Denmark and Sweden, made up of a bridge, a tunnel, an artificial island and a peninsula. Although this gave rise to serious environmental concerns, the impacts turned out to be remarkably restricted, largely as a result of careful planning and tough environmental requirements (Øresundskonsortiet, 2000b). This included a model based design to limit the blocking of water flow in and out of the Baltic Sea (Dynesen, 1999), specific limits on sediment discharge from dredging, specific criteria for acceptable local impacts (Øresundskonsortiet, 2000a), well-defined environmental responsibilities of the contractors, comprehensive adaptive monitoring (Dynesen, 1999) and a supervising international expert panel. However, the remarkable outcome was achieved only through the political acceptance in both countries of environmental costs amounting to 323 million US$, about 12% of the total construction costs (1990 prices, Gray, 2006).

*Bathing in the harbour of Copenhagen*

Since 2002 bathing has been possible – and popular – in the very centre of Copenhagen, in a number of harbour baths and bathing zones. This is the result of a targeted strategy after 46 years with a ban of bathing due to health risks. Through the 90s, more than EUR 100 million was invested in better sewer systems and large underground basins to reduce overflows into the harbour during heavy rainfall. Now bathing is allowed 90% of the time. Sensors provide data for real time 3D modelling of the water quality, which is communicated on the web and in a special app, which relays where bathing is possible (Lars Anker Angantyr, pers. comm.). Bathing is also possible in the harbour of Malmö.

### 6.5.3 Management of terrestrial ecosystems and ecosystem services

As mentioned previously, most terrestrial natural ecosystems in the region are managed by national or EU-legislation. Both in Denmark and in Sweden, there is regulation regarding shoreline protection (SE: Strandskydd enligt Miljöbalken 7:e kapitlet 13 §), which protects the beaches from being exploited and allows public access to beaches. However, the future of nature conservation strongly depends on the future governance, and thus the municipalities have an important role through city planning. Urban development still puts pressure on natural areas. One example is the recent development of the district "Ørestad" on the island of Amager just south of central Copenhagen, which now occupies more than 5 km² of formerly protected semi-natural coastal habitats. Plans for further development of urban settlements in the same area exist, but they are currently debated. Furthermore, the neighbouring and protected nature reserve Vestamager, is expected to receive a fast growing number of visitors for recreational purposes. The area is also obliged to receive rainwater from Ørestad, which has already required enlargement of drainage channels and establishment of a rainwater reservoir.

The pressure on land for development of the urban areas is reinforced by continuous urbanisation. The increasing population and changes in lifestyle increase the demand for better housing and recreational outdoor facilities. This, in turn, leads to crowding effects and increased pressure on existing natural areas.

In Denmark near-coastal state forests even in Natura2000 sites are subject to commercial logging. However, according to a new strategic plan from the Danish government, logging will be discontinued in 20% of all state forests. This will presumably also cover areas in the Danish Sound region.

### 6.5.4 *The Sound in the Future*

Marine spatial planninig (MSP) is being implemented and plays an important role in the future of the Sound. MSP will help to safeguard the ecosystem services and livelihoods that create the basis for tourism, recreation and a thriving culture. The ecosystem approach to MSP is applied to ensure a sustainable use of marine resources. There is a need for an increased collaboration between the different municipalites in order to meet the various demands from a heterogenous society.

**Figure 60: Area of marine spatial planning in Öresund**


Source: Havs- och vattenmyndigheten. *Havsplan Östersjön*. Draft 2016, p. 26.

One recent initiative is to improve the protection of the Sound to achieve sustainable development of the area. Several nature NGOs, both in Denmark and in Sweden, along with "The Sound Water Cooperation", have recommended the establishment of a marine protected area covering the entire Sound, potentially under UNESCO's Biosphere Programme. The organisations include e.g. WWF, Greenpeace, Friluftsrådet (The Outdoor Council, Denmark), Danmarks Sportsfiskerforbund (the Danish association of Sport Fishing), Naturskyddsföreningen Skåne (the Nature Protection Association of Scania) and Øresundsakvariet (The Sound Aquarium) (e.g. The Sound Water Cooperation, 2014).

As described above (see 6.3.1 and 6.3.2), the ecological status of the benthic biodiversity in the Sound is likely to have benefitted from a trawling ban, which was implemented in 1932 for navigation safety reasons. However, changing the status of the trawling ban into a nature conservation regulation could support the longterm maintenance of the good ecological conditions, if technological and other developments in navigation make the trawling ban unnecessary as a safety regulation.

In the Danish Planning Act special restrictions apply to the coastal zone, reaching three kilometres inland from the coast. However, according to a proposal from the Danish government to improve and modernise The Planning Act, some of these restrictions will be relieved to stimulate development of production and the retail-business within the coastal zone (Ministry of Industry, Business and Financial Affairs, 2016). The "beach protection line" (Nature Protection Act) still affirms a very restrictive protection 300 meters inland, but even here it will be easier to get dispensations to carry out minor changes. (Ministry of Industry, Business and Financial Affairs 2016)

## 6.6 Insights from indigenous and local knowledge

Local communities around the Sound have been dependent on local fish stocks throughout history. However, urbanization has reduced the number of people directly dependent on fishing. Three groups of fishermen, commercial fishermen, sport fishermen and household fishermen, compete for a share of the common fish stocks. In official contexts however, sports- and household fishermen are both considered recreational activities, although the management of the two groups are different. Furthermore, the demographics of the two groups are notable. The household fishermen are fewer, older and with a lower average income. The ban on marketing of catch from all recreational fisheries therefore influences the household fishermen more than the sports fishermen. The household fishermen perceive their influence as deteriorating with the development. They also find themselves politically invisible, since the Swedish national sportfishing association has 60,000 members, while household fishermen mainly rely on local and/or regional associations with few members and comparatively less political influence. From the household fishermen's perspective, the most important difference is that the main purpose of their fishing is to bring food to the table, while true recreational fishing is mainly for sport, sometimes even as catch-and-release. According to official Swedish statistics, sport fishing and household fishing represent less than 4% of the total landings in the Sound (Havs- och vattenmyndigheten, 2016, p. 1 & 2017, p. 10–11).

The recruitment of new commercial fishermen in the Sound is limited. According to Säwe and Hultman (2013a) a number of factors contribute to this. The number of small-scale coastal commercial fishermen has been steadily declining over the past 50 years, as the technical and economic development, as well as the management of fisheries, has favoured productivity and economy of scale. Thus, representatives of the commercial fishery in Scania (southern Sweden) find that their fishing is over-regulated and that they lack influence and participation in management decisions. They also claim that there is a lack of knowledge and understanding within the local administration and among household fishermen and fishing tourism. Other perceived challenges are competition for the available fishing waters and fish stocks, along with the fact that seals and cormorants have become more abundant during recent decades. Commercial fishermen argue for more flexible local governance and options to develop local markets and sell directly to consumers. The regulations of today make this impossible.

Several small-scale fishing harbours of historical importance for commercial fishing are today maintained by local household fishermen. According to them, they attract tourists and maintain services for summer guests and visiting sports fishermen. Furthermore, local social relationships were strengthened when household fishermen could sell part of their catch to local consumers, but this was banned in 2011. Local household fishermen also maintain traditional knowledge on local fish stocks and the handicraft of small-scale fishing. In Sweden, some stakeholders find that fishing policies of the last decade, including some specific regulations, have favoured large-scale commercial fishing and sports fishing or fishing tourism, and thus hampered local household fishing. It is claimed that things are generally viewed from an economic perspective, with arguments like "fishing tourism creates jobs and revenues to local communities", while the benefits to the households (e.g. economic) and the cultural and social importance of the fisheries is generally lost in such calculations. Local politicians are also accused for being short sighted and not acting in favour of sustainability. At the same time, the coastal estate market works against both household fishing and sports fishing, since high prices tend to limit public access to fishing and living along the coast (Säwe & Hultman, 2013b).

People involved in household fishing and sport fishing often value their activities with common terms like "environmentally friendly", "quality of life", "intergenerational contactso", "respect for other people", "connecting man with nature", and "a part of our common cultural heritage". Even though these values reflect mainly social and cultural ecosystem services, the two parties evaluate the services differently. The sports fishermen often point at the potential economic profit from fishing tourism, while household fishermen tend to focus on softer non-monetary values of emotional and cultural gains (Säwe & Hultman, 2013b).

In 2006, the regional association "Öresundsfiskarna" was formed in order to bridge opinions between all stakeholders relevant to fisheries: Commercial and recreational fishermen, as well as local authorities and municipalities. A new initiative is community-supported fishery, where consumers buy the catch from fishermen in advance, which is supposed to create a social relationship between consumers and fishermen and support the local economy. Another recent initiative is the planning for marine protected areas (MPAs) in the northern parts of the Sound. However, local fishing interest have not yet been consulted on this matter (Protocols 2014-05-28, 2015-05-29, 16-06-03, 16-12-02). MPAs may conflict with fishing interests, if fishing with nets and other standing tackle are banned here. However, the definitions and regulations of MPAs vary and in the existing areas in the Sound (Figure 59), no such ban exists.

## 6.7 Concluding remarks

As mentioned above, the Sound has a viabrant vibrant local fishery. However, the prospects of lucrative fishing opportunities in the Sound may, in the future, lead to increased effort and an increased number of vessels. This is a probable issue as those vessels that have access to the western Baltic cod fishery, also have access to the local cod stock in the Sound. Thus, both biological advice and access regulations are part of a larger management area. This lack of sub-stock specific assessments prevents scientific evaluation of the status and productivity of the stock. Thus, local management decisions need to ensure a healthy cod stock and economically viable fishing opportunities for local fishermen.

In conclusion, the ecosystems and ecosystem services of the Sound are generally well managed. In general, the policies and regulations dealing with these matters have been ambitious and effective. But in a densely populated area like this, continuous pressures exist. These are not only restricted to the direct ones from urban development and accompanying recreational facilities and activities. Constant pressures from the primary industries and the maritime community for laxing restrictions also constitute a challenge to future governance. To meet these challenges, it is recommended to:

- thoroughly assess and consider the consequences of further urban development and associated pressures on biodiversity, ecosystems and ecosystem services;
- thoroughly assess and consider the impacts before reducing any regulations already in place;
- consider the implementation of marine spatial planning across the entire Sound;
- consider all kinds of ecosystem services in decision making and governance;
- increase the dialogue between different groups of users of biological resources in the region;

- consider changing the trawling ban from a navigational regulation into a nature conservation regulation;
- consider the possibility of implementing sub-stock assessments of the fish stocks in the Sound;
- consider stricter regulations of the use of jet skis.

## 6.8 References


Andersson, J., Westerberg, H., & Thörnqvist, S. (1999). *Fiskeriundersökningar i Öresund 1998*. Fiskeriverket Kustlaboratoriet. Unpublished report in Swedish.

Andersen-Harild, P. (1991). *Vandfugle og sæler i Øresund.* Miljøministeriet, Skov- og Naturstyrelsen. 86 p.

Anonymous. (1932). *Kommissionen med Danmark angående fiskeriförhållandena i det till Sverige och Danmark gränsande farvattnen*. Stockholm, 31 December 1932.

BACC Author Team. (2008). *Assessment of Climate Change for the Baltic Sea Basin*. BACC Author Team, Springer.

Baden, S., Gullström, M., Lundén, B., Pihl, L., & Rosenberg, R. (2003). Vanishing seagrass (*Zostera marina*, L.) in Swedish coastal waters. *AMBIO: a Journal of the Human Environment*, *32*, 374–377.

Bagge, O. G., Thurow, F., Steffensen, E. & Bay, J. (1994). The Baltic cod. *Dana*, *10*, 1–29.

Bendtsen, J., & Hansen, J.L.S. (2013). Effect of global warming on hypoxia in the Baltic Sea-North Sea transition zone. *Ecological modelling*, *264*, 17–26.

Börjesson, P., Jonsson, P., Pacariz, S., Björk, G., Taylor, M.I. & Svedäng, H. (2013). Spawning of Kattegat cod (*Gadus morhua*) – mapping spatial distribution by egg surveys. *Fisheries Research*, *147*, 63–71.

Carstensen, J., Conley, D. J., Andersen, J.H., & Ærtebjerg, G. (2006). Coastal Eutrophication and trend reversal: A Danish case study. *Limnol. and Oceanogr, 51*, 398–408.

Christensen, T.K., & Bregnballe, T. (2011). Status of the Danish breeding population of Eiders *Somateria mollissima* 2010. *Dansk Ornitologisk Forenings Tidsskrift, 105*, 195–205.

Christensen, T. K., & Noer, H. (1994). *Base-line investigations of nocturnal foraging by wintering waterbirds in Øresund, 1994.* National Environmental Research Institute. Commissioned report to Øresundskonsortiet. 35 pp.

Clausen, P., Kahlert, J., Andersen-Harild, P., & Nilsson, L. (1996). *Base-line investigations of moulting mute swans around Saltholm, 1993-1995: Results and conclusions.* National Environmental Research Institute. Commissioned report to Øresundskonsortiet. 59 pp.

Clausen, P., Holm, T.E., Therkildsen, O.R., Jørgensen, H.E., & Nielsen, R.D. (2014). *Rastende fugle i det danske reservatnetværk 1994-2010. Del 2: De enkelte reservater.* Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 236 p. – Videnskabelig rapport fra DCE – Nationalt Center for Miljø og Energi nr. 132.

Cole, S. G., & Moksnes, P.-O. (2016). Valuing multiple eelgrass ecosystem services in Sweden: fish production and uptake of carbon and nitrogen. *Frontiers in Marine Science 2*, Article 121. https://doi.org/10.3389/fmars.2015.00121

Diaz, R.J., & Rosenberg, R. (1995). Marine benthic hypoxia: A review of its ecological effects and the behavioural responses of benthic macrofauna. *Oceanogr. Mar. Biol. Ann. Rev., 33*, 245–303.

Diaz, R. J., & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science*, *321*, 926–929.

Duarte, C. M., Middleburg, J.J., & Carao, N. (2005). Major role of marine vegetation on the oceanic carbon cycle. *Biogeosciences*, *2*, 1–8.

Dynesen, C. (1999). *Environmental Management and the Impact on Execution.* Proceedings of the Øresund Link Dredging and Reclamation Conference, 26–28 May 1999, Copenhagen, Denmark. Iversen, C. & Mogensen, B. (Eds.). pp. 51–59.

Fox, A. D., Kahlert, J., Christensen, T. K., Hounisen, J. P., & Clausen, P. (2000). *Monitoring of migrating waterfowl on Saltholm, 1993–1998.* Commissioned report to Øresundskonsortiet, 48 p.

Fødevareministeriet, (2010). *Analyse af adfærd, motiver og præferencer blandt danske lystfiskere* Part of project 'Samfundsøkonomisk betydning af lystfiskeri i Danmark' Marts 2010. Kongens Lyngby: COWI A/S.

Gray, J. (2006). Minimizing Environmental Impacts of a Major Construction: The Øresund Link. *Integrated Environmental Assessment and Management*, *2*, 196–199.

Göransson, P., Bertilson, V.S., Karlfeldt, J., & Börjeson, L. (2010). *Haploops-samhället och modiolus-samhället utanfor Helsingborg 2000-2009*. Miljönämnden i Helsingborg. 79 pp.

Hansen, J.L.S., & Bendtsen, J. (2013). Rarameterisation of oxygen dynamics in the bottom water of the Baltic Sea- North Sea transition zone. *Marine Ecology Progress Series, 481*, 25–39.

Hansen, J. L. S., & Bendtsen, J. (2014). Seasonal bottom water respiration in the North Sea – Baltic Sea transition zone: rates, temperature sensitivity and sources of organic material. *Marine Ecology Progress series, 499*, 19–34.

Hansen, J. L. S., Dinesen, G., Bastardie, F., & Eigaard, O. R. (2016). *Notat om effekter af fiskeri med bundslæbende redskaber på bundfaunaen i de indre danske farvande.* Notat fra DCE. Århus University: DCE – Center for Miljø og Energi.

Hansen, J. L. S. & Bendtsen, J. (in prep.). *Respiration data from the bottom water in the Sound, spring 2008*.

Hansen, J. L. S., & Blomquist (in prep.). *Effekt af bundtrawling på bundfaunasamfund i Kattegat undersøgt med forskellige bundfaunaindeks på NOVANA-overvågningsdata*. Report from DCE. Århus University: DCE – Center for Miljø og Energi.

Harley, S.J., & Myers, R.A. (2001). Hierarchical Bayesian models of length specific catchability of research trawl surveys. *Canadian Journal of Fisheries and Aquatic Sciences, 58*, 1569–1584.

HELCOM. (2003). *The oxygen depletion event in the Kattegat Belt Sea and Western Baltic*. Baltic Sea Environmental Proceedings, No 90.

Hutchings, J. A. (2009). Avoidance of fisheries-induced evolution: management implications for catch selectivity and limit reference points. *Evolutionary Applications, 2*, 324–334.

ICES. (2012). *Report of the ICES advisory committee*. ICES Advice. Books 1–11, International Council for the Exploration of the Sea (www.ices.dk).

ICES. (2013) *WGBIFS BITS Manual 2013*. Manual for the Baltic International Trawl Surveys, March 2013, Tartu, Estonia. pp. 17 and appendix (http://www.ices.dk/sites/pub/)

ICES. (2015) *ICES WGBFAS Report 2015*. Section 2.1 Cod in Subdivisions 25–32.

ICES ADVISORY COMMITTEE, I. (2016). *Report of the Herring Assessment Working Group for the Area South of 62° N (HAWG)*. International Council for the Exploration of the Sea. Copenhagen: ICES.

IPCC. (2007). Climate change 2007. The physical science basis. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., Miller, H. L. (Eds.), *Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK & New York, USA, Cambridge University Press.

Havs- och vattenmyndigheten. (2016). Jo 55 SM 1601, *Det yrkesmässiga fisket i havet 2015*. Sveriges officiella statistik/Statistiska meddelanden. (Swedish official statistics).

Havs- och vattenmyndigheten. (2017). Jo 57 SM 1703, *Fritidsfisket i Sverige 2015*. Sveriges officiella statistik/Statistiska meddelanden. (Swedish official statistics).

Joensen, A. H. (1974). *Waterfowl populations in Denmark 1965–1973.* Danish Review of Game Biology 9. 206 p.

Jonasson, L., Hansen, J. L. S., Wan, Z., & She, J. (2012). The impact of physical processes on oxygen variation in the North Sea- Baltic sea transition zone. *Ocean Science, 8*, 37–48.

Josefson, A. B. & Hansen, J.L.S. (2004). Species richness of benthic macrofauna in Danish estuaries and coastal areas. *Global Ecol. and Biogeogr*, *13*, 273–28.

Josefson, A. B., Blomqvist, M., Hansen, J. L. S., Rosenberg, R., & Rygg, B. (2009). Assessment of marine quality change in gradients of disturbance: Comparison of different Scandinavian multi-metric indices. *Marine Pollution Bullentin*, *58*, 1263–1277.

Josefson, A. B., & Hansen, J. L. S. (2004). Species richness of benthic macrofauna in Danish estuaries and coastal areas J. *Global Ecol. Biogeography*, *13*, 273–288.

Kahlert, J., Clausen, P., & Nilsson, L. (2000). *Monitoring of moulting mute swans around Saltholm, 1999.* Commissioned report to Øresundskonsortiet. 42 p.

Lagenfelt, I., & Svedäng, H. (1999). *Fisk och fiske i Västerhavets och Öresunds kustområden*. Fiskeriverket rapport 1999:7. 51 p.

Lindegren, M., Waldo, S., Nilsson, P. A., Svedäng, H., & Persson, A. (2013). Towards sustainable fisheries of the Öresund Cod (*Gadus morhua*) through sub-stock specific assessment and management recommendations. *ICES Journal of Marine Science*, *70*, 1140–1150.

Magnus, O. (1555). *Historia de gentibus septentrionalibus* ("Description of the Northern Peoples"). Rome.

Ministry of Industry, Business and Financial Affairs (2016). *Aftale om Danmark i bedre balance – Bedre rammer for kommuner, borgere og virksomheder i hele landet.* http://em.dk/aftaler-og-udspil/16-06-09-planlovsaftale

Moksnes, P.-O., Gipperth, L., Eriander, L., Laas, K., Cole, S., & Infantes, E. (2016). *Förvaltning och restaurering av ålgräs i Sverige – Ekologisk, juridisk och ekonomisk bakgrund*. Havs- och vattenmyndigheten, Rapport nummer 2016:8, 150 p

Nilsson, L. (1975). Midwinter distribution and numbers of Swedish Anatidae. *Ornis Scandinavica*, *6*, 83–107.

Nilsson, L. (2005). Wintering swans *Cygnus* spp. and Coot *Fulica atra* in the Ôresund, South Sweden, in relation to available food resources. *Ornis Svecica*, *15*, 13–21.

Noer, H., Fox, A. D., Madsen, J., Christensen, T. K., Clausen, P. Ettrup, H., Kahlert, J. & Petersen, B. M. (1994). *Base-line investigations of waterfowl in Øresund, 1993-1994: Results and conclusions*. National Environmental Research Institute. Commissioned report to Øresundskonsortiet. 57 p.

Norén, F., Haamer, J., & Lindahl, O. (1999). Changes in the plankton community passing a *Mytilus edulis* mussel bed. *Marine Ecology Progress Series,* 191, 187–194.

Olsson, P. (2016). *Undersökningar in Öresund 2015 – ålgräs*. ÖVF Rapport 2016:5.

OSPAR (2003). *OSPAR list of threathned and/or declining species adopted in 2003*. http://www.helcom.fi/publications/bsep/en_GB/bseplist

Petersen, J. K., & Malm, T. (2006). Offshore windmill farms: threats to or possibilities for the marine environment*. Ambio*, *35*, 75–80.

Petersen, C. G. J. (1913). Havets bonitering II: Om havets dyresamfund og disses betydning for den marine zoogeografi. *Beretning fra Ministeriet for Landbrug og Fiskeri. Den Danske Biologiske Station*, *21*, 1-42.

Pommer, C. D., Olesen, M., & Hansen, J. L. S. (2016). Impact and distribution of bottom trawl fishing on mud-bottom in the Kattegat *Mar. Ecol. Prog. Ser*, *548*, 47–60.

Politiken.dk (2010) http://politiken.dk/kultur/art5444565/Amager-Strand-s%C3%A6tter-bes%C3%B8gsrekord

Schoeman, K., Van der Merwe, P., & Slabbert, E. (2016, 09). The Perceived Value of a Scuba Diving Experience. *Journal of Coastal Research*. pp. 1071–1080.

Stephenson, R. L. (1999). Stock complexity in fisheries management: A perspective of emerging issues related to population sub-units*. Fisheries Research, 43*, 247–249.

Sundelöf, A., Wennhage, H., & Svedäng, H. (2013). A red herring from the Öresund (ICES 40G2): the apparent recovery of the Large Fish Indicator (LFI) in the North Sea hides a non-trawled area. *ICES Journal of Marine Science, 70*, 1081–1084.

Svedäng, H. & Hornborg, S. (2017). Historic changes in length distributions of three Baltic cod (*Gadus morhua*) stocks: Evidence of growth retardation. *Ecology & Evolution*, *7*(16), 6089–6102. https://doi.org/10.1002/ece3.3173

Svedäng, H., Hagberg, J., Börjesson, P., Svensson, A., & Vitale, F. (2004). *Bottenfisk i Västerhavet. Fyra studier av beståndens status, utveckling och lekområden vid den svenska västkusten*. Finfo 2004:6. 42p.

Svedäng, H., André, C., Jonsson, P., Elfman, M., & Limburg, K. (2010a). Migratory behaviour and otolith chemistry suggest fine-scale sub-population structure within a genetically homogenous Atlantic cod population. *Environmental Biology of Fishes*, *89*, 383–397.

Svedäng, H., Stål, J., Sterner, T., & Cardinale, M. (2010b). Consequences of Subpopulation Structure on Fisheries Management: Cod (*Gadus morhua*) in the Kattegat and Öresund (North Sea). *Reviews in Fisheries Science*, *18*, 139–150.

Säwe, F., & Hultman, J. (2013a). *Fråga oss!! Vi vet!! Skånska yrkesfiskare om det kustnära fisket*. Helsingborg: Lunds universitet (Campus Helsingborg).

Säwe, F., & Hultman, J. (2013b). *Det är ett sätt att vara … Skånska husbehovs- och sportfiskare om fisketurism och kustens framtid*. Helsingborg: Lunds universitet (Campus Helsingborg).

The Sound Water Cooperation (2014). *Beskyt Øresunds natur? Bør der oprettes et marint reservat*. Øresundsvandsamarbejdet, 2014.

Toivonen, A. L., Appelblad, H., Bengtsson, B., Geertz-Hansen, P., Guoebergsson, G., Kristofersson, D., Kyrkjeboe, H. *et al*. (2000) *Economic value of recreational fisheries in the Nordic countries* TemaNord 2000:604. Nordic Council of Ministers.

Toxicon AB. (2017). *Ålgräs i Skåne 2016 – Fältinventering och satellitbildstolkning*. Malmö: Sweden.

Ulrich, C., Post, S. L., Worsøe Clausen, L., Berg, C. W., Deurs, M. V., & Mosegaard, H. *et al*. (2012). *Modelling the mixing of herring stocks between the Baltic and the North Sea from otolith data.* Technical University of Denmark, DTU-Aqua. Charlottenlund: Technical University of Denmark.

Vitale, F., Börjesson, P., Svedäng, H., & Casini, M. (2008). The spatial distribution of cod (*Gadus morhua* L.) spawning grounds in the Kattegat, eastern North Sea. *Fisheries Research*, *90*, 36–44.

Waycott, M., Duarte, C. M, Carruthers, T. J. B., Orth, R. J., Dennison, W. C., Olyarnik, S. *et al*. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, *106*, 12377–12381.

www.kk.dk (2014). http://www.kk.dk/nyheder/havnebadet-p%C3%A5-islands-brygge-s%C3%A6tter-ny-rekord.

Zeller, D., Rossing, P., Harper, S., Persson, L., Booth, S., & Pauly, D. (2011). The Baltic Sea: estimates of total fisheries removals 1950–2007. *Fisheries Research*, *108*, 356–363.

Øresundskonsortiet (1995). *Supplementary Assessment of the Impacts on the Marine environment of the Øresund Link*. March 1995.

Øresundskonsortiet (2000a). *Description of Marine Environmental Criteria for the Øresund Link Project*. Control Procedures.

Øresundskonsortiet (2000b). *Environmental Impacts of the Construction of the Øresund Link*.

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# 7. Helgeland: An Atlantic archipelago (Norway)

*Kasper Hancke, Hege Gundersen, Kristin Magnussen, Egil Postmyr, Guri Sogn Andersen, Karl-Otto Jacobsen, and Håkan Tunón*

## 7.1 Setting the scene

The Helgeland archipelago stretches across 200 km, extending from Trøndelag in the south to Salten in the north. This iconic part of the Norwegian coast comprises a myriad of islands and islets (more than 12,000) and large shallow sea areas (fig. 61 and 62). All along the coast there are white beaches, sheltered coves, fjords and steep towering mountain walls rising straight from the open sea. A wealth of marine life thrives in the area, spanning from the smallest microalgae to the largest mammals. Harbor seals (*Phoca vitulina*), Atlantic puffins (*Fratercula arctica*), white-tailed eagle (*Haliaeetus albicilla*) and greylag goose (*Anser anser*) are among typical species encountered.

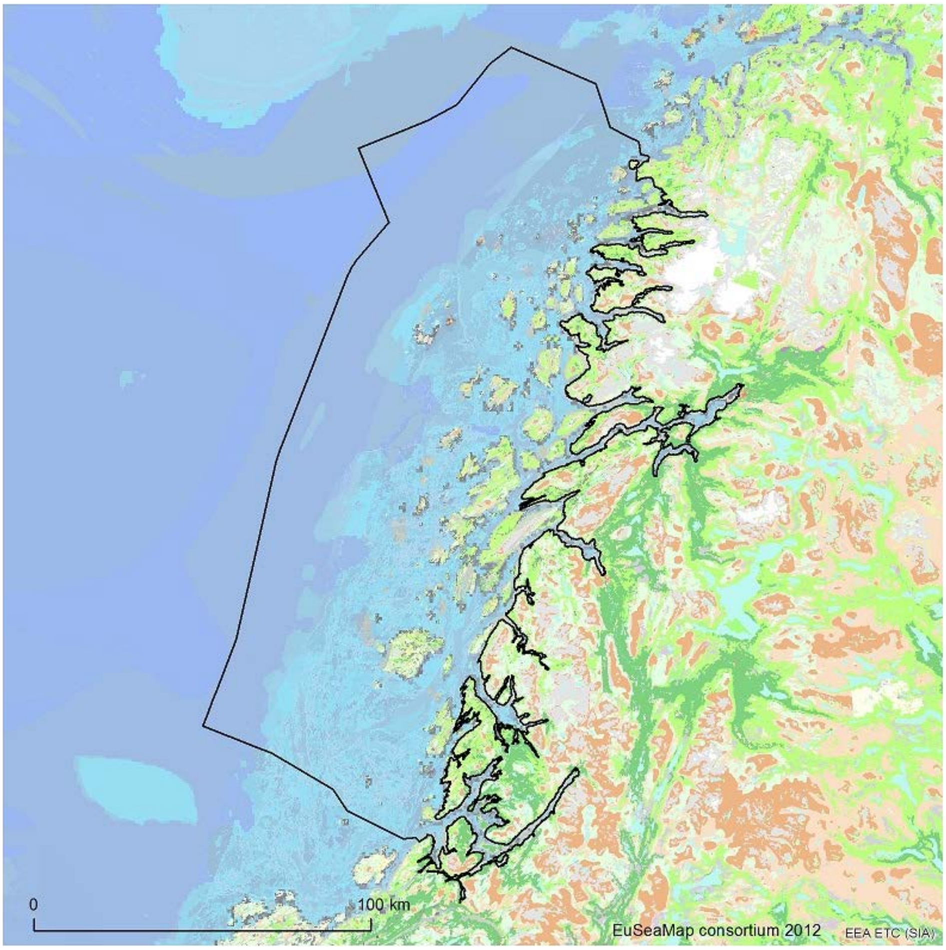
**Figure 61: The Helgeland archipelago**

Photo: I. Mahlum

The seabed is covered with soft sediments with seagrass beds and rocky substrate that are partly covered with kelp forest, some intact and some still suffering from severe grazing by urchins. The intact seagrass beds and kelp forests house thousands of species of invertebrates, fish and numerous other species.

People have harvested natural resources provided by nature in the Helgeland archipelago for more than 1,500 years (Box 8). Today, main livelihoods are agriculture and fishing, but hydropower, mining and industrial activities also influence the region. Approximately 85,000 people live in the Helgeland region today, distributed between several small municipalities.

**Figure 62: Map of the Helgeland archipelago, Nordland County, at the north-western coast of Norway**




Note: The archipelago lies in the Norwegian Sea, which is a part of the north-eastern Atlantic Ocean.

Source: EuSeaMap consortium 2012.

**Box 8: Vegaøyan – A UNESCO World Heritage Site**

A part of the Helgeland archipelago, "Vegaøyan", was inscribed as a cultural landscape in the UNESCO World Heritage List in 2004. This is a cluster of islands centered around the Vega island, just south of the Arctic Circle. The landscape covers approximately 100,000 ha, of which only 7% is land (fig. 62). In the past, several hundred people populated the small islands, while today, only three people live permanently within the World Heritage Site. Traditionally, locals have been self-sufficient fisher-farmer holdings, where gathering of eggs and down from eider ducks (Somateria mollissima) has been an important part of the islanders' income (fig. 63). The main reasons for its world heritage status is the maintenance of sustainable living practices over the past 1500 years, along with the significance of women contributing to eider down harvesting. The UNESCO status is also given due to the extraordinary landscape of Vega, the rich diversity of birds and high coastal biodiversity.

**Figure 63: The small sheds in the foreground are for breeding eider**

Note: In these, people used to harvest eggs and down from eider ducks. Today, only down is harvested.

Photo: Inger Hosen.

## 7.2 Key Ecosystem Services

The Helgeland coast gives rise to a number of ecosystem services, including provisioning, regulating, cultural and supporting services (Table 6). Among many, a few of the key ecosystem services are described in more detail below. It should be noted that this is not a complete list of ecosystem services from the area.

**Table 6: Key ecosystem services of the Helgeland archipelago**

| Category | Ecosystem Services |
|---|---|
| **Provisioning** | |
| | Fisheries (fish, crabs) |
| | Kelp and algae for food, energy, and bioprospecting |
| | Genetic resources |
| **Regulating** | |
| | Carbon storage and deposition (sequestration) |
| | Water purification |
| | Nature protection, erosion control |
| **Cultural** | |
| | Recreation and nature based tourism |
| | Natural heritage |
| | Cultural heritage |
| | Aesthetic services |

### 7.2.1 *Commercial fisheries*

Fisheries have been and still are a key source of income and an important basis for culture along the Helgeland coast. Seafood from fisheries and aquaculture is still a major industry in Norway. The industry also supplies technology and knowledge-based services that are important internationally. For many small settlements along the Norwegian west coast, the marine sector is a pillar in terms of settlement and employment (Meld. St. 37. 2008–2009).

Some fisheries and fish species are of particular importance in the area. The Norwegian spring-spawning herring (*Clupea harengus*) is one of the most important fish in the Norwegian Sea, ecologically as well as commercially. It provides food for higher-trophic level species such as seals, whales and humans. The Norwegian spring-spawning herring is migratory and at certain times of the year, herring can be found across large parts of the Norwegian Sea. Some of the main spawning grounds are in Helgeland, where they arrive in January/February and spawn between February and April.

Cod and haddock are, and have for a long time been, two of Norway's most important fish stocks and exported resources. The Northeast Atlantic cod (*Gadus morhua*) and Northeast Atlantic haddock (*Melanogrammus aeglefinus*) spawn on and along the edge of the continental shelf in the Norwegian Sea. There are several stocks of coastal cod distributed from Stadlandet at about 62°N northward to the Russian border.

The Northeast Atlantic cod and the coastal cod are the same species, but are considered separate strains. In contrast to the Northeast Atlantic cod, coastal cod does not migrate into the Barents Sea. It spawns in fjord systems, most frequently in the inner parts. It is present year-round and has thus been an important source of food to local people. Other commercially important species are saithe (*Pollachius virens*), Norwegian pollock *(Theragra finnmarchica)*, pollack (*Pollachius pollachius*), shrimp and crab.

In mid-Norway and Helgeland (63°–67°N), the peak crab fishing season is from August to November. Some 75% of Norwegian landings of edible crab (*Cancer pagurus*) are from these regions, with nearly 90% of the landings going to processing factories. The number of reported landings have declined in the Helgeland area in recent years (www.imr.no). Crab play an important role in the kelp forest ecosystem (Box 9 and 10).

The Helgeland coastal region is also an important nursery area for salmon (*Salmo trutta*).

### 7.2.2 *Kelp and algae for food, feed, energy and other non-edible resources*

Norwegian kelp has the potential to be utilised in the production of fertilizer and bio-fuel (Gundersen *et al*., 2016). Currently, there is also growing interest in kelp for human consumption (Chapman *et al*., 2015).

As far north as Helgeland, about 200,000 tons of kelp is harvested for alginate extraction (Vea & Ask, 2011) with a first-hand value of more than EUR three million. As the kelp forest returns to these shores (Box 11), there is increasing interest in expanding the harvesting area northward, also into the Helgeland region. However, this has led to massive concern, as the effects of kelp harvesting on cultural and natural values in the area are unknown. The red-listed eider population (Box 8) may be among the affected.

### *7.2.3 Nature protection, erosion control and purification of water*

Kelp forests of *Laminaria hyperborea* are located in highly exposed areas, where they mitigate the forces of breaking waves (Løvås & Tørum, 2001), thus providing protection from wave impacts, storm surges and other oceanographic events that can cause harm to coastal communities. Seagrass (i.e. eelgrass *Zostera marina*) meadows are found in more sheltered areas, where they play an important role in reducing the risk of sediment erosion on soft and sandy bottoms.

Water purification and filtration services are also provided by kelp forests, sea grass meadows, and blue mussel (*Mytilus edulis*) banks. Improved water quality (in terms of transparency) is believed to infer enormous benefits for the production of food, along with for all aspects of ecosystems and their function.

### *7.2.4 Carbon regulation*

Algae (e.g. kelp) and plants regulate the global climate by taking up carbon dioxide ($CO_2$) from the water (Box 9). Carbon in its organic form is stored in living algal and plant material, but eventually deposited on the seafloor sediments, where a fraction is permanently buried (deposited on geological time scales). Globally, kelp forests and sea grass meadows contribute to a burial of large amounts of organic carbon from the biosphere (Duarte *et al*., 2010).

**Box 9: Kelp – a potential important player in the blue carbon budget**

Among many functions, kelp (fig. 64) regulate the global climate by taking up and using carbon dioxide (CO2) for photosynthesis. Thus, kelp plants act as reserves for CO2 when they are alive, whereas most of the carbon is released back to the system when the plant dies and decomposes, or when it is consumed. Because of the large and expanding (Box 11) areas of kelp forests along the Norwegian coast, the binding and release of carbon in kelp will have a great impact on the total carbon and greenhouse gas balance.

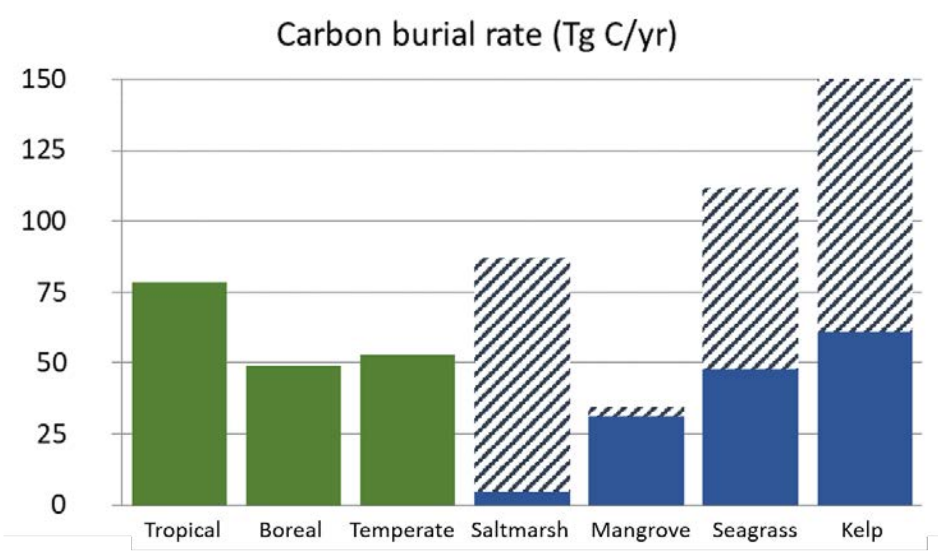
Many other marine ecosystems have been shown to be major contributors to carbon storage and sequestration (McLeod *et al*., 2011). The general understanding for kelp however, has been that they "do not bury carbon, as they grow on rocky substrates where burial is impossible" (Nellemann *et al*., 2009). But recent research shows that detached kelp materials are transferred to both shallow and deep-sea sediment areas where a fraction of it is permanently stored (in geological time scales). In fact, a recent study suggests that kelp and other macroalgae could represent a significant part of the carbon sequestered in marine sediments and the deep ocean (Krause-Jensen & Duarte, 2016).

Combining estimates from Krause-Jensen and Duarte (2016) with previous numbers from terrestrial and marine ecosystems (McLeod *et al*., 2011, see fig. 65), reveals that the importance of kelp forests as carbon sinks have been largely overlooked, and that more studies on this subject are needed to map the pathways and role of kelp in the marine carbon circulation (see also Gundersen *et al*., 2011).

**Figure 64: Healthy kelp (*Laminaria hyperborea*) forest with young saithe fish swimming above it**

Photo: Kjell Magnus Norderhaug/NIVA.

**Figure 65: Estimates of carbon burial rates of different terrestrial and marine blue forest types in Tg (teragram) C per year globally, equivalent to millions of tons of carbon per year. Shaded areas indicate estimated potential (references in text)**



### 7.2.5 Recreation and nature based tourism

Enger *et al*. (2013) describe the essence of tourism in northern Norway, including Helgeland, with the marketing slogan "Enter the world of natural wonders", referring to four themes of adventure and experiences: nature phenomena, the Arctic, the coast & coastal culture, and Saami culture. The ecosystems and the mix of services they provide are used in the marketing of Helgeland, and are visible in most descriptions of recreation and tourism in the area. One headline is, for instance, "White beaches and undiscovered islands". Others state "Rambling in high mountains", "Exploring thousands of islands and islets and white sandy beaches" and "Island-hopping with a bicycle or kayak in an area that many people see as the very best area in Norway for ocean kayaking".

Helgeland has areas ideal for recreational activities including fishing and scuba diving. Kelp forests, rocky slopes and maerl beds with myriads of species are scenic underwater habitats that are central for these activities, due to their rich biodiversity. These habitats' ability to purify water and mitigate eutrophication, further increases the Helgeland archipelago's value for scuba diving, swimming, kayaking and similar activities (Gundersen *et al.*, 2016). In summer, the midnight sun makes outdoor life attractive both day and night. During winter the northern lights, another tourist magnet, can be seen on clear nights. Further, it is emphasised that the archipelago is a dream for bird watchers wanting to see eider ducks (Box 8), Atlantic puffins, Eurasian eagle-owl (*Bubo bubo*), white-tailed eagle (*Haliaeetus albicilla*), cormorants (*Phalacrocorax aristotelis* and *P. carbo*), ducks, geese and more than 200 other bird species (fig. 66–69).

Helgeland is also very attractive as a seasonal feeding ground for numerous larger species, some of which are considered tourist attractions in themselves, such as seals, killer whales (*Orcinus orca*) and minke whales (*Balaenoptera acutorostrata*).

Enger *et al*. (2013) estimated that the tourist sector in Helgeland was valued at amost EUR 100 million in 2011; EUR 65 million of these from the transport sector (airplanes, the Hurtigruten tourist ship, etc.), and EUR 30 million from other sectors including hotels and activities.

Recreational fishing at sea is an important activity in Helgeland, as well as in other areas along the coast. It was estimated that the economic value of recreational sea fishing in northern Norway, including turnover and wider economic effects, was about EUR 50 million in 2009 (Borch *et al.*, 2011).

**Figure 66: Charismatic birds in the Helgeland Archipelago: Atlantic puffins (*Fratercula arctica*)**

Photo: Carron Brown.

**Figure 67: Charismatic birds in the Helgeland Archipelago: White-tailed eagle (*Haliaeetus albicilla*)**

Photo: Karl-Otto Jacobsen.

**Figure 68: Charismatic birds in the Helgeland Archipelago: Greylag goose (*Anser anser*)**

Photo: Michael Maggs.

**Figure 69: Charismatic birds in the Helgeland Archipelago: Eurasian eagle-owl (*Bubo bubo*)**

Photo: Karl-Otto Jacobsen.

## 7.3 Biodiversity and Ecosystem Characteristics

### *7.3.1 The Helgeland ecosystem*

The Helgeland coast offers a range of natural habitats hosting a large number of marine species whose lifecycles are connected to terrestrial animals (birds and mammals), forming a diverse and complex ecosystem. Kelp and other macrophytes (both algae and plants), along with microalgae, drive primary production in the Norwegian Sea outside the Helgeland coast. A high number of "sun-hours" during summertime contribute to fuelling the system's primary production. Transforming the solar energy to organic matter, macrophytes provide both the food source and the habitat for all species higher up in the food-web, hereby playing a key role in the Helgeland marine ecosystem and people associated to it (Chapter 7.2).

### *7.3.2 Key ecosystems and typical habitats*

The key marine ecosystems in the Helgeland region are kelp forests, maerl beds, sandy- and soft sediments, seagrass meadows, intertidal areas, islands and bird cliffs. These key ecosystems provide the physical and biological structures that support the living of key species and the rich biodiversity, that again provide the main functions and services of the ecosystem (Table 7).

**Table 7: Key ecosystems and examples on corresponding key species groups making up the rich biodiversity of the Helgeland archipelago**

| Key ecosystems | Key species groups |
|---|---|
| **Kelp forests** | Brown, green and red algae<br>Sea urchins, snails, small crustaceans<br>Crabs, fish, birds, seals |
| **Seagrass beds** | Seagrass<br>Bivalves, snails, small crustaceans<br>Fish, birds |
| **Maerl beds** | Coralline red and other algae<br>Bivalves, snails, small crustaceans, echinoderms<br>Crabs, fish, birds |
| **Sandy- and soft sediments** | Bivalves, polychaetes and other infauna<br>Crabs, fish, birds |
| **Open water masses** | Phytoplankton<br>Zooplankton<br>Fish, birds, seals, whales |
| **Intertidal areas, islands and bird cliffs** | Seaweeds<br>Crustaceans, bivalves, snails<br>Birds, seals |

### 7.3.3 *Key habitat forming species*

The Helgeland region includes several key species that play essential roles in maintaining the structure and function of ecological communities. On the seafloor, kelp (e.g. *Laminaria hyperborea* and *Saccharina latissima*, Box 10) are important habitat forming species (Teagle *et al.*, 2017) that create large underwater forests. Under the canopy of these forests, several brown, red, and green algae of various sizes thrive, some even growing on the kelp itself (epiphytes). Together, these algae communities function as habitat for invertebrates such as bivalves and sea urchins, crustaceans such as crab, and benthic fish such as cod and wolf fish. The kelp plants grow more than two meters tall and their biomass can reach more than 30 kg per square meter. Kelp are among the world's fastest growing primary producers (Krumhansl & Scheibling, 2012) and in Helgeland, kelp are the most important primary producers, contributing more than 1,000 g carbon/$m^2$ annually.

Eelgrass is also found in the region, having many of the same functions as kelp forests (e.g. Fredriksen *et al.*, 2005). How sea grasses contribute as a key habitat forming species are described in detail in the "Øresund case study".

Shell sand is a common habitat that is found along the coast of Helgeland. Shell sand consists of partially disintegrated carbonate shells from marine organisms such as bivalves, barnacles, sea urchins, snails and skeletal calcareous algae. These habitats are important as they contain a large number of animals, providing good spawning grounds and growing areas for different fish species, shellfish and crustaceans. Shell sand is also harvested for limestone, chicken feed, artificial beaches, covering polluted seafloor and in wastewater filter treatment technology. Shell sand develops slowly and is regarded as a non-renewable marine resource.

**Box 10: The blue forests – key habitats for thousands of species**

Blue forests are underwater coastal ecosystems that are particularly important as primary producers and ecosystem engineers, and they play a central role in structuring coastal habitats (Teagle *et al.*, 2017). The Nordic blue forests consist of habitats such as kelp forests and sea grass meadows (fig. 70 and 71); these are key players in the coastal ecosystem. In addition to providing a high number of key ecosystem services, these habitats also provide extensive substrata for colonizing organisms, enhancing conditions for understory assemblages and provide three-dimensional habitat structure for a vast array of marine plants and animals, including commercially important species (Christie *et al.*, 2003). Recent studies have found a surprisingly rich fauna of mobile invertebrates. Such animal societies can consist of 200–300 different species at densities of more than 100,000 individuals of snails, crustaceans, clams, polychaetas and other invertebrates per square meter (Christie *et al.*, 2009).

In 2015, a network to strengthen the Norwegian understanding and knowledge of blue forests was established. The network aims to understand the full potential of blue forests in addressing the global climate challenge, along with their ability to provision ecosystem services nationally and abroad. More information on The Norwegian Blue Forests Network (NBFN) can be found at www.nbfn.no.

**Figure 70: Typical kelp forest dominated by Tangle kelp (*Laminaria hyperborea*) and its richness of associated species, including fish seen above the kelp canopy**

Photo: J. Gitmark/NIVA.

**Figure 71: Eelgrass meadow (*Zostera marina*), also an important feeding and nursery ground providing a high biodiversity to coastal communities. Here with the common lion's mane jellyfish (*Cyanea capillata*) hovering over**

Photo: Kasper Hancke/NIVA.

### 7.3.4 *Lower-trophic key species*

Lower trophic animals are important for maintaining ecosystem function. These include a range of fish and sea birds (e.g. eider ducks) that prey on invertebrates such as snails and bivalves (e.g. blue mussels). Some sea birds, such as geese, graze the seafloor vegetation (fig. 72).

In the open water masses (the pelagic zone) microalgae, zooplankton (e.g. copepods), and pelagic fish represent the key species. They have essential roles in the food-web, along with the turnover of carbon and nutrients in the marine ecosystem. Microalgae, which harvest light energy the same way as seaweeds and seagrass do, are the main food source for copepods, krill and other small crustaceans. These small animals provide a food source for fish, sea birds and mammals.

**Figure 72: Image showing typical species at a semi-exposed tidal (littoral) zone**

Note: The rocks are covered by barnacles (*Semibalanus balanoides*), Atlantic dogwinkle (*Nucella lapillus*) and seaweeds such as bladderwrack (*Fucus vesiculosus*), spiral wrack (*F. spiralis*) and red dulse (*Palmaria palmata*).

Source: Image from Arenholmen, Vega by NIVA.

Photo: Janne Kim Gitmark.

### 7.3.5 *Fish of Helgeland*

Cod and herring have played significant roles in the shaping of society in Helgeland. Stocks of herring and Northeast Arctic cod have declined since 2013. The coastal cod populations have declined substantially since the mid-90s due to poor recruitment (www.imr.no). Both cod and herring are important in ecosystems around Helgeland.

Herring is a food source for many larger fish and marine mammals, and along with crabs, cod may play an important role in the balance between kelp and sea urchins (Box 11). Other local fish may also be important by controlling the meso-grazer populations, thus maintaining trophic structures in habitats including eelgrass meadows and kelp forests (Baden *et al*., 2012; Östman *et al*., 2016; Andersen *et al*., 2017).

### *7.3.6 Birds of Helgeland*

The younger age classes of saithe and coastal cod are nutritionally important for cormorants (*Phalacrocorax* spp.) and black guillemot (*Cepphus grylle*) that forage on fish from the coastal zone. The Northern gannet (*Morus bassanus*) dives after somewhat bigger fish, such as herring and mackerel that are important prey. The gulls utilise fish for prey when available, but also eat other birds, molluscs, larger invertebrates like crabs, waste from fisheries and even garbage.

Like many of the larger fish in Helgeland, sea birds are important as predators in the biological communities associated with kelp forest and eelgrass meadows. Common species include greylag goose (*Anser anser*), common shelduck (*Tadorna tadorna*), red-breasted merganser (*Mergus serrator*), black guillemot and several species of gulls. The Atlantic puffin (*Fratercula arctica*) is also found in Helgeland, but only breeds on Lovund (fig. 66). The white-tailed eagle (*Haliaeetus albicilla*) has increased steadily since its protection by law in 1968, and is now an iconic species in Helgeland (fig. 67).

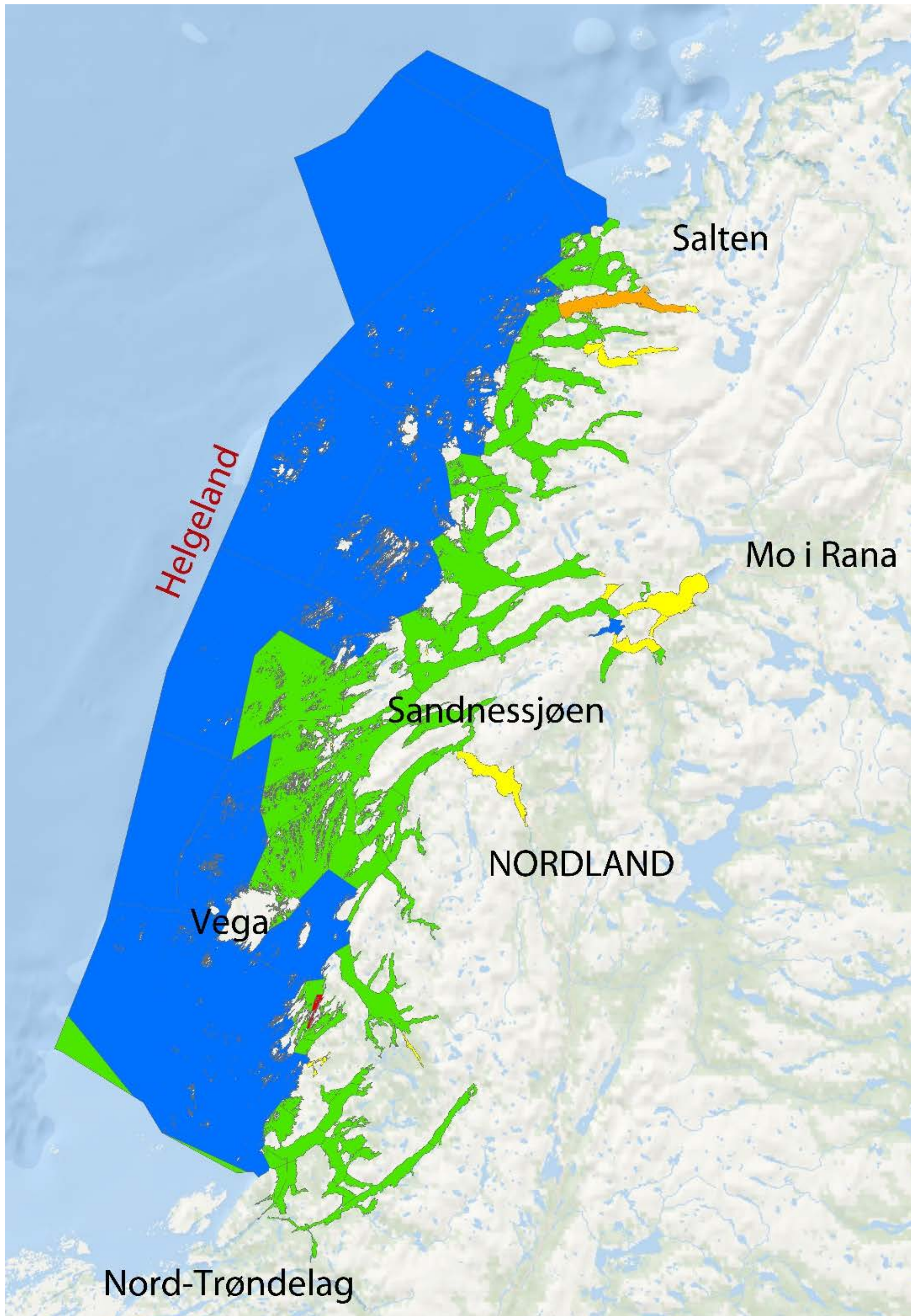
### *7.3.7 Marine mammals of Helgeland*

Seals are probably the most important mammals in the marine coastal ecosystems of Helgeland, feeding mainly on fish and crustaceans in areas where there is seaweeds and kelp. Eurasian Otter (*Lutra lutra*) and whales, such as killer whales (*Orcinus orca*), are also present, and may follow schools of herring along the coastline while foraging. Even minke whales and long-finned pilot whale (*Globicephala melas*) have occasionally been registered at Helgeland (www.biodiversity.no, 29.5.2017). Harbour porpoise (*Phocoena phocoena*), white-beaked dolphin (*Lagenorhynchus albirostris*) and the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) are also relatively commonly observed in this area.

### *7.3.8 Ecosystem status*

According to the Water Framework Directive, the ecological status of Helgeland is generally good. As much as 88% of more than 200 water bodies, and 99% of the total area, is classified as "Good" or "Very good" (fig. 73). The assessment applies to the benthic habitats as well as the pelagic environment (Directorate Group, 2013). Both physio-chemical and biological quality elements are included, of which some of the parameters also measure soft bottom biodiversity. In general, water bodies in the outer exposed sea are classified as "Very good", whereas closer to the coast and within fjords, the status turns into "Good", "Moderate" and even "Poor" in a few cases. Areas with less than "Good" conditions are usually associated with eutrophication.

**Figure 73: Ecosystem status in the Helgeland archipelago**

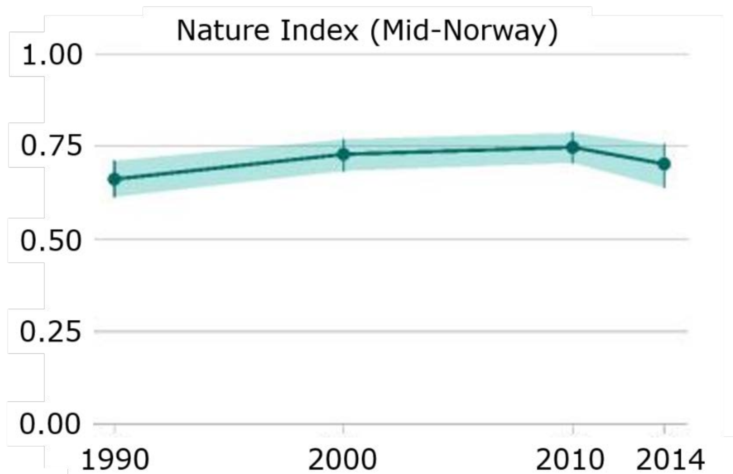



Note: Helgeland includes more than 200 water bodies in coastal waters, of which almost 90% of them are in Good (green) or Very good (blue) condition according to the Water Framework Directive. The last remaining conditions are Moderate (yellow), a few Poor (orange), and very few Very Poor (red).

### 7.3.9 Status and trends in biodiversity and ecosystem function

The Nature Index of Norway measures the condition of biological diversity in Norway and gives an oversight of the development of ecosystems for selected species groups and geographical regions. A report from 2015 (Gundersen *et al.*, 2015) divides the Norwegian coast into four different regions, and according to this index, there has been a steady improvement of the biodiversity in the coastal zone of Mid-Norway during the last 25 years (fig. 74). The index consists of many different indicators ranging from richness of phytoplankton to abundance of harbor seals.

**Figure 74: The Nature Index of Norway calculated for the coastal seafloor and pelagic zone**




Source: 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 (Araújo *et al.*, 2016).

Stocks of herring, cod and crab are reported to have declined in the last decade (Bakketeig *et al.*, 2015; Gundersen *et al.*, 2015). Estimated coastal cod population numbers are considered close to a critical limit and their decline seems highly linked to poor recruitment.

The European shag (*Phalacrocorax aristotelis*) population in central Norway is also strongly linked to kelp forests, especially during their nesting period. Recent studies (e.g. Bustnes *et al.*, 2013; Lorentsen *et al.*, 2015) show that many nesting parameters correlate strongly with the occurrence of young saithe. Changes in the kelp forest that affect the appearance of the youngest age groups of saithe, will therefore also likely affect the shag population.

Reforestation of kelp forests may have important positive effects on native populations and will certainly affect the species trends and biodiversity in a broader sense, by re-establishing habitats for a myriad of species of algae, invertebrates, fish, birds and mammals in the years to come.

Along with Atlantic puffins, several other red listed species are found in Helgeland (nine species of marine birds, eight species of fish and five marine mammal species according to the Norwegian Biodiversity Information Centre).

Bird populations in Helgeland have experienced large fluctuations in the last decades, with a few species in growth, but most of them in decline. Greylag goose has increased considerably along the entire coast during the last 20 years and is now a common species in Helgeland. Common eider (*Somateria mollissima*) was once very abundant and has been sustainably managed and exploited commercially through many decades (Chapter 7.6). The population has decreased markedly in Helgeland in recent years. Two other widespread duck species present also in Helgeland are common shelduck and red-breasted merganser. The trends in populations of these two species are uncertain (Shimmings & Øien, 2015).

In Helgeland, Atlantic puffin breed only on the island of Lovund. The population trend was negative for several decades, but in recent years there has been an increase in numbers. Razorbill (*Alca torda*) breed very sparsely in the region. Black guillemot is a rather common species, but suffers from predation pressures in areas where the American mink (*Neovison vison*) is present.

Several species of gull occur in Helgeland. Black-legged kittiwake (*Rissa tridactyla*) and lesser black-backed gull (*Larus fuscus*) have declined dramatically in Norway, including in Helgeland. There are now only a few colonies left of these two species in the area. The populations of great black-backed gull (*L. marinus*), European herring gull (*L. argentatus*), and common gull (*L. canus*) have also declined.

Both the European shag and great cormorant (*Phalacrocorax carbo*) nest along the coast of Helgeland, and after a period of increase, their populations are now presumed stable.

Peregrine falcon *(Falco peregrinus*) breed along the coast and have shown an increasing trend in population size. Previously, Eurasian eagle-owl was abundant in Helgeland, but is currently largely restricted to the municipality of Lurøy (Directorate for Nature Management, 2009; County Governor of Nordland, 2017). One of the reasons for its decline in the area is a reduction in the population of European water vole (*Arvicola amphibius*), which is its primary food source. Vole has declined largely in many areas due to predation from American mink.

## 7.4 Drivers and Pressures

Coastal habitats are among the most threatened due to the steadily growing human pressures from physical disturbance, fishing, pollution and nutrient input from terrestrial sources. A changing climate influence waves, water currents, water temperature, water acidity and transparency (e.g. UNEP, 2006), which may all drive biological changes at a global scale. However, compared to most Nordic and European coastal areas, the coastal habitats of Helgeland seem minimally impacted by local human activity, and are mostly influenced by the trends in global drivers. Drivers and pressures regulating biodiversity and ecosystem function and services in the Helgeland region are listed in Table 8. The drivers and pressures cause both short-term variability and long-term changes in biodiversity and ecosystem functioning, and are categorised as natural direct drives, anthropogenic direct drivers and anthropogenic indirect drivers (see Chapter 4 in Belgrano (Ed.), 2018). Selected drivers are described below, with particular focus on those regulating long-term changes in the ecosystem. However, the list should not be read as a complete list of the present drivers.

**Table 8: Key ecosystem drivers of the Helgeland archipelago**

| Category | Ecosystem Services |
|---|---|
| **Natural drivers** | |
| | Weather and solar radiation |
| | Water physicochemical properties, incl. nutrients |
| | Major predator and prey species |
| **Anthropogenic direct drivers** | |
| | Fisheries and aquaculture |
| | Eutrophication and pollution |
| | Invasive species |
| | Climate change, incl. warming, ocean acidification and water darkening |
| **Anthropogenic indirect drivers** | |
| | Tourism |
| | Society development |

### 7.4.1 *Natural drivers*

Natural drivers are independent of human activities. These include natural weather and climate patterns, physicochemical properties of water such as concentrations of inorganic nutrients, as well as natural prey- and predator pressures on key species. Also, natural extreme events such as big storms, landslides and major disease outbreaks are among the natural drivers that have formed ecosystems through time.

Temperature, light and the availability of inorganic nutrients are the main natural drivers in most ecosystems, shaping the biodiversity in the area, including that in Helgeland. Each year, when the sun light returns in the spring, solar radiation and nutrient availability fuels plants, microalgae and seaweed growth. With the growth of organic matter, more resources for ecosystems function and services are provided, e.g. for kelp harvest, fishing and hunting. As light, nutrient concentration and temperature show large annual and seasonal fluctuations, these natural drivers impose large variability on key habitats and the species within them. In many ways, this natural variation complicates the assessment of anthropogenic drivers of long-term change to system biodiversity and ecosystem function (see Chapter 4 in the main report for details).

### *7.4.2 Anthropogenic direct drivers*

Direct anthropogenic drivers are the consequences of human activities. These drivers have a *direct* impact on biodiversity and ecosystem function and services. They include marine construction and landscape modifications (e.g. harbors and marine fairways), boat traffic, mining, fishing, aquaculture and eutrophication on regional scales, while changing climate and pollution are drivers at a global scale.

Helgeland connects to the North-east Atlantic Ocean and major fish stocks migrate in and out of this coastal region. Over the past two centuries, overfishing has driven widespread declines of kelp forests along major parts of the Norwegian coast, through cascading effects on sea urchin and crab abundance (Araujo *et al*., 2015). Whether this also is the case for the Helgeland region is unknown, but there are reasons to believe that over-fishing may be a part of the problem (Baden *et al*. 2012; Östman *et al.*, 2016; Andersen *et al*., 2017).

Over 200 locations in the Helgeland region have licences for aquaculture and most of these sites are utilised, many for salmon production. Salmon farming is associated with several factors that may influence biodiversity and ecosystem function on both local and regional scales. The farms and connected infrastructure take up space and contribute to intensified boat traffic and human presence, which may disturb animal life locally. Furthermore, increased input of nutrients and organic matter to the marine environment may lead to increased sedimentation and eutrophication, which may also affect biodiversity and ecosystem function at larger scales. How and to what extent these different factors influence biodiversity and ecosystem function in Norway is not fully understood. Considering the national goal of future increases in sustainable aquaculture (Meld. St. 16, 2014–2015), there is a pressing need for a better grasp of these connections.

Helgeland is strongly influenced by the North Atlantic water currents and thus directly impacted by nutrient export and contaminants, including heavy metals, PCBs and micro/macro plastics, exported from western Europe and transported northward along the Norwegian coast with the coastal current (Gundersen *et al*., 2016; Andersen *et al*., 2016; Ferreira *et al*., 2011; Borja *et al*., 2013).

Seagrass ecosystems are threatened by human activity, including through the development of roads, bridges and harbour infrastructure along the coast. The response of seagrass ecosystems to coastal nutrient enrichment has shown to follow a "threshold pattern" when nutrient enrichment exceeded moderate levels, with a switch from positive to negative net leaf production. This shift is potentially driven by increased epiphyte load due to nutrient enrichment, which blocks light and reduces health of the seagrass leaves (Connell *et al*., 2017). Effective management of land-derived nutrient inputs from e.g. wastewater and agricultural runoff, could help to avoid threshold values being surpassed.

*Invasive species* have been reported in increasing numbers across the European and Nordic marine systems, with impacts on habitats and ecosystems, sometimes also with cascading effects (Katsanevakis *et al*., 2014). One example is the introduction of American mink into the Norwegian fauna (in the 1920s) that has caused detrimental effects on local populations of sea birds. Since monitoring data on invasive species is virtually non-existent, very little is known about their expansion and impacts on the coastal systems of Helgeland.

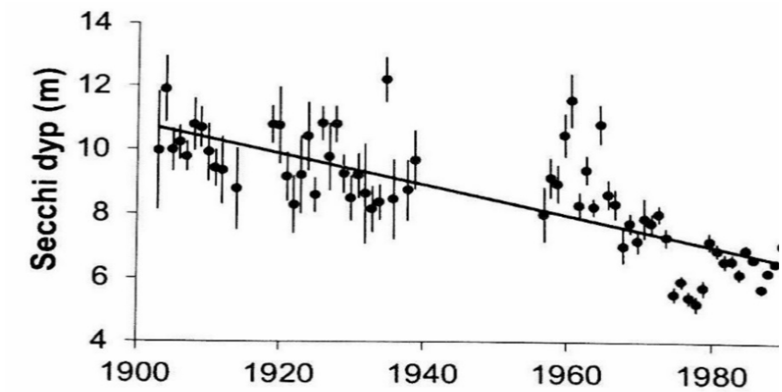
*Climate change* has, over the last few decades, led to pronounced changes to the marine ecosystem in Helgeland. Warming and changes in ecosystem function have, along with impacts from commercial fisheries, led to pronounced loss of kelp forest systems along the Norwegian Atlantic coast (Norderhaug & Christie, 2009; Wernberg *et al*., 2010). In the 1970s, a nearly 2,000 $km^2$ area of kelp forest stretching from Møre on the Norwegian west coast to the Russian border, was completely grazed down by green sea urchins (*Strongylocentrotus droebachiensis*) (Box 11). This previously rich kelp forest ecosystem came to resemble a marine desert of barren grounds for decades. The mechanism behind the disappearance of the kelp forest is not completely understood, but the phenomenon is observed globally and has been prescribed to human impacts from fishing of predator species, eutrophication and poor resistance of kelp to changing environmental conditions (e.g. Ling *et al*., 2015).

In recent years however, kelp forests have started reestablishing in the Helgeland region bringing back a rich kelp forest ecosystem with high biodiversity and ecosystem services (Box 11). The rise in seawater *temperature* may be part of the explanation, making unfavorable conditions for sea urchin larvae, with resultant decreased grazing pressure allowing for kelp forest recovery (e.g. Norderhaug & Christie, 2009; Rinde *et al*., 2014).

The increase of $pCO_2$ in the atmosphere increases the concentration of inorganic carbon (including $CO_2$) in coastal waters. The consequence is a more *acidic underwater* world with direct, though variable, implications for the calcifying organisms that need to produce shells and skeletons (reviewed in Kroeker *et al*., 2010). An increase in $pCO_2$ may also stimulate growth in kelp and other macroalgae and thus increased coastal primary production (Koch *et al*., 2013). There is, however, no scientific consensus on this subject yet, as realistic experiments with elevated $pCO_2$ concentrations have shown complex to perform and interpret (Olischlager *et al*., 2012; Iniguez *et al*., 2016; Connell & Russell, 2010). The effects on ecosystems from ocean acidification are largely unknown. The application of ecological theory does however predict impacts on biodiversity and ecosystem function globally, with species interactions playing a major role in outcomes (Gaylord *et al*., 2015).

Reductions in water quality from increased input of particulate and dissolved organic matter (POM/DOM) has continued during the last decade(s) leading to *ocean darkening* (fig. 75) (Dupont & Aksnes 2013; Aksnes *et al.*, 2009; Urtizberea *et al.*, 2013). Ocean darkening may affect photosynthesis (reduction in photon availability) as well as the behaviour of animals (reducing visibility) and physiology of both animals and algae (by changes in light cues).

**Figure 75: Reduction in water transparency in the North Sea over the last century (measured as Secchi depth, which is the depth at which a specific black and white disk becomes invisible from the surface)**




Source: Aksnes (2015).

### *7.4.3 Anthropogenic indirect drivers*

Indirect anthropogenic drivers are the indirect consequences of human activities. These can be a consequence of how people and societies organise themselves and how they interact with nature at different scales. The effects can be both positive and negative. Examples are tourism, legislation, demographic changes and policies, along with economic-, technological-, and cultural developments. In Helgeland, examples of functional indirect drivers include all of these, however, little quantitative knowledge exists on the impact of indirect drivers on the ecosystem.

*Ecotourism*, a form of tourism involving visiting fragile, pristine and relatively undisturbed natural areas with focus on low-impact recreational activity, is popular in Helgeland (Chapter 7.2). Such activity is in line with the natural values of the area and the marketing of the landscape and pristine resources in the region. Among popular activities are kayaking tours, bicycle riding and hiking across the islands or inland mountain peaks, often with overnights in tents or small traditional boat houses (www.visithelgeland.com) (fig. 76–77).

Islands in Helgeland have been given the label "Sustainable Destinations" – a quality stamp given by Innovation Norway (www.innovasjonnorge.no) to destinations that work systematically to reduce negative impacts from tourism on the environment, along with to those who take care of nature, culture and guests.

**Figure 76: Popular recreational activities are kayaking, bicycling, riding, hiking, fishing and hunting in Helgeland**

Note: These ecosystem services are in principle indirect anthropogenic drivers, but attempts are made to impose minimal impact on nature and its ecosystem services through organised tours with a Sustainable Destinations trademark (www.innovasjonnorge.no).

Photo: KelpScotland.com ©.

**Figure 77: Popular recreational activities are kayaking, bicycling, riding, hiking, fishing and hunting in Helgeland**

Photo: KelpScotland.com ©.

**Box 11: Kelp reforestation – climate impact on urchins, crabs and kelp growth**

Since the early 1970s, more than 50% of kelp forests in the sheltered and moderately exposed areas from ~63 to 71°N have been grazed by green sea urchins (*Strongylocentrotus droebachiensis*, fig. 78). They have transformed the previous rich kelp forest areas along the Norwegian coast into marine deserts or so-called barren grounds (Sivertsen, 1997). The reason for this development is not fully understood, but might relate to both stochastic and cyclic events. However, in the last decade, a gradually northward recovery of kelp has been observed (Norderhaug & Christie, 2009; Rinde *et al.*, 2014). This recovery is partl*y explained by the negative effects of warming on sea urchin recruitment* (Fagerli *et al.*, 2013) and to some degree from increased predation by northward expanding Cancer pagurus and Carcinus maenas crabs (Fagerli *et al.*, 2014).

**Figure 78: Green sea urchins (*Strongylocentrotus droebachiensis*) on the seafloor between the remaining parts of kelp forest trunks (stipes) from the large Laminaria (*Laminaria hyperborea*)**

Photo: Hartvig Christie/NIVA.

## 7.5 Governance of ecosystem services and influencing policies

In the water management plan for the Norwegian Sea (Meld. St. 35, 2006–2017), the coastal zone, which is 12 nautical miles beyond the low water mark, is considered an especially vulnerable area subject to external influences.

The management plan describes how the main source of pollution is non-local, involving borth air- and sea-born pollution. This is also assumed to be the case for the Helgeland coast. However, it is difficult to disentangle the impacts of local versus distant sources on ecosystem function and services. Therefore, management strategies aim to consider both distal and local sources.

Oil and gas activities in the Norwegian Sea create potential for oil spills with impacts on the coastline. Shipping along the coast, as well as further out at sea, causes emissions of combustion gases and creates potential environmental risks associated with shipping accidents.

Pollution from aquaculture is potentially increases the influx of nutrients and waste into rivers and the sea along most of the Norwegian coast. This subject gets increasingly more attention through, for instance, the H2020 TAPAS project and Norwegian Research Council funded KELPPRO project.

Anadromous fish, which live in both fresh and salt water, are exposed to a number of negative factors. In rivers and lakes these are mainly from hydropower developments and heavy loads of the parasite *Gyrodactylus salaris*. In the sea, escaped fish from the aquaculture industry may mix with wild fish and impoverish the natural gene pool. Farmed fish also contribute to the spreading of salmon lice (*Lepeophtheirus salmonis*), which are natural parasites in marine waters on the northern hemisphere that have caused reduced harvests in some places in Norway (Anon. 2017).

Fisheries have potential large-scale impacts on biodiversity through bycatch and overfishing. Lost fishing gear may drift or settle on the seafloor, continuing to catch animals, a phenomenon called ghost fishing. Hunting and marine mammals may also affect local populations and impact ecosystems in ways that may be difficult to foresee.

In order to maintain vital ecosystems along the coast, including those of Helgeland, it is important that primary producers, plankton, fish and bird populations are protected from negative impacts. This includes monitoring and managing nutrient inputs and pollutants from local activities, and assessing the impacts of kelp harvesting, recreational fishing and ghost fishing on local populations of important species, along with evaluating, improving and implementing potential management strategies.

Further measures may include reducing the risk for potential shipping accidents near the coast, from which large oil spills can have severe impacts on coastal communities. The same applies to reducing the risk of blow-outs and other accidents in oil and gas operations.

### *7.5.1 Influencing factors and policy*

Norway has implemented the EU Water Framework Directive through the Water Regulation. The main purpose of the Water Regulation is to provide a framework for determining environmental goals that will safeguard the sustainable use of water resources. The Water Regulation covers all water bodies, from mountains streams, to fjords and out to one nautical mile beyond the low water mark. The regional water management plan for Nordland (including Helgeland) and Jan Mayen Island has been approved by the Norwegian Ministry of Climate and Environment. The regional water authority for Helgeland is Nordland County Council. Information about the Water Regulation in general, along with the Nordland water region in particular, can be found at www.vannportalen.no.

The fisheries represent some of the most important ecosystem services and natural resource providers in Helgeland. Fisheries are administered by the Ministry of Trade, Industry and Fisheries and its subordinate Directorate of Fisheries through the Marine Resources Act.

The Marine Resources Act applies to all living wild marine resources (whales, seals, fish, crustaceans, echinoderms, mollusks, snails, seaweed, kelp, etc.) and ensures that the resources belonging to the Norwegian society, are managed to secure sustainable and profitable exploitation in to the future. This includes preserving marine biodiversity and genetic material, as well as maintaining coastal communities through protecting coastal culture, traditions and employment. In essence, fishing for all stocks and resources is permitted, but there are regulation-based limitations. Regulations apply to whom may fish, what methods may be used, quantities (quotas), in which time periods, as well as in which areas catch is allowed.

Following the reestablishment of large kelp forests in the southern parts of Helgeland a few years ago after 30 years of absence, the area has now been opened to one kelp trawling company. The company has been granted trial permits for harvesting that are conditional on surveys performed by the Institute of Marine Research in Bindal, Sømna, Brønnøy and Vega.

Fishing for anadromous species such as salmon, brown trout (*Salmo trutta*) and Arctic char (*Salvelinus alpinus*) both in salt water and fresh water, is administered according to the Salmon and Inland Fishing Act by the County Governor and the Norwegian Environment Agency. Fishing in rivers is mainly regulated by fishing seasons and stocks must be kept sustainable. River fishing is most commonly carried out in Vefsenfjorden (Vefsna) and Ranafjorden (Ranaelva).

In Helgeland, aquaculture is carried out lumpfish, mussels and for salmon harvesting and stocking. The practice is administered according to the Aquaculture Act by the Ministry of Trade, Industry and Fisheries and the Directory of Fisheries. Also, some aspects of permit application are delegated to the County Council. Permits are limited by national concessions for salmon and rainbow trout (*Oncorhynchus mykiss*), and all locations have to be approved by local authorities. Concessions are also controlled by the Aquaculture Act, the Harbour Act (Norwegian Coastal Administration), the Food Act (Norwegian Food Safety Authority) and the Pollution Control Act (the County Governor). Facilities for fish stocking are also subject to the Water Resources Act (Norwegian Water Resources and Energy Directorate, NVE – applies to land-based constructions).

Hunting is managed under the Natural Diversity Act and the Game Act. The administrative bodies are The Ministry of Climate and Environment and The Norwegian Environment Agency. The aim of the Natural Diversity Act is to sustainably uphold genetically viable species populations witin their natural distribution limits. Seal hunting is managed within and through the Marine Resources Act. While eider can be hunted in southern parts of the country, hunting eider is not allowed in Helgeland.

Important habitats associated with high biodiversity, like eelgrass meadows, softbed areas, kelp forests and shell sand areas, are largely administered by local authorities through the Planning and Building Act. Gravel and sand are resources that are managed according to the Continental Shelf Act and by the County Council.

The Vega islands have been placed on UNESCO's World Heritage list because of the eider and the millennia-old tradition of egg and eider down production (Chapter 7.6). Natural values are also managed in areas with protected area status according to the Natural Diversity Act, with either the local authority or the County Governor as the administrative authority.

Areas have also been secured for outdoor activities by being bought and secured for public use, pursuant to the Outdoor Recreation Act. The authorities are the County Governor and the Norwegian Environment Agency. The common right of access, pursuant to the Outdoor Recreation Act, ensures that people can go where they wish at sea and ashore on uncultivated land all year and in farmed fields from 14th October to 14th April.

Development of wind energy is administered by the Ministry of Petroleum and Energy and its subordinate Norges vassdrags- og energidirektorat (NVE) according to the Marine Energy Act. Fifteen areas along the Norwegian coast have been identified as suitable for wind power production, including two in Helgeland: Træna West and Trænafjorden – Selvær according to the administration plan for the Norwegian Sea (Meld. St. 35, 2016–2017).

### 7.5.2 Past and present management

A coastal protection plan for Nordland was implemented in the 1990s. It involved the protection of valuable nature, land and marine areas through the creation of protected areas and nature reserves to best preserve the iconic coastal flora and fauna.

Work on a regional coastal plan for Helgeland is progressing, in which 13 local authorities have been asked to clarify local use. The purpose of the coastal plan is to regulate and facilitate the use of marine areas in Helgeland in terms of traffic, fishing, aquaculture, nature conservation, protection of cultural heritage, tourism and outdoor recreation. The regional council of South Helgeland is the responsible party.

A number of mammals and birds are being monitored along the Helgeland coast, including greylag geese, eagle-owls, golden eagles (*Aquila chrysaetos*) and otters. The County Governor has initiated a monitoring programme focusing on the salmon population and threat factors, including enhancing knowledge on the effects of aquaculture.

Rules on the minimum sizes for sea fish catch were expanded to also apply for leisure anglers with effect from January 1st 2010. Fishing for mackerel with hooks or nets, and for saithe for own use, are exempted from the rules for minimum sizes. There are also limits on the quantity of fish that can be taken out of the country by leisure anglers.

A national action plan for sea birds is expected to be ready in 2018, which will contain proposed measures against the continued demise of several species. Decimation of mink is one measure that may be enforced in protected areas, along with trials for reducing bycatch (of surface grazing birds such as fulmar, *Fulmarus glacialis*) by setting out bird scare lines.

## 7.6 Insights from indigenous and local knowledge

### *7.6.1 ILK in Helgeland "eider duck local knowledge"*

Coastal communities are commonly dependent on fishing, but the Vega archipelago has a much more unique tradition. Already in the 9th century, the islands constituted an important centre for trade in down from common eider. Wild harvesting of eider down from nests has been a tradition all around the coastlines of Nordic countries, but the tradition in the Vega archipelago has been based on harvesting from almost semi-domesticated eiders (Andersson, 2001, p. 171). The UNESCO World Heritage Committee decided, based on its "cultural landscape based on cultural criterion", to accept the Vega archipelago as a World Heritage. In the decision, it is highlighted that the area qualified "based on the now unique practice of eider down harvesting, and it also celebrates the contribution made by women to the eider down process" (World Heritage Nomination and decision, WHC-04/28.COM/26 Paris, 29 October 2004, 14B.45). Beyond the down harvest, the Vega archipelago has had similar uses for local biodiversity as those of most Nordic coastal cultures. The cultural landscape is described in the nomination by the Norwegian government as follows:

> "This exposed seascape contains fishing villages with breakwaters, quays and warehouses, sites with eider houses where eggs and down were collected, the homes of fishermen-farmers with dwellings, outhouses, boathouses and islets where livestock grazed and hay was scythed, and navigational aids like lighthouses, lights and other beacons to aid seafaring in the perilous, foul waters. All told, these elements shaped by people relate a long history of use under exceptional living conditions controlled by the climate and the basis endowed by nature."
> (World Heritage Nomination and decision, WHC-04/28.COM/26 Paris, 29 October 2004, 14B.45, p. 5).

It was women who stayed on the outer isles of the archipelago and protected the female eiders while nesting in small eider houses. For centuries the inhabitants have gathered bladder wrack (*Fucus vesiculosus*), dried it and made nests in different driftwood shelters in small houses built of stones to attract female eiders. The eider tenders then chased away predators, like crows, ravens, gulls and foxes to gain the optimum amount of eggs, chicks, adult female eiders and primarily down. Even white-tailed eagle and Eurasian eagle-owl have been hunted for this reason for a long time – the latter species is still on the red list. The birds nest from May until late June, after which the tedious work cleansing the down from the impurities begins. High quality eider down has an extremely high price on the market, and has had so for at least a millennium. A duvet containing about a kilo of down from Vega costs approximately EUR 4,400.

The tradition was about to disappear in the 1990s due to depopulation and abandonment of the isles, leading to increased predator pressure on the bird population that resultantly decreased rapidly. Intense work documenting people's knowledge ensued and a pilot project on one of the isles to re-establish the eider population was implemented. In 1997, a documentation and visitor centre was established in Nes on Vega ("The Nordland Ærfugllag", www.eiderducks.no).

The relationship between local communities and the birds did not only constitute a provisioning ecosystem service, i.e. eggs and down. It is often claimed that this symbiotic relationship also developed a sense of closeness and pleasure, and can thus also be described as a substantial cultural and spiritual ecosystem service. Previously, local women took time to tend the nesting birds, but today, volunteers also take part. It is possible to take a course in eider custodianship and learn more about the tradition, along with the management of eiders and down harvesting.

## 7.7 References


Aksnes, D. L., Dupont, N., Staby, A., Fiksen, O., Kaartvedt, S., & Aure, J. (2009). Coastal water darkening and implications for mesopelagic regime shifts in Norwegian fjords. *Marine Ecology Progress Series*, *387*, 39–49.

Aksnes, D. L. (2015). Mørkere kystvann? *Naturen*, *139*, 125–132. (In Norwegian).

Andersen, J. H., Berzaghi, F., Christensen, T., Geertz-Hansen, O., Mosbech, A., Stock, A., Zinglersen, K. B., & Wisz, M. S. (2017). Potential for cumulative effects of human stressors on fish, sea birds and marine mammals in Arctic waters. *Estuarine Coastal and Shelf Science*, *184*, 202–206.

Andersen, J. H., Aroviita, J., Carstensen, J., Friberg, N., Johnson, R. K., Kauppila, P., Lindegarth, M., Murray, C., & Norling, K. (2016). Approaches for integrated assessment of ecological and eutrophication status of surface waters in Nordic Countries. *Ambio*, *45*, 681–691.

Andersson, Å. (2001). Fattigmans hönor och kapuner. In *Människan och naturen. Etnobiologi i Sverige 1* (p. 166–174). Eds. B. Pettersson, I. Svanberg & H. Tunón. Stockholm: Wahlström & Widstrand.

Anker-Nilssen, T., Barrett, R. T., Christensen-Dalsgaard, S., Erikstad, K. E., Lorentsen, S.-H., Lorentzen, E., Moe, B., Reiertsen, T.K., Sivertsen, K., Strøm, H., & Systad, G. H. (2017). *Sjøfugl i Norge 2016. Resultater fra SEAPOP-programmet*. SEAPOP, 28 pp.

Anon. 2017. *Status for norske laksebestander i 2017*. Rapport fra Vitenskapelig råd for lakseforvaltning nr 10, 152 pp.

Araújo, R. M., Assis, J., Aguillar, R., Airoldi, L., Bárbara, I., Bartsch, I., Bekkby, T., Christie, H., Davoult, D., Derrien-Courtel, S., & Fernandez, C. (2016). Status, trends and drivers of kelp forests in Europe: an expert assessment. *Biodiversity and Conservation*, *25*, 1319–1348.

Baden, S., Emanuelsson, A., Pihl, L., Svensson, C.-J., & Åberg, P. (2012). Shift in seagrass food web structure over decades is linked to overfishing. *Marine Ecology Progress Series*, *451*, 61–73.

Bakketeig, I. E., Gjøsæter, H., Hauge, M., Sunnset, B. H., & Toft, K. Ø. (2015). Havforskningsrapporten 2015. In *Ressurser, miljø og akvakultur på kysten og i havet.* Fisken og havet, special issue 1–2015.

Borch, T., Moilanen, M., & Olsen, F. (2011). *Sjøfisketurisme i Norge – debatter, reguleringer, struktur og ringvirkninger*. NORUT report 1.

Borja, A., Elliott, M., Andersen, J. H., Cardoso, A.C., Carstensen, J., Ferreira, J. G., Heiskanen, A. S., Marques, J. S., Neto, J. M., Teixeira, H., Uusitalo, L., Uyarra, M. C., & Zampoukas, N. (2013). Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*, *76*, 16–27.

Bustnes, J. O., Anker-Nilssen, T., Erikstad, K. E., Lorentsen, S.-H., & Systad, G. (2013). Changes in the Norwegian breeding population of European shag correlate with forage fish and climate. *Marine Ecology Progress Series*, *489*, 235–244.

Bustnes, J. & Lønne, O. (1995). Sea ducks as predators on sea urchins in a northern kelp forest. Ecology of fjords and coastal waters. In: *Proceedings of the Mare Nor Symposium on the Ecology of Fjords and Coastal Waters, Tromsø, Norway, 5–9 December, 1994*. Amsterdam: Elsevier Science B.V. p 599–608.

Chapman, A., Stévant, P., & Larsen, W. E. (2015). *Potensial for makroalger som mat i en nordisk sammenheng*. Møreforsking report, 15-06. 49 pp.

Christie, H., Jorgensen, N. M., Norderhaug, K. M., & Waage-Nielsen, E. (2003). Species distribution and habitat exploitation of fauna associated with kelp (*Laminaria hyperborea*) along the Norwegian coast. *J. Mar. Biol. Assoc. UK*, *83*, 687–699.

Christie, H., Norderhaug, K. M., & Fredriksen, S. (2009). Macrophytes as habitat for fauna *Marine Ecology Progress Series*, *396*, 221–233.

Connell, S. D., Fernandes, M., Burnell, O. W., Doubleday, Z. A., Irving, A. D., Leung, J. Y. S., Owen, S., Russell, B. D., & Falkenberg, L. J. (2017). Testing the threshold effect for ecosystem persistence in seagrass meadows. *Conservation Biology*, *31*(5), 1196–1201.

Connell, S.D. & Russell, B.D. (2010). The direct effects of increasing $CO_2$ and temperature on non-calcifying organisms: increasing the potential for phase shifts in kelp forests. *Proceedings of the Royal Society B-Biological Sciences,* 277, 1409–1415.

Directorate for Nature Management. (2009). *Handlingsplan for hubro (*Bubo bubo*)*. DN Rapport 2009-1. Trondheim: Directorate for Nature Management.

Directorate Group. (2013). *Veileder 02:2013: Klassifisering av miljøtilstand i vann: Økologisk og kjemisk klassifiseringssystem for kystvann, grunnvann, innsjøer og elver*. 229 p.

Duarte, C. M., Marbà, N., Gacia, E., Fourqurean, J. W., Beggins, J., Barrón, C., & Apostolaki, E. T. (2010). Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. *Global Biogeochemical Cycles*, *24*, GB4032, https://doi.org/10.1029/2010GB003793.

Dupont, N. & Aksnes, D. L. (2013). Centennial changes in water clarity of the Baltic Sea and the North Sea. *Estuarine Coastal and Shelf Science*, *131*, 282–289.

Enger, A., Jacobsen, E. W., Grünfeld, L. A., Løvland, J., Iversen, E. K. & Holmen, R. B. (2013). Sektoranalyse av reiselivsnæringen i Nord-Norge. Kunnskapsinnhenting – Verdiskaping i nord. *Menon report* 14/2013.

Fauchald, P., Barrett, R. T., Bustnes, J. O., Erikstad, K. E., Nøttestad, L., Skern-Mauritzen, M., & Vikebø, F. B. (2015). *Sjøfugl og marine økosystemer. Status for sjøfugl og sjøfuglenes næringsgrunnlag i Norge og på Svalbard*. NINA report 1161. 44 pp.

Fagerli, C. W., Norderhaug, K. M., & Christie, H. C. (2013). Lack of sea urchin settlement may explain kelp forest recovery in overgrazed areas in Norway. *Marine Ecology Progress Series*, *488*, 119–132.

Fagerli, C. W., Norderhaug, K. M., Christie, H., Pedersen, M. F., & Fredriksen, S. (2014). Predators of the destructive sea urchin *Strongylocentrotus droebachiensis* on the Norwegian coast. *Marine Ecology Progress Series, 502*, 207–218.

Ferreira, J. G., Andersen, J. H., Borja, A., Bricker, S. B., Camp, J., da Silva, M. C., Garces, E., Heiskanen, A. S., Humborg, C., Ignatiades, L., Lancelot, C., Menesguen, A., Pett, T., Hoepffner, N., & Claussen, U. (2011). Overview of eutrophication indicators to assess environmental status within the European Marine Strategy Framework Directive. *Estuarine Coastal and Shelf Science*, *93*, 117–131.

Fredriksen, S., Christie, H., & Sæthre, B. A. 2005). Species richness in macroalgae and macrofauna assemblages on *Fucus serratus* L. (Phaeophyceae) and *Zostera marina* L. (Angiospermae) in Skagerrak, Norway. *Marine Biology Research*, *1*, 2–19.

Gaylord, B., Kroeker, K. J., Sunday, J. M., Anderson, K. M., Barry, J. P., Brown, N. E., Connell, S. D., Dupont, S., Fabricius, K. E., Hall-Spencer, J. M., Klinger, T., Milazzo, M., Munday, P. L., Russell, B. D., Sanford, E., Schreiber, S. J., Thiyagarajan, V., Vaughan, M .L. H., Widdicombe, S., & Harley, C. D. G. (2015). Ocean acidification through the lens of ecological theory. *Ecology*, *96*, 3–15.

Gundersen, H., Norderhaug, K. M., Rinde, E., Johnsen, T. M., van der Meeren, G., Nilssen, K. T., & Lorentsen, S. H. (2015). Kyst. In: E. Framstad (Ed.). *Naturindeks for Norge 2015. Tilstand og utvikling for biologisk mangfold* [The Norwegian Nature Index 2015 – state and trends of biodiversity] (pp 50–59). M-441|2015. Trondheim, Miljødirektoratet.

Gundersen, H., Christie, H., de Wit, H., Norderhaug, K. M., Bekkby, T., & Walday, M. (2011). *$CO_2$ uptake in marine habitats – an investigation*. NIVA Report no. 6070-2010. 25 p.

Gundersen, H., Norderhaug, K. M., Christie, H. C., Oug, E., Johnsen, T. M., van der Meeren, G., & Lorentsen, S.H., 2015. Kyst. In E. Framstad (Ed.), *Naturindeks for Norge 2015, Tilstand og utvikling for biologisk mangfold* (pp. 50–58) M-441. Trondheim: Miljødirektoratet.

Gundersen, H., Bryan, T., Chen, W., Moy, F. E., Sandman, A. N., Sundblad, G., Schneider, S., Andersen, J. H., Langaas, S., & Walday, M. G. (2016). *Ecosystem services in the coastal zone of the Nordic countries*. TemaNord report 2016:552. 108 pp.

Iñiguez, C., Carmona, R., Lorenzo, M. R., Niell, F. X., Wiencke, C., & Gordillo, F. J. L. (2016). Increased temperature, rather than elevated $CO_2$, modulates the carbon assimilation of the Arctic kelps *Saccharina latissima* and *Laminaria solidungula*. *Marine Biology,* 163, 248. https://doi.org/10.1007/s00227-016-3024-6.

Johansen, R. & Næss, I. E. (2013). *The Vega archipelago: a cultural history and travel guide*. Stamsund: Orkana, 214 pp (In Norwegian.)

Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M. E., Oztürk, B. *et al*. (2014). Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions*, *94*, 391–423.

Koch, M., Bowes, G., Ross, C., & Zhang, X.-H. (2013). Climate change and ocean acidification effects on seagrasses and marine macroalgae. *Glob. Change Biol.*, *19*, 103–132.

Krause-Jensen, D. & Duarte, C. M. (2016). Substantial role of macroalgae in marine carbon sequestration. *Nature Geoscience*, *9*, 737–742.

Kroeker, K. J., Kordas, R. L., Crim, R. N., & Singh, G. G. (2010). Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. *Ecology Letters*, *13*, 1419–1434.

Krumhansl, K. A. & Scheibling, R. E. (2012). Production and fate of kelp detritus. *Marine Ecology Progress Series*, *467*, 281–302.

Ling, S. D., Scheibling, R. E., Rassweiler, A., Johnson, C. R., Shears, N., Connell, S. D., Salomon, A. K., Norderhaug, K. M., Pérez-Matus, A., Hernández, J. C., Clemente, S., Blamey, L. K., Hereu, B., Ballesteros, E., Sala, E., Garrabou, J., Cebrian, E., Zabala, M., Fujita, D., & Johnson, L. E. (2015). Global regime shift dynamics of catastrophic sea urchin overgrazing. *Phil. Trans. R. Soc. B*, *370*, 20130269. https://doi.org/10.1098/rstb.2013.0269

Lorentsen, S.-H., Anker-Nilssen, T., Erikstad, K. E., & Røv, N. (2015). Forage fish abundance predicts timing of breeding and hatching brood size in a coastal seabird. *Marine Ecology Progress Series*, *519*, 209–220.

McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M. *et al*. (2011). A blueprint for blue carbon: towards an improved understanding of the role of vegetated coastal habitats in sequestering $CO_2$. *Front. Ecol. Environ.*, *9*, 552–560.

Meld. St. 37. 2008–2009. *Integrated management of the marine environment of the Norwegian Sea (management plan)*.

Nellemann, C., Corcoran, E., Duarte, C. M., Valdés, L., De Young, C., Fonseca, L., & Grimsditch, G. (Eds). 2009. *Blue Carbon. A Rapid Response Assessment*. United Nations Environment Programme, GRID-Arendal, www.grida.no.

Norderhaug, K. & Christie, H. (2008). *Reetablering av tareskog på Helgelandskysten - Kvantitative målinger av tare og kråkeboller*. NIVA report 5661-2008. 19 pp. (In Norwegian).

Norderhaug, K. M. & Christie, H. C. (2009). Sea urchin grazing and kelp re-vegetation in the NE Atlantic. *Marine Biology Research*, *5*, 515–528.

Olischlager, M., Bartsch, I., Gutow, L., & Wiencke, C. (2012). Effects of ocean acidification on different life-cycle stages of the kelp *Laminaria hyperborea* (Phaeophyceae). *Botanica Marina, 55*, 511–525.

Östman, Ö., Eklöf, J., Eriksson, B. K., Olsson, J., Moksnes, P.-O., & Bergström, U. (2016). Top-down control as important as eutrophication effects in North Atlantic coastal ecosystems. *J Appl Ecol.*, *53*(4), 1138–1147.

Rinde, E., Christie, H., Fagerli, C. W., Bekkby, T., Gundersen, H., Norderhaug, K. M., & Hjermann, D. O. (2014). The Influence of Physical Factors on Kelp and Sea Urchin Distribution in Previously and Still Grazed Areas in the NE Atlantic. *PLOS ONE 9*(6), e100222.

Shimmings, P. & Øien, I. J. (2015). *Bestandsestimater for norske hekkefugler*. NOF report 2015-2. 268 pp. ISBN: 978-82-78-52126-7.

Sivertsen, K. (1997). Geographic and environmental factors affecting the distribution of kelp beds and barren grounds and changes in biota associated with kelp reduction at sites along the Norwegian coast. *Canadian Journal of Fisheries and Aquatic Sciences*, *54*, 2872–2887.

Teagle, H., Hawkins, S., Moore, P. J., & Smale, D. A. (2017). The role of kelp species as biogenic habitat formers in coastal marine ecosystems. *J. Exp. Mar. Biol. Ecol.*, *92*, 81–98.

UNEP. (2006). *Marine and Coastal Ecosystems & Human Well-being: A synthesis report based on the findings of the Millenium Ecosystem Assessment*. Eds. C. Brown, E. Corcoran, P. Herkenrath, & J. Thonell. UNEP. 76 pp.

Urtizberea, A., Dupont, N., Rosland, R., & Aksnes, D. L. (2013). Sensitivity of euphotic zone properties to CDOM variations in marine ecosystem models. *Ecological Modelling*, *256*, 16–22.

Vea, J. & Ask, E. (2011). Creating a sustainable commercial harvest of *Laminaria hyperborea*, in Norway. *J. Appl. Phycol.*, 23, 489–494.

Wernberg, T., Thomsen, M. S., Tuya, F., Kendrick, G. A., Staehr, P. A., & Toohey, B. D. (2010). Decreasing resilience of kelp beds along a latitudinal temperature gradient: potential implications for a warmer future. *Ecology Letters*, *13*, 685–694.

WHC-04/28 (World Heritage Committee).COM/26 Paris, 29 October 2004, 14B.45. http://whc.unesco.org/en/decisions/128

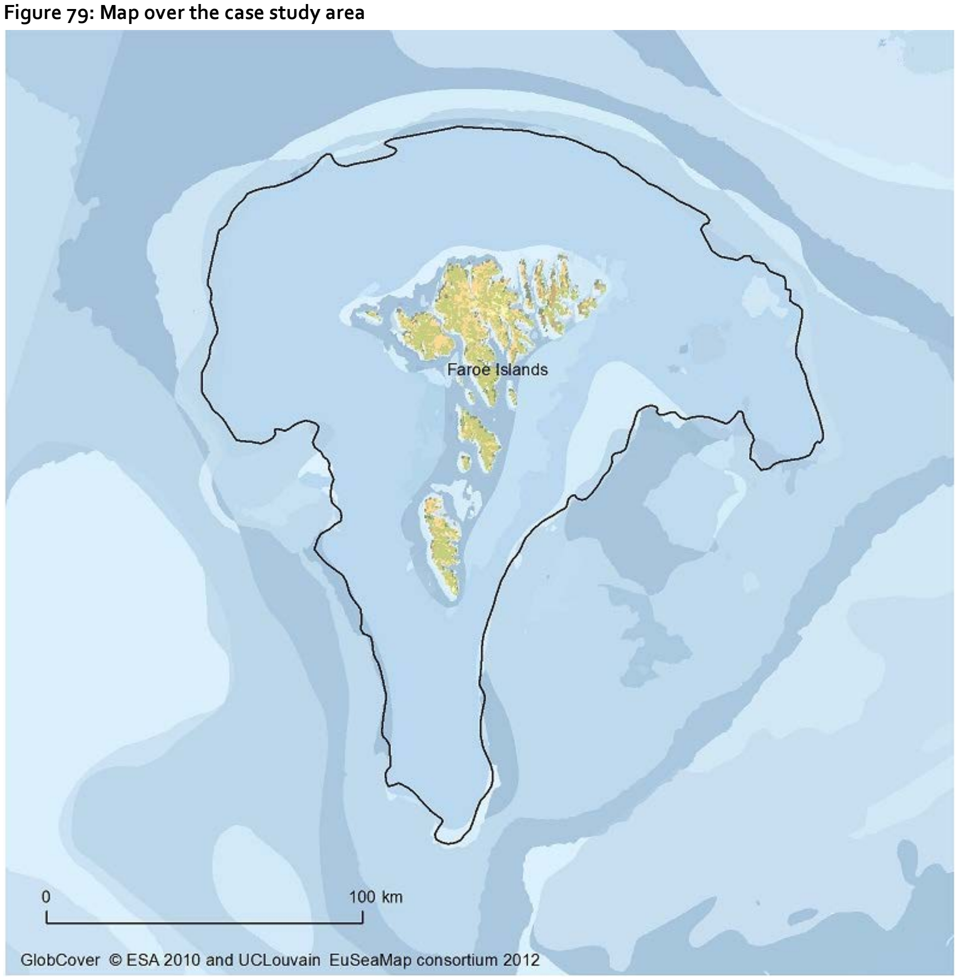
# 8. Faroe Islands (Føroyar)

*Jan Sørensen, Johanna Roto, and Håkan Tunón*

## 8.1 Setting the scene

The Faroe Islands (Faroes) is an archipelago consisting of 18 islands about halfway between Norway and Iceland, 320 kilometres north-northwest of Scotland (62°00′N 06°47′W). The islands cover a land area of 1,400 km². The maritime economic zone is approximately 274,000 km².

**Figure 79: Map over the case study area**




Source: ESA 2010 and UCLouvain, EuSeaMap consortium 2012.

50,000 people live in the Faroes. The settlement structure with small often isolated villages, larger regional towns and a dominant capital city is characteristic in the Faroes. Some 20,000 people live in the capital region of Tórshavn. In total, there are 115 villages in the Faroe Islands, of which 58 have less than 100 inhabitants.

**Figure 80: Tórshavn, the picturesque capital of the Faroe Islands**

Photo: Håkan Tunón, 2017.

The language spoken is Faroese (Føroyskt) and belongs to the West Scandinavian group of the North Germanic languages. Danish has the same legal status as Faroese on the islands.

The Faroe Islands are fundamentally dependent on the sea and on marine resources. The economy is almost entirely based on offshore fisheries and aquaculture. In 2016 the total export was approximately EUR 1 million, of which 96% was fish, mostly chilled or frozen. Some 40% of Faroese export consists of aquaculture and some 30% comes from the catch of mackerel, cod, herring, haddock, blue whiting and saithe (Hagstova, 2017; Rigombudsmandens beretning, 2016).

**Figure 81: Fishing and aquaculture are the fundament of Faroese economy**

Photo: Håkan Tunón, 2017.

**Figure 82: Salmon farming in a fjord on the island of Vágar**

Photo: Håkan Tunón, 2017.

## 8.2 Nature's contributions to people

Fishing and sheep farming are considered the most important parts of traditional everyday life in the Faroes, both from a subsistence and social/cultural point of view. Historically, it was essential to have sheep, hunt or fish to make a living, but nowadays it is more of a supplement to the household economy.

The conditions for cultivation are not very favourable as only some 4% of the terrestrial area is suitable for cultivation. The main crops are hay, potatoes and rhubarbs.

Farming of semi-domestic sheep that graze freely on semi-natural pastures is popular as a family tradition and very important as a supplement to the household. There are approximately 70,000 sheep in the Faroe Islands.

**Figure 83: Most of the Faroese landscape consists of open pastures that have been grazed for centuries by sheep**

Photo: Håkan Tunón, 2017.

Fishing from small boats has been practiced for centuries – both as a hobby and as a supplement to the household economy. The practice is considered everyman's right and there are no regulations.

Pilot whale hunting and seabird harvesting are thriving local traditions in the Faroe Islands that form an important aspect of the cultural heritage. Pilot whale hunting in particular, is an iconic Faroese tradition.

### 8.2.1 *Seabird hunting*

Ever since the islands were inhabited, seabirds have been a main source of nourishment for the Faroese. Puffins, fulmars and guillemots have been a crucial source of meat, but even gannets, kittiwakes, shags, Manx shearwater, razorbills and other species have been hunted (e.g. Storå, 1968, p. 121–126). Some of these species are still hunted today, but they do not play the same vital role for the Faroese household.

Around 1.5 million pairs of seabirds live in the Faroe Islands today – a reduction of about 25% over the last 15 years. A hunting regulation is in place and accepted among hunters. It has been estimated that the annual harvest fluctuates between 65,000 and 240,000 birds, mainly fledglings and puffins (CAF 2008: 4), but due to the decline in populations during the last decades, the total number of harvested sea birds is probably somewhere between 50,000 and 100,000. These are thought to be mainly fulmars, but no concrete statistics have been recorded.

**Figure 84: Puffins (*Fratercula arctica*) were earlier one of the main species for the Faroese bird hunt, but due to the rapid decline in population a provisional stop has been implemented**

Photo: Nazuno Nakao, 2015.

The Faroes hold some of the largest colonies of Atlantic puffin, which used to be the most important species for the hunt. The traditional hunting method involves a prolonged net-catcher "fleyðingarstong", best described as a long stick with a net at the end. The hunt thus requires a landscape that allows the hunter to get close to the bird, but these landscapes lie in areas where hunting rights belong to landowners, reducing the availability of viable hunting grounds. Historically, the puffin hunt was an important part of the household economy. However, low population numbers have resulted in local protection methods and hunting bans since 2013.

Today Atlantic fulmar is considered the most important species for the hunt. The population size is estimated at 800,000 birds, of which about 100,000 youngsters are harvested every year. Adult birds are mostly hunted using the net-catcher technique. Fledglings are caught at sea from boats using a landing net.

The Faroes hold a small gannet population of about 2,000–2,400 birds. Most of the year, gannets are out in open seas and only migrate to the Faroes to breed. The single gannet colony in the Faroes is located on Mykines, where the birds place their crowded nests on top of steep inaccessible cliff formations. Locals catch about 200 gannet fledglings annually. The catch is divided between landowners and hunters.

### *8.2.2 Egg harvest*

Egg harvesting is a century-old tradition in the Faroe Islands, carried out in cooperation between villagers, allowing them to reach guillemot and fulmar eggs on shelves of steep bird-cliffs, which can be up to 400 metres high.

Today egg harvesting is less important in Faroese tradition, but still practiced at a small scale for lesser black-backed gull, guillemot and fulmar. It is mostly practised in small villages with strong egg-harvesting traditions, where fulmar eggs are particularly favoured. For example, local people in Sandoy and Skúvoy now harvest eggs once a year on a single day, but the date varies. Specific sites that have been selected for the harvest, due to their relatively secure accessibility, have been used for generations and hence have well-established names. Traditional equipment constructed from wool and wood is used. The eggs are divided between the people participating in the harvest according to their role in the activity (https://www.atlanticseabirds.info).

### *8.2.3 Pilot whale hunting*

Whaling in the Faroes is traditionally non-commercial and restricted to species that are spotted from land or near to the shore. Whaling in the Faroes is regulated by "the act on whaling in the Faroes". The hunt targets five species: the white-beaked dolphin, Atlantic white-sided dolphin, bottlenose dolphin, harbour porpoise and long finned pilot whale, the latter of which is the most important as a food resource. Long finned pilot whale is the largest of these whales and the one that is being caught in larger numbers. Other species are more like "by catch". In the 1890s, Norwegian whalers developed modern commercial whaling in the Faroe Islands targeting blue, fin, humback, sei and sperm whales. However, in 1902, a law safeguarding Danish and Faroese interests reserved the whaling practice for Danish citizens or companies in which Danes held at least 50% of the share capital. Commercial whaling of large whales stopped in 1984, but traditional household whaling has continued. Catch statistics (Statistics Faroe Islands, www.hagstova.fo has that statistic) show that some hundred white-beaked- and white-sided dolphins, and between zero to five bottlenose dolphins and harbour porpoises, are caught annually.

The traditional pilot whale hunt is presumed to be as old as the earliest settlements in the Faroes. Pilot whaling is mentioned in the Sheep Letter, a Faroese law from 1298, which is a supplement to the Norwegian Gulating law. Catch statistics have been recorded sporadically since 1584 and consistently since 1709. The records are thought to be one of the most comprehensive data sets for hunt in the world (Bloch 2000; Kerins 2010).

The pilot whales in Faroese waters are considered to be part of the North Atlantic population. The population is estimated to consist of about 800,000 animals, of which approximately 100,000 live around the Faroes. From 1992 to 2013, between 228 and 1,572 pilot whales were killed annually (Hagstova, 2017; IUCN, 2017). The number of whales killed each year is completely dependent on opportunities. The hunt happens only when someone spots a grind (a school of pilot whales) close to shore. The harvest is presumed sustainable as the annual catch corresponds to some 0.1% of the population (IUCN 2017).

**Figure 85: The traditional pilot whale harvest is still important for Faroese meat production**

Photo: Nazuno Nakao, 2013.

**Table 9: Pilot whales killed in Faroes**

| Year | Numbers | Schools | Min | Max | Food units (skinn) | Food units (kg) | Meat (kg) | Blubber (kg) | Per capita (kg) | Dried (kg) | Kills of total pop. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 1,104 | 11 | 21 | 267 | 8,302 | 597,744 | 315,476 | 282,268 | 12 | 5 | 0.1 |
| 2012 | 713 | 12 | 2 | 195 | 4,885 | 351,720 | 185,630 | 166,090 | 7 | 3 | 0.1 |
| 2011 | 726 | 9 | 21 | 204 | 4,682 | 337,104 | 177,916 | 159,188 | 7 | 3 | 0.1 |
| 2010 | 1,107 | 14 | 17 | 228 | 8,008 | 576,576 | 304,304 | 272,272 | 12 | 5 | 0.1 |
| 2009 | 310 | 3 | 23 | 188 | 2,974 | 214,128 | 113,012 | 101,116 | 4 | 2 | 0.0 |
| 2008 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 2007 | 633 | 10 | 1 | 231 | 5,522 | 397,584 | 209,836 | 187,748 | 8 | 3 | 0.1 |
| 2006 | 856 | 11 | 1 | 176 | 6,614 | 476,208 | 251,332 | 224,876 | 10 | 4 | 0.1 |
| 2005 | 302 | 6 | 5 | 116 | 2,194 | 157,968 | 83,372 | 74,596 | 3 | 1 | 0.0 |
| 2004 | 1,010 | 9 | 1 | 445 | 8,276 | 595,872 | 314,488 | 281,384 | 12 | 5 | 0.1 |
| 2003 | 503 | 5 | 44 | 153 | 3,968 | 285,696 | 150,784 | 134,912 | 6 | 2 | 0.1 |
| 2002 | 626 | 10 | 3 | 114 | 4,276 | 307,872 | 162,488 | 145,384 | 6 | 2 | 0.1 |
| 2001 | 918 | 11 | 22 | 186 | 7,376 | 531,072 | 280,288 | 250,784 | 11 | 4 | 0.1 |
| 2000 | 588 | 9 | 4 | 246 | 5,344 | 384,768 | 203,072 | 181,696 | 8 | 3 | 0.1 |
| 1999 | 608 | 8 | 4 | 196 | 5,398 | 388,656 | 205,124 | 183,532 | 8 | 3 | 0.1 |
| 1998 | 815 | 8 | 54 | 251 | 6,001 | 432,072 | 228,038 | 204,034 | 9 | 3 | 0.1 |
| 1997 | 1,172 | 15 | 5 | 172 | 7,588 | 546,336 | 288,344 | 257,992 | 11 | 4 | 0.1 |
| 1996 | 1,524 | 14 | 16 | 435 | 11,122 | 800,784 | 422,636 | 378,148 | 16 | 6 | 0.2 |
| 1995 | 228 | 5 | 4 | 108 | 1,216 | 87,552 | 46,208 | 41,344 | 2 | 1 | 0.0 |
| 1994 | 1,201 | 6 | 26 | 666 | 7,781 | 560,232 | 295,678 | 264,554 | 11 | 4 | 0.2 |
| 1993 | 808 | 10 | 11 | 193 | 5,237 | 377,064 | 199,006 | 178,058 | 8 | 3 | 0.1 |
| 1992 | 1,572 | 14 | 17 | 341 | 11,798 | 849,456 | 448,324 | 401,132 | 17 | 7 | 0.2 |

There are four phases in the traditional hunt. In *grindaboð*, a flock of whales is spotted, people are informed and gathered to hunt according to hierarchic rules and social relations. In *grindarakstur* a flock of whales is driven to a bay using boats. In the bay, the whales are killed in *grindadráp*. The hunt ends when the meat and blubber is shared in *grindabýti* (Joensen, 1976).

There are 23 authorised whaling bays in the Faroes. The selction of which bay to use for a specific hunt is mostly dependent on the current, as it is hard to drive whales against the current. If currents are equally suitable for two bays, the finder of the flock or local authority-figure decides. As there are no special whaling boats, regular fishing- & leisure boats are used. When the whales have beached themselves, they are killed (Bloch *et al.*, 1990, p. 38; Bloch & Joensen, 2001, p. 62; Kerins, 2010, p. 113–148).

### *8.2.4 Tourism*

The number of visitors to the Faroe Islands is growing. Especially outdoor activities including birdwatching and angling are of great interest, but also more cultural aspects, including traditional livehoods, are attracting tourists.

The Faroes have flight connections to Denmark, Norway and Iceland all year, as well as a regular ferry connection to Denmark and Iceland. In recent years, a growing number of visitors have arrived in the summer months on large cruise ships.

**Figure 86: The Faroese landscape attracts many tourists**

Photo: Håkan Tunón, 2017.

## 8.3 Biodiversity and ecosystem characteristics

### *8.3.1 Habitats*

The Faroe Islands are located on the Faroe shelf, which reaches 200 m depth. The seabed is varied and comprises everything from bedrock, rocks and boulders, to sand and clay, and combinations of these. Due to strong tidal currents, the seabed in shallow regions on the shelf consists of mainly sand and stones. Silt and organic material can be found in deeper areas (ICES, 2008).

The Faroe Islands comprise eighteen islands that are separated by fjords and sounds, with maximum depths of 100 m. The rugged landscape is characterised by ice-carved mountains covered in grass and heather without any tree-like vegetation, strongly marked by grazing sheep all year around. The Faroe Islands have been shaped by glaciers. The coastline is mostly rocky, with sandy or gravelly beaches along fjords and bays.

### *8.3.2 Key Species*

The few terrestrial species in the Faroe Islands have all been introduced by man. However, the islands have plenty of native seabirds and a diverse marine fauna consisting of numerous fish, marine mammals and shellfish.

Over 300 bird species have been recorded in the Faroe Islands. Of these, around 50 species breed regularly on the islands and another 60 are regular visitors.

Some 200 fish species are found in Faroese waters. Most of these species occur in low abundance and are not exploited. Around 20 species of fish are commercially exploited on the Faroe plateau.

**Table 10: Key Species in the Faroes**

| Classification | Species names |
|---|---|
| **Terrestrial species** | Mountain hare (*Lepus timidus*), mouse (*Mus domesticus*), rat (*Rattus norvegicus*) and semi-domestic sheep |
| **Birds** | Seabirds: Northern fulmar (*Fulmarus glacialis)*, European storm-petrel (*Hydrobates pelagicus)*, northern gannet (*Morus bassanus)*, common eider (*Somateria mollissima)*, black legged kittiwake (*Rissa tridactyla*), common guillemot (*Uria aalge*), shag (*Phalacrocorax aristotelis*), Manx shearwater (*Puffinus puffinus*), razorbills (*Alca torda*), lesser black-backed gull (*Larus fuscus*) and Atlantic puffin (*Fratercula arctica*).<br>Waders: Eurasian oystercatcher (*Haematopus ostralegus*) (the national bird of the Faroe Islands) |
| **Marine mammals** | Long finned pilot whale (*Globicephala melas*), white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), bottlenosed dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*) and grey seal (*Halichoerus grypus*). |
| **Fishes** | Demersal species: cod (*Gadus morhua*), saithe (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*) and ling (*Molva molva*)<br>Pelagic species: Atlantic mackerel *(Scomber scombrus),* Atlantic herring *(Clupea harengus)* and blue whiting *(Micromesistius poutassou)*<br>Flat fishes: Greenland halibut (*Reinhardtius hippoglossoides*), monkfish (*Lophius piscatorius*) and Atlantic halibut (*Hippoglossus hippoglossus*)<br>Other common species of economic importance: tusk (*Brosme brosme*), blue ling (*Molva dypterygia*), ocean perch (*Sebastes marinus*), whiting (*Merlangius merlangus*) and Atlantic catfish (*Anarhichas lupus*)<br>The farming of Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*)<br>Ecologically important species: sandeel (*Hyperoplus lanceolatus*) and Norway pout (*Trisopterus esmarkii*) |
| **Shellfish** | Horse mussel (*Modiolus modiolus*), blue mussel (*Mytilus edulis*), Norwegian lobster (*Nephrops norvegicus)*, knife-mussel (*Ensis ensis*), common sea urchin (Echinus esculentus), edible crab (*Cancer pagurus*), queen scallop (*Equipecten opercularis*) and common whelk (*Buccinum undatum*) |

### *8.3.3 Significant structural features*

The Gulf Stream is one of the most important factors influencing ecosystems in the Faroese region. More locally the islands are surrounded by warm water masses in the uppermost 500 m. This "Modified North Atlantic Water" derived from the North Atlantic Current flows towards the east and northeast. The water is typically around 8 °C with salinity around 35.25 ppt. Below 500–600 m, the water in most areas is dominated by cold water (< 0 °C) with salinities close to 34.9 ppt (ICES, 2008).

There are strong tidal currents reaching 1–2 m/s, allowing for efficient mixing of the shelf water. This results in homogeneous water masses in the shallow shelf areas with constant temperatures from surface to bottom. The temperature ranges from around 6 °C in March to 10–11 °C in August–September. The well-mixed shelf water is separated relatively well from the offshore water by a persistent tidal front, which surrounds the shelf at about 100–130 m bottom depth. In addition, residual currents have a persistent clockwise circulation around the islands (ICES, 2008).

### 8.3.4 Ecosystem function

The marine ecosystems around the Faroe Islands are highly productive with a high diversity and abundance of marine species. The Faroes are part of a larger Atlantic ecosystem, but on a more local scale, there is a clear difference between on-shelf and off-shelf areas. The on-shelf ecosystem has distinct planktonic communities, benthic fauna, and several fish stocks. Furthermore, about 1.5 million pairs of seabirds breed on the Faroe Islands and take most of their food from the shelf waters (ICES, 2008). The marine primary production on the Faroe plateau is concentrated to the period between April and September, with rather large differences between years according to nutrient availability and weather.

On land primary production is mainly linked to the grass-like vegetation, which reaches its maximum in June to August.

Many seabirds breed on the sea cliffs. Most sea cliffs in the Faroe Islands are to the northern and to the western parts of the islands and can be up to 500m high. In some areas the black sea cliffs are painted white by the sheer number of birds breeding there. Some birds, like puffins, breed in colonies on grassy steep slopes, where they dig a nesting burrow.

The clean temperate waters and strong currents around the Faroe Islands provide ideal conditions for many marine species.

## 8.4 Drivers and pressures

### 8.4.1 Direct

The stock sizes of the most important fish species (cod, haddock and saithe) are historically low and recruitments have been bad for several years. Regulative authorities have discussed changing quotas and/or fishing days for industrial fishing. Restrictions on small boat fishing has also been mentioned, but not actively discussed.

Sand extraction from the seabed is widely practiced in the Faroes due to its economic value and accessibility in fjords and along coastlines. Furthermore, there is no legal restriction on sand extraction. Sand eels prefer sand with specific grain size and quality, and continued sand extraction from near-shore areas could result in habitat loss for sand-eel and puffins. The population losses of the sand eel are also thought to be a result of industrial fishing.

Increased activities in bays including transportation, sand extraction and aquaculture, can change the landscape and topography of the bay. These issues can have impacts on biodiversity and key species, along with the suitability of bays for pilot whaling (Joensen, 2002).

### *8.4.2 Indirect*

The waters around the Faroes are getting warmer, with temperatures rising from 12 °C to 13 °C across the last twenty years. This increase, together with large-scale, climate-related ecological changes has disrupted the food web in the North Atlantic. A northward shift in the distribution of plankton and copepods is affecting stock size and distribution of some fish species. Several pelagic fish species such as Atlantic mackerel and Atlantic herring, now migrate into Faroese waters in greater numbers. Demersal stocks are, however, diminishing. Cod larvae feed on a very specific copepod (*Calanus finmarchicus*) and successful recruitment depends on a plentiful supply of this food item. Changes in climate have altered the balance of food, with resultant bad cod recruitment.

Changes in climate, including sea temperature, has effects on fishing, with impacts differing depending of the type of fish stock. Pelagic fish are highly mobile and move easily to more favourable locations. With modern fishing equipment, travelling longer distances to follow stocks is possible, and thus the economic impacts of the changes in stocks are not that large. Instead, the risk of over-fishing has become a challenge for fisheries management. Dermersal fish tend to be slower to respond to change and thus fisheries dependent communities might be able to adjust to slow changes in stock locations. However, if temperatures change suddenly, stocks can crash (Thostrup & Rasmussen, 2009, p. 14) with ensuing challenges for fisheries communities.

Seabirds including kittiwake, puffin, guillemot, Arctic tern and seagull have decreased significantly during the last decade, whereas gannet, fulmar, shag and black guillemot have not experienced similar declines. Many factors are thought to contribute to changes in population numbers, including changes to food source, changing currents and other consequences of global warming. Improved waste management at fish factories may contribute to reduced food availability for seagulls.

**Figure 87: Black guillemot (*Cepphus grylle*) in winter plumage in the harbour of Tórshavn**

Note: This species has not undergone the same decline as several other seabird species in the Faroe Islands.

Photo: Håkan Tunón, 2017.

### *8.4.3 Urbanisation*

The traditional resource related activities – hunting, fishing and sheep farming – have created the backbone to settlement structure in the Faroe Islands. During the last decades, the population in the Faroe Islands has undergone remarkable changes. Globalization, along with the changes in the economy towards the service sector and knowledge-based economies, have challenged traditional settlement structures. Today almost 90% of the Faroese population has a road connection to Tórshavn with a maximum driving time of around 90 minutes and some 40% of Faroese population live in the growing capital region itself. Especially better housing and job opportunities are particularly attracting women and younger generations to capital.

At the same time, the population in the smaller villages and especially on the small islands, has decreased dramatically with only 1% of population now living on small islands without road connection (Hagstova, 2017).

These small islands are the most viable locations for traditional livelihoods of bird hunt and egg gathering. Urbanisation threatens the traditional egg-harvest and the hunt of some bird species, as the catch is highly dependent on good cooperation between skilled hunters. Even though many of these small islands have more inhabitants during summertime, depopulation makes it difficult to maintain traditions as the number of skilled hunters is decreasing and fewer are interested in learning traditions. Generally a shift away from traditional village life is occurring.

The harvest of both eggs and birds from the cliffs requires a group of people. Apart from the persons descending the cliff in order to collect the eggs or catch the birds, many strong arms are needed to pull up the climber. But hands are becoming fewer. For example, Skúvoy only had 32 residents in 2017, and Mykines only had 14. To meet this shortage of labour, an ATV (4-wheeled All Terrain Vehicle) is now often used to pull the ropes for fulmar egg harvesting in Skúvoy.

Changes in the population is also affecting pilot whale hunting. If the catch takes place in a sparsely populated area with bad accessibility, it can be hard to organise a successful hunt. If the catch takes place in a densely populated area or in a bay with good accessibility, large numbers of people often participate and dividing the catch in an equitable way can be challenging.

### *8.4.4 Traditional local food*

Local food is of a great importance in the Faroe Islands. The harvest, distribution and consumption of traditional food occurs in relation to availability of food items. Apart from formal distribution methods in commercial systems, informal distribution systems exist and increase access to traditional food. Rasmussen *et al*. (2014, p. 195–199) list three ways of accessing traditional local food:

- on the one hand, there is an extensive distribution of fish and lamb because those are available through commercial systems. They can be bought in larger stores and are distributed in local market places;
- on the other hand, subsistence hunting, farming and fishing for personal consumption is common. These products do not only include fish and lamb, but also sea mammals, seabirds and their eggs. The number of persons involved in these activities is hard to estimate, but activities are generally considered an important part of life either through personal involvement or through family and good neighbour relations;
- furthermore, informal access to traditional products occurs through sharing. The availability and sharing of pilot whale blubber and meat after a hunt is an important social and cultural activity.

The importance and relatively high consumption of local food can be seen in the following statistics: In the population census in 2011, 73% of the households stated that supplement food sources are available – meaning that the household uses food from local sources that is not purchased from stores. Use and access to local and especially traditional food, is heavily dependent on social relations, where one lives and one's access to a boat (Hagstova, 2017).

The importance of self-caught fish is remarkable. 70% of the Faroese households that do not have a boat have access to local food. 94% of households with a boat have access to local food.

In Tórshavn the access to local food (64% of households) is not as high as elsewhere in the islands (80% of households). Particularly the younger generation is not as closely connected to hunting and gathering traditions, both in terms of distance and in lifestyle choices. For example, attitudes to whale meat are particularly impacted by international trends. However, local foods are becoming trendier in Tórshavn where the restaurant KOKS, which serves local food with modern inspiration, was just presented with its first star in the Guide Michelin. KOKS and other popular restaurants serve fulmar, fermented meat and other traditional specialities on their menu.

### 8.4.5 Activities

There is a growing international movement against whaling on the Faroes, which has further indirect negative impacts on fish export. Widespread media campaigns by international environmental and wildlife protection groups have increased international focus on the traditional whale hunting in the Faroes. Organisations have tried to force Faroese authorities to end pilot whale hunting since the mid-80s. During the latest email campaign in mid-2010s, there was an attempt to put pressure on the Danish Parliament to stop the hunt. This is despite all laws and regulations regarding fishing and hunting, including whaling, on the Islands are governed by the Faroese Parliament since the adoption of the home rule act in 1948 (Kerins, 2010, p. 13–30).

In addition, Sea Shepherd Conservation Society has led operations in the Faroe Islands, especially in 2008, 2014 and 2015. The Sea Shepherd works with direct action, resulting in several confrontations between them and the Faroese/Danish police. Several activists were arrested for disrupting ongoing pilot whale hunts, both at sea and on land. The organisation succeeded in getting big media attention from all around the world (Kerins, 2010, p. 27–28; Singleton, 2016).

**Figure 88: An unfriendly message painted of the walls of the historical fortress of Tórshavn, probably connected to the traditions related to pilot whales**


Photo: Håkan Tunón, 2017.

The expansion of tourism might generate new challenges, with demands on infrastructure that can have negative impacts on ecologically sensitive regions (Thostrup & Rasmussen, 2009, p. 15). Birds, in particular, may be among the most impacted species.

### 8.4.6 Threats

Animals high on the food chain are exposed to high levels of industrial chemicals, heavy metals and PCBs, which accumulate in all levels of the marine food web. Several epidemiological studies show that the traditional marine food of the Faroes, that consists of fatty pilot whale blubber, fish and seabird fledglings, is particularly rich in methylmercury, polychlorinated biphenyls, perfluorinated compounds and polybrominated diphenyl ethers (Axelrad *et al*., 2007; Myers *et al*., 2007; Fliedner *et al*., 2012; Weihe & Joensen, 2012). This health hazard has the potential to change Faroese cuisine in the long run.

Environmental toxins including mercury, as well to a smaller extent arsenic, cadmium, zinc, lead, copper and selenium, can be found in pilot whale meat. Many organochlorine compounds such as PCBs can be found in blubber. Therefore, health authorities recommend restricted intake of whale meat and blubber. Nowadays, whale meat is not recommended for children or for females in a fertile age, with strong impacts on the maintenance of traditions (Bloch, 2000, p. 29; Diet recommendation…, 1998).

Plastic is also becoming a major threat to many seabird species, particularly Atlantic fulmar seem to be especially attracted to picking up and eating floating plastic.

Tunnels between the islands increase accessibility for people, but also increase the potential for the spread of rats with potential risk for bird colonies as theyeat eggs and chicks.

## 8.5 Governance of ecosystem services and influencing policies

The Faroe Islands are a self-governed (autonomic) part of the Danish Kingdom with their own legislative parliament (Føroya løgting) and a government that is chaired by the prime minister (løgmaður) and no less than two other ministers. The Faroes are organised in to 30 municipalities, of which the largest is Tórshavnar with 20,885 inhabitants (Hagstova – Statistics Faroe Islands, 2017) and the smallest is Skúvoyar with 42 inhabitants.

### *8.5.1 International / EU*

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. Faroese autonomy in foreign relations is provided by a treaty between the Faroe Islands and Denmark, which is enacted in legislation.

The Faroe Islands participate actively in a range of international fisheries management arrangements and organisations in the North Atlantic, including the Northeast Atlantic Fisheries Commission (NEAFC), the Northwest Atlantic Fisheries Organization (NAFO), the North Atlantic Marine Mammal Commission (NAMMCO), the North Atlantic Salmon Conservation Organization (NASCO) and the International Council for the Exploration of the Sea (ICES).

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.

### 8.5.2 National

To protect the rich bird life in the Faroe Islands, the government has appointed Mykines, Nólsoy and Skúvoy as Ramsar sites.

Several national acts and decrees exist to protect nature and limit the use of resources:

- act on Bird hunting (FO: Fuglaveiðilógin): "Løgtingslóg nr. 27 frá 9. september 1954 um fuglaveiðu v.m., sum seinast broytt við løgtingslóg nr. 48 frá 15. mai 2014";
- act on "Grannastevna" (FO: Lóg um grannastevnu, Eng. "meeting of the villagers"): "Lov nr. 170 af 18. maj 1937 for Færøerne om Grandestævne m.m.";
- act on hare hunting (FO: Haruveiðulógin): "Løgtingslóg nr. 128 frá 25. oktober 1988 um haruveiðu;
- act on Nature conservation (FO: Náttúrufriðingarlógin): "Løgtingslóg nr. 48 frá 9. juli 1970 um náttúrufriðing, sum seinast broytt við løgtingslóg nr. 110 frá 29. juni 1995";
- act on protection of the environment (FO: Umhvørvisverndarlógin): "Løgtingslóg nr. 134 frá 29. oktober 1988 um umhvørvisvernd, sum seinast broytt við løgtingslóg nr. 128 frá 22. desember 2008";
- act on protection of the marine environment (FO: Havumhvørvislógin);
- decree on dragging of puffins from their burrows (FO: Loyvi at draga lunda): "Kunngerð nr. 120 frá 21. november 1986 um serliga fuglaveiðu";
- decree on sampling of guillemot eggs (FO: Loyvi at rana egg): "Kunngerð nr. 60 frá 16. mai 1986 um ræning av lomvigaeggum".

## 8.6 Insights from indigenous and local knowledge

Apart from the on-going traditions surrounding the harvest of pilot whales, fish and seabirds, there is rich folklore on the Islands, especially the tradition of chanting many verses about traditional livelihoods. As there was no written Faroese language until the end of the 19th century, the ballad (fo: kvæði) survived through the centuries orally. Chanting is still popular, especially in combination with the traditional Faroe circle dance. For example, the first record of named birds in the Faroes comes from the old Faroese Bird Ballad, presumably dating back over 500 years (Schei & Moberg, 1991).

One of the most famous and well-known ballads are *Grindavísan*, the pilot whaling ballad from the 1830s that describes the hunt. This song describes pilot whaling as a symbol that has later become a growing part Faroese national identity (Joensen, 1976, p. 21–22; 1990, p. 182). The pilot whale hunt is an important motif in literature, music, art and handicrafts. *Grindaknívur*, the knife used for the pilot whale hunt, is an impressive example of Faroese handicrafts (Joensen, 1976, p. 15; 1990, p. 182).

Pilot whale have a long history as the Faroese national symbol, adopted in the 19th century to symbolise Faroese nationalism and identity. Pilot whaling was proudly shown as a part of local culture i.e. in postcards and travel stories. However, since the mid-70s when international criticism against whaling started, and especially after 1986 when commercial whaling stopped, the national romantic picture of a pilot whale has undergone symbolic inversion (Joensen, 1990, p. 182–184; Sanderson, 1994, p. 187; Nauerby, 1996, p. 24, 177–178). Despite this, pilot whalea still represent traditional ways of living in the Faroe Islands and contribute to the close relationship between man and nature that even still thrives in the urbanised population on the Faroes (Nauerby, 1996, p. 177–178).

The importance of the pilot whale hunt was more significant historically than it is today. Nowadays the hunt is maintained as a traditional and social practice, as well as a supplement to more modern cuisine. Strict regulations apply to the hunting procedure and the distribution of the meat. Hunting has never been based on economic issues, but is a local, social activity. Everyone, including children, is invited to participate in the hunt and as there are no professional hunters – it involves "learning by doing", and one normally learns how to kill a whale from a close relative. A lot of knowhow in pilot whaling has its origin in fishing, including boating skills and judging currents and weather conditions (Hauan & Mathisen, 1993, p. 126–127).

Successful hunts require cooperation and established social organisation (Joensen 1976, p. 37), with controlled processes and clear working roles. It is said that a successful pilot whale hunt requires not only local knowledge and knowhow, but also superstitious traditions, like specific *grind* weather, tools and behaviour of the hunters (Bloch & Joensen, 2001, p. 57–64).

**Figure 89: The hunting of pilot whales is more than just a way to get meat**

Note: It is a cultural symbol and an important social context for the Faroese people.

Photo: Nazuno Nakao, 2015.

Meat and blubber has always been freely shared between the local people following specific rules. The harvested whale meat and blubber is divided amoung participants in the hunt. Depending on the size of the catch, the people who live in the area typically also receive a share. The local sheriff decides how to divide share. In order to divide the catch in an equitable way, each whale is measured in "skind". One skind corresponds to approximately 38 kg meat and 34 kg blubber. Each participant and/or local gets their share according to hunting law, after which the meat and blubber is often shared with friends and family (Bloch *et al*., 1990, p. 41; Bloch, 2000, p. 26–28). Thus whale meat is a part of a non-economic exchange system that combines people and households, creating both economic and social connections (Kalland, 2000, p. 208).

Even pilot whaling has undergone both social and technological developments, but the main function is still to get food for the household and not to make any economic profit. The new tools are more effective and do less harm to the whale before it is killed, but a successful hunt is still dependent on knowhow and cooperation between the participants (Sanderson, 1994, p. 194–195).

### *8.6.1 What is it to be Faroese?*

It is often claimed that to feel Faroese one has to be brought up on the islands or have adapted to the way of living and the values in the Faroes. Faroese people are influenced by the rough and changeable nature, the unpredictability of the weather, the wind, the rain, the beauty of nature, the long daylight in the summer and the darkness in the winter, the strong family bonds and close connection to friends and the community in general. The possibility to wander freely in nature is defining, along with the watching eye of everyone in a small community where Christian values are everyday life and where the Faroese language is spoken (Andreassen, 1992; Gaini, 2013; Joensen, 1987).

## 8.7 References


Andreassen, E. (1992). *Folkelig offentlighed*. Keypmannahavn: Museum Tusculanums Forlag.

Axelrad, D. A., Bellinger, D. C., Ryan, L. M., & Woodruff, T. J. (2007). Dose–response relationship of prenatal mercury exposure and IQ: An integrative analysis of epidemiologic data. *Environmental Health Perspectives*, *115*(4), 609–615.

Bloch, D. (2000). *Færøernes grindefangst med en tilføjelse om dødlingefangsten*. 51 p. Tórshavn: Føroya náttúrugripasavn.

Bloch, D., & Joensen, H. P. (2001). Faroese pilot whaling – conditions, practice and superstition. In: T. A. Vestergaard (ed.). *Shamanism and traditional beliefs*. SNAI – North Atlantic Studies 4:1+2, 57–72. Århus: North Atlantic Publications & Aarhus university press.

Bloch, D., Desportes, G., Hoydal, K., & Jean, P. (1990). Pilot whaling in the Faroe Islands – July 1986 – July 1988. Teoksessa Vestergaard, Elisabeth (ed.). *Whaling communities*. SNAI – North Atlantic Studies 2:1+2, 36–44. Aarhus: North Atlantic Publications & Aarhus university press.

*Diet recommendation concerning pilot whale meat and blubber – Faroe Islands August 1998* (1998). Heilsufrøðliga stravsstovan, Tórshavn.

Fasaa, A. M., Gaard, E., & Dalsgaarð, J. (2006). *Føroya Náttúra – Lívfrøðiligt margfeldi*. Tórshavn: Føroya skúlabókagrunnur, 270 pp.

Fliedner, A., Rüdel, H., Jürling, H., Müller, J., Neugebauer, F., & Schöter-Kermani, C. (2012). Levels and trends of industrial chemicals (PCBs, PFCs, PBDEs) in archived herring gull eggs from German coastal regions. *Environmental Sciences Europe*, *24*(7), https://doi.org/10.1186/2190-4715-24-7

Fulmar egg harvest at Sandoy. Seabird harvest in the North Atlantic. https://www.atlanticseabirds.info/copy-of-skuvoy-1 accessed 2017-04-26

Fulmar egg harvest at Skúvoy. Seabird harvest in the North Atlantic. https://www.atlanticseabirds.info/skuvoy accessed 2017-04-26

Gaard, E. (2000). *The Plankton Community Structure on the Faroe Shelf*. Dr. philos thesis. University of Tromsø.

Gaini, F. (2013). Lessons of Islands. Place and Identity in the Faroe Islands. Torshavn: Faroe University Press.

Hagstova – Statistics Faroe Islands. (2017). *Statistical database*. http://www.hagstova.fo

Hansen, B. (2000). *Havið*. Tórshavn: Føroya skúlabókagrunnur. 232 pp.

Hauan, M. A., & Mathisen, S. R. (1993). Kvalfangst og kystkultur. In N. C. Stenseth, A. H. Hoel & I. B. Lid (Eds.). *Vågehvalen – valgets kval*, p. 125–133. Oslo: Ad Notam Gyldendal.

ICES (International Council for the Exploration of the Sea) Advice 2008, Book 4 (2008). http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2008/2008/4.1-4.2%20Faroe%20plateau%20ecosystem%20overview.pdf

IUCN. (2017). The IUCN *Red List of Threatened Species 2017 – 1, Globicephala melas*. http://www.iucnredlist.org/details/9250/0

Joensen, J. P. (1976). *Pilot whaling in the Faroe Islands*. 42 p. Ethnologia Scandinavica. Lund: Berlingska Boktryckeriet.

Joensen, J. P. (1987). *Fólk og mentan*. Tórshavn: Føroya Skúlabókagrunnur.

Joensen, J. P. (1990). Faroese pilot whaling in the light of social and cultural history. In E. Vestergaard (Ed.). *Whaling communities*. SNAI – North Atlantic Studies 2:1+2, 179–184. Aarhus: North Atlantic Publications & Aarhus University Press.

Joensen, J. P. (2002). Jakten och jägaren. In: *Fångstkultur i Västnorden – Hunters of the North*, p. 26–79. Stockholm: Föreningen Norden.

Kalland, A. (2000). The whalers of Lofoten, Northern Norway. In M. M. R. Freeman (Ed.). *Endangered peoples of the Arctic. Struggles to survive and thrive*, p. 203–222. Westport: Greenwood Press.

Kerins, S. (2010). *A thousand years of whaling. A Faroese common property regime*. Alberta: CCI Press.

Ministry of Fisheries and Natural resources (n.a.). *Faroe Islands – Fisheries & Aquaculture. Responsible management for a sustainable future*. http://cdn.lms.fo/media/6850/final_070408.pdf

Myers, G. J., Davidson, P. W., & Strain, J. J. (2007). Nutrient and methyl mercury exposure from consuming fish. *Journal of nutrition*, *137*, 2805–2808.

Nauerby, T. (1996). *No nation is an island – language, culture and national identity in the Faroe Islands*. 237 p. Århus: SNAI – North Atlantic publications, Aarhus university press.

Rasmussen, R. O., Roto, J., & Hamilton, L. C. (2014). West-Nordic Region. In J.N. Larsen, P. Schweitzer & A. Petrov (Eds.), *Arctic Social Indicators. ASI:II Implementation*. p. 155–209. TemaNord 2014:568. Copenhagen: Nordic Council of Ministers.

Roto, J. (2004). Ecological monitoring and observations of cultural hunting of pilot whales in the Faroe Islands – The local societys perspective. In: E. Helander & T. Mustonen (Eds.). *Snowscapes – Dreamscapes. Snowchange book on community voices of change*, 251–252. Vaasa: Tampere polytechnic publications. Ser C. Study materials 12.

Rigombudsmandens beretning. (2016).

Sanderson, K. (1994). Grind – Ambiguity and pressure to conform: Faroese whaling and the anti-whaling protest. In: M. M. R. Freeman, & U. P. Kreuter (Eds.). *Elephants and whales – resources for whom?* p. 187–201. Basel: Gordon and Breach science publishers.

Schei, L. K., & Moberg, G. (1991). *The Faroe Islands*. 248 p. London: John Murray Publishers Ltd.

Singleton, B. E. (2016). *From the sea to the land beyond. Exploring plural perspectives on whaling.* Doctoral diss. Örebro: Örebro Studies in Sociology 21.

Storå, N. (1968). *Massfångst av sjöfågel i Nordeurasien. En etnologisk undersökning av fångstmetoderna*. Åbo: Åbo akademi.

Thostrup, L., & Rasmussen, R. A. (2009). *Climate change – and the North Atlantic*. 128 p. Tórshavn: NORA.

Weihe, P., & Joensen, H. D. (2012). Dietary recommendations regarding pilot whale meat and blubber in the Faroe Islands. *Int. J. Circumpolar Health*, 71, 1–5. https://doi.org/10.3402/ijch.v71i0.18594

# 9. Disko Bay

*Michael Køie Poulsen*

**Figure 90: Map over the Disko Bay case study area**


Source: ESA 2010 and UCLouvain.

## 9.1 Setting the scene

Disko Bay (*Qeqertarsuup tunua*) has been selected as the case study area for Greenland (*Kalaallit Nunaat*) because it has a rich and intensely-used biodiversity and because a local initiative, PISUNA, forms an excellent example of a community-based monitoring scheme. Local fishers and hunters are developing and testing PISUNA, through which they regularly report their observations of living resources and share their interpretations and their management recommendations based on their indigenous and local knowledge (ILK). Disko Bay is part of the West Greenland Shelf ecoregion, which is one of the world's 232 marine ecoregions identified by Spalding *et al*. (2007).

The case study area is located approximately 70° 17′ 39 N and 68° 37′ 12 N and covers some 45,000 km$^2$. The case study area includes Disko Island, inner Disko Bay, Vaigat Strait and the marine area just west and north of Disko Island. The Disko Bay area lies within Qaasuitsup municipality, the world's largest (660,000 km$^2$) and most northerly municipality, which in 2018, has been split into two separate municipalities. The area has more than 10,000 inhabitants, many of whom are full-time or part-time hunters and fishers. The towns in the Disko Bay area are Ilulissat (> 4,000 pers.), Aasiaat (> 3,000 pers.), Qasigiannguit (> 1,000 pers.) and Qeqertarsuaq (c. 850 pers.). There are a further eight settlements (Saqqaq Qeqertaq Akunnaaq Ikamiut Ilimanaq Kitsissuarsuit Oqaatsut Kangerluk), each with 20–200 inhabitants. Disko Bay, and especially the most active glacier *Sermeq Kujalleq* (Ilulissat Glacier), is an attractive tourist destination.

**Figure 91: Niaqornaarsuk, a community south of Disko Bay with about 300 persons who rely on Disko Bay for fishing in the summer and hunting seals in the winter**

Photo: Michael Køie Poulsen.

## 9.2 Key Ecosystem Services in Disko Bay

### 9.2.1 *Provisioning services*

*Food provision*: Shrimp, crab, scallop and fish are very important economically. Fish, mammals and birds are caught for local consumption.

*Energy provision*: Sledges pulled by dogs fed with seal meat and marine fish are still frequently used. In the past, people used to burn driftwood and bones in their fireplace and may have used blubber for oil lamps.

*Water*: Water is available through lakes and rivers and good drinking water is provided to towns and settlements via waterworks.

*Biotic raw materials*: Sealskin is used for clothing or trade. Seal meat and marine fish are used for fodder for sledge dogs.

*Genetic and medical resources*: The potential for harvesting genetic and medical resources in Disko Bay is not well explored nor understood.

### 9.2.2 *Regulating services and supporting services*

*Carbon sequestration and climate regulation*: Carbon may be stored when phytoplankton or higher taxon in the food chain die and fall to the bottom of the deep sea from where the carbon will not return to the atmosphere. Recent studies show that *Calanus finmarchicus* hibernates at depths of 600–1,400 m and that carbon is sequestrated when they respire into the (Jónasdóttir *et al*., 2015).

*Primary production*: Primary production by phytoplankton in Disko Bay is very high for Arctic waters.

*Purification of water and air*: The marine ecosystem of Disko Bay provide some wastewater decomposition and detoxification.

*Erosion prevention*: Large areas of Disko Bay are covered with seaweed (macroalgae) that stabilise sediments and reduce the power of waves, thereby reducing coastal erosion.

### 9.2.3 *Cultural services*

*Spiritual experience and sense of place*: The identity of the Inuit is closely tied to their geography, history and their attitudes towards hunting – "For Inuit, ecology, hunting and culture are synonymous" (Wenzel, 1991). Almost all Inuit adults consider hunting/fishing, gathering and traditional food preserving activities important to their identity (Poppel *et al.*, 2015).

*Inspiration for culture*: The biodiversity, scenic beauty and life as hunters in small isolated communities are reflected in their language, music, myths, clothing, food and homes (Greenland.com, 2017). Art in Greenland almost always describes or depicts elements of biodiversity.

*Recreation*: Subsistence fishing and hunting are cultural heritage activities crucial for sustaining cultural cohesion and are also recognised by many as a part of Inuit heritage (FAO, 2016).

*Tourism*: Disko Bay, with its breathtaking natural beauty and traditional Inuit life, attracts many tourists. The *Sermeq Kujalleq* glacier, declared a UNESCO World Heritage Site in 2004, is especially popular. Ilulissat had about 58,000 hotel nights in 2012.

### 9.2.4 *Security, health and quality of life*

#### Provisioning services

*Food security*: The marine living resources are the main reason why people have settled and live in Disko Bay, and most of the food consumed by people here comes from the sea. Findings from the "Survey of Living Conditions in the Arctic" show that artisanal fishing and hunting remain important to food security in Greenland (Poppel *et al*., 2015).

**Figure 92: Meat and fish plays a vital role to the local people in the area. The skinning of a seal**

Photo: Michael Køie Poulsen.

*Livelihood security*: Fishing is the primary industry of Greenland and contributes more than 90% of the country's total export value (Danish National Bank, 2014; Statistics Greenland, 2016). Small and large-scale fishing activities, commercial fishing and related land-based, post-harvest activities are essential for the local economies in both settlements and towns. The marine ecosystem of Disko Bay sustains a large part of Greenland's fisheries. The largest landings by volume in Greenland are in Ilulissat and Aasiaat in Disko Bay (FAO, 2016).

### Regulating and supporting services

*Primary production*: The high primary production is the basis for the abundance and diversity of living resources.

*Purification of water*: All wastewater in Disko Bay is discharged into the sea (Qaasuitsup Municipality, 2014). The sea is considered to be so large that the decomposition and detoxification of waste from the population is unproblematic.

### Cultural services

Greenlanders' identity is deeply rooted in hunting. The biodiversity and scenic beauty of coastal marine areas in Disko Bay is hugely important for the quality of life and for maintaining mental health for the local people. The Inuit in Disko Bay are culturally connected with nature to a degree where they have difficulties in adapting to a life with limited access to nature. Inuit men will often find it nearly impossible to stay indoors if the conditions outside are right for going hunting. Inuit women are better at accepting indoor life, but also need to connect with nature. The scenic beauty, wildlife and traditional fishing and hunting, including the use of dog sledges, have recreational benefits for the people living in the area and also attract many tourists.

**Figure 93: A fairly shallow coastal environment from Niaqornaarsuk in the southern part of the Disko Bay area**

Photo: Michael Køie Poulsen.

**Table 11: Examples of Nature's Contributions to People (NCP) in Disko Bay: Positioning services**

| Food | Energy | Water | Biotic raw materials | Genetic and medical resources |
|---|---|---|---|---|
| Shrimp<br>Crab<br>Scallop<br>Fish<br>Mammals<br>Birds | Seal<br>Fish<br>Driftwood<br>Bones | Lakes<br>Rivers | Seal<br>Fish | Not well explored |

**Table 12: Examples of Nature's Contributions to People (NCP) in Disko Bay: Regulating services and supporting services**

| Carbon sequestration and climate regulation | Primary production | Purification of water and air | Erosion prevention |
|---|---|---|---|
| Phytoplankton<br>Copepods | Phytoplankton | Marine waters | Seaweed |

**Table 13: Examples of Nature's Contributions to People (NCP) in Disko Bay: Cultural services**

| Spiritual experience and sense of place | Inspiration for culture | Recreation | Tourism |
|---|---|---|---|
| Geography<br>History<br>Hunting<br>Fishing | Biodiversity<br>Scenery<br>Hunting | Fishing<br>Hunting | Nature<br>Culture |

## 9.3 Biodiversity and Ecosystem Characteristics in Disko Bay

### *9.3.1 Ecosystem components and function*

Disko Bay is an area of complex oceanographic and bathymetric features, impacted by tidal driven upwelling. The Irminger Current, which travels north along the west Greenland coast and shelf, brings relatively warm waters, generating reduced sea ice cover and an open water period. The *Sermeq Kujalleq* glacier feeds large numbers of icebergs, fresh water and nutrients into Disko Bay. The mixture of fresh melt water and the warmer, salty seawater forms a system with high productivity. The cooling in the winter months causes mixing of the water column down to 150 meters (Mosbech *et al*. 2007; Rysgaard *et al*., 1999; Arendt, 2011; Christensen *et al*., 2012; Merkel *et al*., 2012; Ministry of Environment and Nature, 2014).

### *9.3.2 Key habitats*

Disko Bay has a diverse seabed terrain with areas of rather shallow waters near the coast, traversed by deep troughs. Macroalgae form wide belts of vegetation along the coasts and may occur from the tidal zone to water depth of more than 50 m (Boertmann *et al*., 2013). Low cliffs and extensive areas of reefs and islets form the coast in the southern part of Disko Bay. Straighter coasts, often made up of sediments such sand or gravel, characterise the western and more northern areas of Disko Bay. In the northern part, the coasts are characterised by high cliffs, often with narrow foreshores. At the beginning of the melt season, a wide polynya-like feature often forms west of Disko Island and in front of Disko Bay (Mosbech *et al*., 2007). The glacier *Sermeq Kujalleq* is the most active in Greenland and hundreds of icebergs are always present in Disko Bay. The land-areas of Disko Bay are rocky and poor in nutrients, and include bare areas and areas of permanent ice. Where there is vegetation, dwarf scrub heath is the predominant habitat. Lakes, ponds and marshes are scattered throughout. Where the marshes become drier, they transform into grassland (Egevang & Boertmann, 2001). There are no ongoing large-scale changes in the extent and quality of habitats, except for a trend towards rising sea temperature and declining ice cover both at land and at sea. Local communities report that trawlers are destroying the bottom near the coast, and thereby damaging breeding and feeding grounds for fish and invertebrates (Danielsen *et al.*, 2014).

### *9.3.3 Key Species*

The economically most important living resources in Disko Bay are Northern shrimp (*Pandalus borealis*), snow crab (*Chionoecetes opilio*), Atlantic cod (*Gadus morhua*) and Greenland halibut (*Reinhardtius hippoglossoides*). Scallop (*Clamys islandica*) and lumpsucker (*Cyclopterus lumpus*) are also economically important species.

The most important species for local consumption include Atlantic cod, Greenland halibut, seals and whales. Capelin (*Mallotus villosus*), Arctic char (*Salvelinus alpinus*), redfish (*Sebastes mentella*), spotted wolffish (*Anarhichas minor*) and other fish species are also consumed locally. King eider (*Somateria spectabilis*), common eider (*Somateria mollissima*) and thick-billed murre (*Uria lomvia*) are regularly hunted, along with other species of seabirds less frequently.

**Figure 94: A local man from Aasiaat with a spotted wolffish**


Photo: Susanne Fahlén.

The species most frequently selected by local fishers and hunters for monitoring are seals (fluctuating), Atlantic cod (increasing), common eider (increasing), humpback whale (*Megaptera novaeangliae*) (increasing), Greenland halibut (increasing), thick-billed murre (declining), Canada goose (*Branta canadensis*) (increasing), narwhal (*Monodon monoceros*) (stable or increasing) and beluga (*Delphinapterus leucas*) (stable or increasing) (Danielsen *et al*., 2016).

The endangered species, according to the Greenland Red List 2007 (Boertmann, 2008), are walrus (*Odobenus rosmarus*), beluga, narwhal (West Greenland population) and Greenland white-fronted goose (*Anser albifrons flavirostris*).

Key species in the food web include *Thalassiosira* spp. and *Chaetoseros* spp. phytoplankton, *Calanus* copepods, Northern Shrimp, capelin, Atlantic cod, Greenland halibut, seals and whales.

Domestic biodiversity in Disko Bay relates solely to Greenland dogs (*Canis lupus familiaris borealis*), which are used for sled dogs. To keep the ancient breed pure, other dog breeds are not permitted in Disko Bay or other places where there are Greenland dogs.

### Plankton

*Thalassiosira* spp. and *Chaetoceros* spp. are the phytoplankton species in Disko Bay (Krawcyk *et al*., 2014).

Three species of copepods, *Calanus hyperboreus*, *C. glacialis*, and *C. finmarchicus*, are important species in the high marine biodiversity in Disko Bay (Boertmann *et al*., 2013; Garde, 2014). Droppings from the *Calanus* copepods contribute to a species-rich bottom fauna consisting of, for example, mussels, sea sponges, echinoderms, sea anemones, crab and fish (Christensen *et al*., 2015).

### Macroalgae

The macroalgae community is totally dominated by brown algae, with *Fucus evanescens* and *F. vesiculosus* dominating the tidal zone (Boertmann *et al*., 2013). Macroalgae have importance as primary producers, as nursery grounds and by providing shelter and protection from both waves and predation (Boertmann *et al*., 2013; Christensen *et al*., 2015).

### Benthic invertebrates

Northern shrimp are fished in huge quantities in Disko Bay. The population has been declining in recent years (Jensen, 2003). Important benthic species, in an ecosystem context, include the bivalves *Mytilus edulis*, *Hiatella bysifera*, *Serripes groenlandicus* and *Mya truncate*, but many species of polychaetes, echinoderms, amphipods and gastropods are also found (Garde, 2014).

### Fish

Greenland halibut is abundant in Disko Bay and particularly in the deep glacial fjords. The abundance of commercially important Atlantic cod has varied greatly. An ongoing recovery is likely due to the increasing water temperatures (Boertmann *et al*., 2013). Capelin forms a crucial link from lower to higher trophic levels (Boertmann *et al*., 2013). Some 80 fish species are known from Northwest Greenland and more are being added to the list regularly. This is, according to researchers, either a result of warmer waters or simply a result of increased sampling activity in deep waters (Boertmann *et al*., 2013). Local fishers have also noted that new species are occurring and relate this to increasing water temperatures (Danielsen *et al*., 2016). Only two fish species occur in the freshwaters of the area: Arctic char (*Salvelinus alpinus*) and three-spined stickleback (*Gasterosteus aculeatus*) (Wegeberg & Boertmann, 2016).

### Birds

The Arctic tern colony on Kitsissunnguit is Greenland's largest. The sharply declining thick-billed murre colony at Ritenbenk, is the only one in the entire region from Maniitsoq to Upernavik. The number of breeding Canada goose (*Branta canadensis*) is increasing and local people fear a negative effect on rarer species. King eiders from Canada gather in the fjords for molting in the late summer. During this time, they are unable to fly and are therefore especially sensitive to disturbances and oil spills. Charismatic bird species in Disko Bay include white-tailed eagle (*Haliaeetus albicilla*), which is increasing in numbers according to local monitors, and Ross's gull (*Rhodostethia rosea*), which is a very rare pink gull loved by birdwatchers.

### Mammals

There are 18 species of marine mammal in Disko Bay; polar bear, 12 whale species, walrus and four other seal species. Disko Bay is particularly important for marine mammals in the winter and spring months (December–May). Bow-headed whale gather in the area off Kangaatsiaq in Disko Bay during the winter until the beginning of June. Beluga and narwhal gather from November–April. Land mammals include reindeer (*Rangifer tarandus*) and muskox (*Ovibos moschatus*).

**Figure 95: Local hunter with a newly shot muskox**

Photo: Aningaaq Petersen.

### Terrestrial plants

Typical plants of the dwarf scrub heaths are dwarf birch (*Betula nana*), black crowberry (*Empetrum nigrum*), bog bilberry (*Vaccinium uliginosum*), bell-heather (*Erica cinerea*) and blue heath (*Phyllodoce coerulea*) (Normander, 2016).

## 9.4 Direct and indirect drivers of change

The status of key species functional groups may change over time and space resulting in changes to the ecosystem. The two most important drivers of change are climate change and the harvest of wild species. Climatic changes could, for example, have an impact on the copepod composition crucial for the remainder of the marine food chain

(Garde, 2014). It is also feared that species becoming more dominant will play a lesser role in carbon sequestration and climate regulation than the now dominant species (Jónasdóttir *et al*., 2015).

### *9.4.1 Anthropogenic direct drivers*

The anthropogenic direct drivers most relevant for the biodiversity of Disko Bay are climate change and the harvesting of of wild species. Other stressors include human activities such as shipping and tourism, industrial and associated infrastructure development both on land and at sea, pollution and invasive alien species.

#### Climate change

Anthropogenic climate change is related to greenhouse gas emissions, mostly occurring far away from Greenland. Pressures as a result of climate change include melting sea ice, decreased snow cover and permafrost thawing. Local fishers and hunters in Disko Bay point to climate change, anthropogenic or natural, as the main likely reason for the ever-changing status of fish and wildlife populations (Danielsen *et al*., 2016). Sea ice loss has an effect on the entire foodweb and on the human communities that rely on sea ice for travel (Eamer *et al*., 2013).

#### Use of wild species

Hunting and fishing are perhaps still the most important anthropogenic drivers influencing the status and trends of biodiversity in Disko Bay.

#### Habitat degradation

Habitat degradation is not regarded as a major issue in Disko Bay. Local fishers, however, are worried that bottom trawling, especially near the coast, may cause damage to benthic ecosystems (Danielsen *et al*., 2016).

**Figure 96: Human activities are having influence on the Disko Bay ecosystem. Here is a part of the busy harbor area in Aasiaat**

Photo: Michael Køie Poulsen.

### Pollution

Extractive activities related to non-living resources and major infrastructure projects may cause pollution. Mining exploration in the Disko Bay area concerns hydrocarbons (gas and oil – offshore) and hard minerals (mining – land). Five exploratory oil wells were drilled west of Disko in 2010 and 2011.

Use of microplastic trawls in Disko Bay has shown relatively low amounts of microplastics in the ocean surrounding Disko. Lost, discarded and abandoned fishing gear is the major source of marine debris in Disko Bay. Mercury presents a risk to wildlife and human populations in Disko Bay. Reducing human and environmental exposure to mercury in the Arctic will ultimately depend on global action to reduce quantities of mercury (AMAP, 2011).

### Invasive species

No invasive species have yet caused concern for the biodiversity and ecosystems of Disko Bay. A number of marine invasive species have potential for northward expansion as sea-surface temperatures increase (Fernandez *et al*., 2014).

### Natural direct drivers

Natural direct drivers with an impact on biodiversity and ecosystems in Disko Bay 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).

## *9.4.2 Institutions and governance, and other indirect drivers of change*

Institutions and governance systems in Greenland are indirect drivers that can affect the root causes of how wild species are used. The institutional fisheries framework in Greenland is under the Parliament of Greenland and, in particular, under the Ministry for Fisheries, Hunting and Agriculture (FAO, 2016). Catches of most species are regulated following a comprehensive assessment of what stocks can sustain, taking into account their long-term development. Protected areas, license-systems and restrictions on permitted equipment are used to reduce pressures on living resources. Quotas and hunting seasons are adjusted regularly on the basis of biological advice (Christensen *et al*., 2015). Five of Greenland's 11 Ramsar areas are situated within the Disko Bay case study area. Possible future threats to nature and nature's benefits to people in Disko Bay include pollution and invasive species. Over the past decade, considerable effort has been invested in identifying marine areas and coastlines vulnerable to oil spills, resulting in a number of strategic environmental impact assessments (SEIAs) for hydrocarbon exploration and exploitation activities (Ministry of Environment and Nature, 2014). Before extractive activities of non-living resources and major infrastructure projects can be commenced, an environmental impact assessment (EIA) has to be carried out in order to minimise the impacts on wildlife

(Jensen, 2003; Ministry of Environment and Nature, 2014). If projects are assumed to cause substantial damage to the landscape or nature, the Cabinet may decide that the project should not be carried out.

## 9.5 Governance of ecosystem services and influencing policies

### *9.5.1 International policies with impact on the Disko Bay ecosystem*

The most important international policies for Greenland and for Disko Bay are those that relate to anthropogenic drivers such as climate change, harvesting of wild populations and marine pollution. Greenland participates in international collaborations through a large number of conventions and other bodies, either directly or through the Kingdom of Denmark (FAO, 2016). International conventions with an impact on biodiversity and nature's benefits to people in the Disko Bay case study area in Greenland, include the Convention of Biological Diversity (CBD), the Washington Convention (CITES), the Convention on Wetlands (Ramsar Convention) and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). Greenland is not a member of the European Union (EU), but is included as one of the so-called Overseas Countries and Territories that have a special relationship with the EU. The EU Partnership Agreement is a fisheries agreement in which the EU pays for the right to fish within Greenland's Exclusive Economic Zone. In addition, Greenland has a number of bilateral agreements that relate to fisheries with neighbouring countries.

### *9.5.2 National policies of importance for the Disko Bay ecosystem*

The laws attempting to ensure an appropriate and biologically sound utilisation of fish stocks and wildlife are: Parliament Act No. 18 of 31 October 1996 on fishing and Parliament Act No. 12 of 29 October 1999 on hunting, including whaling. Orders of interest to the local fishers and hunters in Disko Bay or with a special focus on the area include: Self-government Order No. 1 of 5 January 2017 on the protection and capture of birds; Order No. 12 of 13 September 2004 on the Export and Import of Wild Animals and Plants (related to CITES); and Home Rule Order No. 10 of 15 June 2007 on the conservation of Ilulissat Isfjord. Parliament Act No. 29 of 18 December 2003 on nature protection aims to protect biodiversity in accordance with the precautionary principle. Parliament Act of no. 7 of 7 December 2009 on mineral resources and mineral resource activities (the Mineral Resources Act) may become increasingly important for the Disko Bay area. Activities with an expected significant impact on the environment must be accompanied by an environmental impact assessment (EIA) (Wegeberg & Boertmann, 2016).

### 9.5.3 Living resources management in Greenland and Disko Bay

The Greenland Institute of Natural Resources (GINR) provides the Greenland Self Rule with biological advice on the sustainable exploitation of living resources and safeguarding of the environment and biodiversity. For species where Greenland's stocks are shared with other countries, management advice is provided through scientific committees under the relevant international organisations, in which GINR represents Greenland. The advice is based on systematic scientific research by biologists from the GINR, the Danish Centre for Environment and Energy (DCE) or relevant international organisations such as ICES and the Northwest Atlantic Fisheries Organization (NAFO). The main fisheries of Greenland are managed through an array of allocation systems. The basis is the total allowable catch (TAC) as recommended by the biological advice and mandated by the Ministry of Hunting, Fisheries and Agriculture (FAO, 2016). The government is obliged to consult the Fishery Council on all matters that are central to the Greenlandic fisheries policy, including TAC, fishing rights, fishing capacity and conservation measures. The Fishery Council consists of organisations representing the fishing companies and the commercial fishers and hunters. The Employers' Association of Greenland (GA) represents companies of the sea-going fleet, "the industry", whereas KNAPK (Association of Fishers and Hunters in Greenland) increasingly represents small-scale fishers and hunters (Jacobsen & Raakjær, 2012).

Rasmussen (2003) argues that an unequal power relation exists between the fishers/hunters and the industry. There is a prevalent and widespread, but incorrect perception that the local coastal communities do not contribute financially to Greenlandic society. Self-rule government-owned companies thus dominate fishery policy and local communities have little input (Jacobsen & Raakjær, 2012). The inshore fleet is mainly managed via fishing licenses within both the Individual Transferable Quota system (ITQ) and the free quota within TAC limits, also known as Olympic-style fishing whereby individual boats "race" to get as much of the TAC as possible before the fishery closes (FAO, 2016). Young and strong fishers may fish for days without sleep before they collapse. Hunting in Greenland is managed via a system of licenses, quotas, seasons, management areas and rules regarding hunting equipment and transport equipment. The law stipulates that users should be consulted.

### 9.5.4 Regional and local policies of relevance to the Disko Bay ecosystem

The only decisions regarding fishing and hunting that can be taken at municipality level are the addition of new conservation measures, which must also be approved by the central government (Danielsen *et al.*, 2014). There can be special municipal decrees on bird hunting. The individual municipalities can, for example, decide whether or not hunters must sell their catch on the Kalaaliaraq fish and game market.

### 9.5.5 *Feedback processes for living resource governance*

Control of the fisheries is partly undertaken through the fishers' own reporting. Smaller boats report catches to the place where the sell their catch while larger boats keep an updated logbook with records of all catches. Hunters report all catch annually via the Greenland hunting and catch registration system, *Piniarneq* (Merkel, 2010).

## 9.6 Insight from indigenous and local knowledge

### 9.6.1 *History of Man in the Disko Bay ecosystem*

Man has been a part of the Disko Bay ecosystem for more than 4,000 years. The first hunters and fishers (Saqqaq culture) are thought to have arrived in Greenland and Disko Bay from continental North America around 2500 BC. Remains from the similar Dorset culture (800 BC – 1 AD) have also been found in Disko Bay. It is not known if the Dorset culture developed from the Saqqaq culture or if they were descended from more recent immigrants. Greenland seems to have been uninhabited when the Norse arrived from Iceland c. 985 AD during the warmer Medieval Climatic Anomaly. The Norse traveled north to Disko Bay in pursuit of walruses and seals. The ancestors of the present-day Kalaallit, Inuit western Greenlanders of the Thule culture, settled in the Disko Bay area after 1300 AD and came in contact with the Norse. The Norse disappeared from Greenland when living conditions became more difficult due to climatic changes (the Little Ice Age), leaving the Inuit alone for several centuries. Nordic people returned to Greenland again in 1721. The ancestors of the present-day fishers and hunters living in Disko Bay brought with them their indigenous knowledge of biodiversity and ecosystems and have since accumulated additional local knowledge. Hunting and fishing traditions have been passed on from generation to generation (Ministry of Environment and Nature, 2014). The local fishers and hunters often know and understand the status, trends, requirements and behavior of the living resources better than any researcher. Scientists and local communities in Greenland almost always agree on trends where they have monitored the same resources in time and space (Danielsen *et al*., 2014).

### 9.6.2 *ILK aspects in the laws, conventions and the coalition agreement*

International conventions, the law in Greenland and, more recently, the coalition agreement between the ruling parties, request that ILK is recognised and used in matters regarding the management of natural resources. All agree that fishers and hunters have a great deal of ecological knowledge that could contribute more to informing management. When it comes to ILK there is, however, often a huge discrepancy between the good intentions reflected in the text of conventions and policies and the realities on the ground (Danielsen *et al*., 2013). This is a global challenge that is also very real in Greenland. Article 8 of the CBD on "In-situ Conservation" specifies in art. 8(j), the duty of the national parties to the convention "to respect, preserve and maintain the knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant to the conservation and sustainable use of biological diversity and to promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices". Parliament Act No. 12 of 29 October 1999 on catch and hunting states that, in relation to the administration of hunting and fishing, emphasis shall be given to the inclusion of hunters' and users' knowledge. The 2016 government coalition agreement between Siumut, Inuit Ataqatigiit and Partii Naleraq, states that there must be equitable interaction between biologists and fisheries, especially when quotas are fixed, and that biological advisory services and users' knowledge must rank equally when quotas for hunted animals are fixed.

### *9.6.3 Contrast between the intentions and the real situation*

There remains huge unexplored potential for strengthening monitoring efforts across the Arctic by engaging more communities and encouraging linkages with scientific monitoring programs (Huntington, 2008). When ILK can contribute to improved management of the living resources, it is hard to understand why this is not happening more systematically and on a larger scale than it currently is. Obtaining biological knowledge in the Arctic is generally difficult, expensive and dependent on long-term monitoring activities. In addition, extreme weather conditions, remote locations and expensive logistics and transportation may limit collection of biological knowledge. A lack of data thus results in biological advice that often creates controversy between the scientific community and the fishers and hunters. Many researchers do not recognise that the strength of ILK compared to scientific knowledge lies within ecology. While scientists mostly work with fragments, such as single species and whatever can be easily counted and measured, they tend to be weak when it comes to ecology and a more holistic view of ecosystems. It may not always be necessary to have precise counts and measurements for ILK to be relevant. It would require unrealistic resources for researchers to achieve the same level of knowledge of status and trends for all species. Many scientific advisers and decision-makers are sceptical of ILK as they do not understand the "worldview" and language of local fishers and hunters. The scientific advisers are still located far away in Nuuk or even in Denmark. The scientific advisers rarely even understand the Greenlandic language. In colonial times, it was a common belief that the Inuit hunters' nature could undermine the resource base and it was seen as the Danish authorities' obvious task to educate and regulate those hunters (Sejersen, 2003). Biologists, with their scientific language, still dominate the discussion regarding sustainable use and this can marginalise and alienate Greenlandic people (Sejersen, 2003). One question that is often debated, is whether Inuit traditionally use living resources sustainably or if they kill every animal they can, without any thought of the future. Different experts on Arctic matters have different perception of how sustainable the traditional harvest of living resources have been (Meltofte, 2013). Some experts state that the traditional Inuit culture was sustainable; that Inuit have practiced sustainable management for generations and that Arctic biodiversity has been and continues to be managed and sustained by Arctic Indigenous peoples through their traditional knowledge (Sejersen, 2003). Other experts, often biologists, say that Greenlanders lack understanding of nature's boundaries (Sejersen, 2003). The anthropologist Krupnik (1993) found that generally, the hunting ethics among people living in the Arctic is of a conservationist nature. At the same time, he describes the widespread use of an overkill hunting strategy where hunters often harvested more than they could consume. The Danish environmentalist Hansen (2001) calls the idea about the sustainable Inuit a collective self-deception, which is destroying the nature of Greenland.

**Figure 97: Local fishermen and hunters cover vast areas in a desolated region where scientists more seldom go. In the PISUNA projects, the local people's observations are used for informing natural resource management**

Note: Local fishermen and hunters cover vast areas in a desolated region where scientists more seldomly go. In the PISUNA project, the local people's observations are used in developing natural resource management.

Photo: Michael Køie Poulsen.

The reluctance of some scientific experts to accept ILK as a valuable information source is due to a belief that the Inuit lack ability or desire to regulate their own activities, and that fishers and hunters are not accurate enough, as the counts are not precise and not repeated in a scientific way. ILK contributions are also considered to have no quality assurance similar to the peer-review of scientific papers; and fishers and hunters may cheat because they have a vested interest in high population estimates. Even if all this was true, it can be argued that it is still not right to exclude fishers and hunters from having a voice regarding management of the living resources. The way forward must be to make even greater efforts to find ways around the above-mentioned challenges.

The GINR's strategic plan for 2013–2017 recognises that fishers and hunters hold extensive local knowledge that should be included in the scientific work of the Institute. With regards to local knowledge, the strategic plan states that "there should be quality assurance along the same lines as for scientific data". Moreover, it says: "GINR must (likewise) not compromise scientific methods when local knowledge is used". GINR gathers information on local knowledge through meetings with resource persons during the planning of its own studies, through the creation of local networks with active involvement in research projects, through collaborative projects, through scientific interviews and through analysis of information from catch and fishing reporting. It is thus possible for GINR to use data gathered by local people. All members of GINR agree that fishers and hunters have a great deal of ecological knowledge that should contribute more to informing management, but methods enabling GINR to connect between indigenous, local, scientific and other knowledge systems have not yet been developed. All funding for monitoring and advice goes to researchers, while it appears that local fishers and hunters are expected to provide data without any funding.

### *9.6.4 Research and documentation of ILK in Disko Bay*

While the full participation of local communities in monitoring programs continues to be a challenge, there has, over time, been many examples whereby data and information from hunters and fishers in Disko Bay has been gathered and used by researchers. Researchers have often interviewed fishers and hunters in Disko Bay, including with regard to climate change observations (Holm, 2010), sea ice (Taverniers, 2010), Atlantic cod (Petersen, 2002), walrus (Born *et al*., 1994), harp seal (Meldgaard, 2004; Born *et al*., 2011), polar bear (Born *et al*., 2011), narwhal (ELOKA, 2010) and beluga (McDowell, 2013). In northwest Greenland, including Disko Bay, locals and biologists from GINR have, since 2001, been following the breeding of common eiders and it was partly based on the results of this program, that it was possible to extend the hunting season (Ministry of Environment and Nature, 2014; Merkel, 2010, 2016). Since the 1st of January 1993, information on catch has been obtained from hunters, as they have to report their catch via the "Piniarneq" system. The system is linked to the issuing of hunting licenses (Sejersen, 2003).

### *9.6.5 PISUNA*

The Greenland government has, since 1999, been piloting a natural resource monitoring system, PISUNA, in Disko Bay and elsewhere along the west coast of Qaasuitsup municipality. Here local people are directly involved, not only in data collection, but also in analysis and in suggesting resource management. Results from the PISUNA-collaboration will also be uploaded to an Internet-based database, PISUNA-net, that can be accessed via pisuna.org. While there still is a long way to go before ILK from Disko Bay and Greenland is used systematically to inform management decisions, PISUNA is a huge and positive step forward. Gone are the times when local hunters and fishers would have to contact a relevant minister, the Fishery Department or GINR by phone to explain that resources were abundant and that regulations should be relaxed (Jacobsen & Raakjær, 2012). PISUNA was at first met with considerable scepticism from both scientists and the local hunters and fishers. Most of this scepticism has since been overcome as the program has addressed challenges, tested solutions and adapted as appropriate. The community identifies a group of locally recognised "experts" who observe the living resources whenever they are travelling for fishing and hunting. Every three months, they meet to summarise, discuss and interpret their observations. They aim to reach consensus on status, trends, the reasons for these, along with necessary management responses. They then submit a standardised report with their findings to the municipal and central government (Danielsen *et al.*, 2014; Johnson *et al.*, 2016).

## 9.7 References


AMAP (Arctic Monitoring and Assessment Programme). (2011). *AMAP Assessment 2011: Mercury in the Arctic*. Oslo: AMAP.

Arendt, K. E. (2011). *Plankton community structure in a West Greenland fjord – Influenced by the Greenland Ice Sheet*. Nuuk: GINR.

Boertmann, D. (2008). *Grønlands Rødliste 2007*. Aarhus: Danmarks Miljøundersøgelser.

Boertmann, D., Mosbech, A., Schiedek, D., & Dünweber, M. (Eds.). (2013). *Disko West: A strategic environmental impact assessment of hydrocarbon activities*. DCE report No. 71. Aarhus: Danish Centre for Environment and Energy.

Born, E. W., Heide-Jørgensen, M. P., & Davis, R. A. (1994). The Atlantic Walrus (*Odobenus rosmarus rosmarus*) in West Greenland. *Meddelelser om Grønland, Bioscience*. *40*.

Born, E. W., Heilmann, A., Holm, L. K., & Laidre, K. L. (2011). *Polar Bears in Northwest Greenland. An interview survey about the catch and the climate*. Copenhagen: Museum Tusculanum Press.

Christensen, T., Falk, K., Boye, T., Ugarte, F., Boertmann, D., & Mosbech, A. (2012). *Identifikation af sårbare marine områder i den grønlandske/danske del af Arktis*. Aarhus: Danish Centre for Environment and Energy.

Christensen, T., Mosbech, A., Geertz-Hansen, O., Johansen, K. L,. Wegeberg, S., Boertmann, D. *et al*. (2015). *Analyse af mulig økosystembaseret tilgang til forvaltning af skibstrafik i Disko Bugt og Store Hellefiskebanke*. DCE report No. 61. Aarhus: DCE.

Danielsen, J., Frederiksen, P. O., Mølgard, T. *et al*. (2016). *Local observations from the PISUNA Network (PISUNA-net).* P. Jakobsen, N. Levermann, B. Lyberth, M.K. Poulsen, & F. Danielsen (Eds.). Ilulissat: Qaasuitsup Kommunia. Nuuk: Ministry of Fisheries and Hunting, and Greenland Fishers and Hunters Association. Copenhagen: NORDECO. Retrieved May 15, 2017. http://eloka-arctic.org/pisuna-net/en

Danielsen, F., Adrian, T., Brofeldt, S., van Noordwijk, M., Poulsen, M. K., Rahayu, S. *et al*. (2013). Community monitoring for REDD+: international promises and field realities. *Ecology and Society, 18*(3), art. 41. http://dx.doi.org/10.5751/ES-05464-180341

Danielsen. F., Topp-Jørgensen, E., Levermann, N., Løvstrøm, P., Schiøtz, M., Enghoff, M., & Jakobsen, P. (2014). Counting what counts: using local knowledge to improve Arctic resource management. *Polar Geography*, *37*(1), 69–91.

Danish National Bank (2014). *Monetary Review, 2nd Quarter, 2014*. Copenhagen: Danish National Bank.

Eamer, J., Donaldson, G. M., Gaston, A. J., *et al*. (2013). *Life Linked to Ice: A Guide to Sea-Ice-Associated Biodiversity in This Time of Rapid Change*. CAFF Assessment Series 10. Iceland: CAFF.

Egevang, C., & Boertmann, D. (2001). *The Ramsar sites of Disko, West Greenland. A survey in July 2001*. Technical Report No. 368. Aarhus: NERI.

ELOKA. (2010). *Narwhal Tusk Research Interviews*. Retrieved May 8, 2017, from https://eloka-arctic.org/communities/narwhal/interviews.html

FAO. (2016). Fishery and Aquaculture Profile of Greenland (FACP GRL). Working Paper. http://dx.doi.org/10.13140/RG.2.1.2855.3842

Fernandez, L., Brooks, A. K., & Vestergaard, N. (Eds). (2014). *Marine invasive species in the Arctic*. *TemaNord 2014:547.* Copenhagen: Nordisk Ministerråd.

Garde, E. (2014). *Rapid Assessment of Circum-Arctic Ecosystem Resilience (RACER). The West Greenland Shelf*. Copenhagen: WWF.

Greenland.com (2017). *Culture & Spirit*. Retrieved May 15, 2017, from http://www.greenland.com/en/about-greenland/culture-spirit/

Hansen, K. (2001). *Farvel til Grønlands natur*. Copenhagen: Gads Forlag.

Holm, L. K. (2010). Sila-Inuk: Study of the Impacts of Climate Change in Greenland. In I. Krupnik *et al*. (Eds.), *SIKU: Knowing Our Ice*. (pp. 145–160). Dordrecht: Springer.

Huntington, H. (2008). *A Strategy for Facilitating and Promoting Community-Based Monitoring Approaches in Arctic Biodiversity Monitoring*. CAFF CBMP Report No. 13.

Jacobsen, R. B., & Raakjær, J. (2012). A Case of Greenlandic Fisheries Co-Politics: Power and Participation in Total Allowable Catch Policy-Making. *Hum. Ecol. 40*, 175–184. DOI 10.1007/s10745-012-9458-7

Jensen, D. B. (2003). *The Biodiversity of Greenland – a country study*. Technical Report no. 55. Nuuk: Greenland Institute of Natural Resources.

Johnson, N., Behe, C., Danielsen, F., Kruemmel, E.-M., Nickels, S., & Pulsifer, P. (2016). *Community-based monitoring and Indigenous Knowledge in a Changing Arctic. A review for the Sustaining Arctic Observing Networks*. http://www.inuitcircumpolar.com/community-based-monitoring.html

Jónasdóttir, S. H., Visser A. W., Richardson, K., & Heath, M. R. (2015). Seasonal copepod lipid pump promotes carbon sequestration in the deep North Atlantic. *Proceedings of the National Academy of Sciences* 112(39), 12122–12126. http://dx.doi.org/10.1073/pnas.1512110112

Krawcyk, D. W., Witkowski, A., Waniek, J. J., Wroniecki, M., & Harff, J. (2014). Description of diatoms from the Southwest to west Greenland coastal and open marine waters. *Polar biol.*, *37*, 1589–1606.

Krupnik, I. (1993). *Arctic Adaptations: Native whalers and reindeer herders of Northern Eurasia*. Hannover, New Hampshire, University Press of New England.

McDowell, G. (2013). *Report from the Field – Disko Bay region of Greenland*. Retrieved May 15, 2017, from http://www.jamesford.ca

Meldgaard, M. (2004). Ancient Harp Seal Hunters of Disko Bay. Meddelelser on Grønland. *Man & Society Vol. 30*. Copenhagen: Danish Polar Center.

Meltofte, H. (Ed.). (2013). *Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity*. Conservation of Arctic Flora and Fauna, Akureyri, Iceland.

Merkel, F. R. (2010). Evidence of recent population recovery in common eiders breeding in Western Greenland. *Journal of wildlife management*, *74*(8), 1869–1874.

Merkel, F. (2016, December). *Combining efforts and knowledge about common eiders in Greenland, 2000 – 2016*. PISUNA workshop, Nuuk, Greenland.

Merkel, F., Boertmann, D., Mosbech, A., & Ugarte, F. (Eds.). (2012). *The Davis Strait. A preliminary strategic environmental impact assessment of hydrocarbon activities in the eastern Davis Strait*. DCE report No. 15. Aarhus: Danish Centre for Environment and Energy.

Ministry of Environment and Nature. (2014). *The Fifth National Report to CBD*. Government of Greenland.

Mosbech, A., Boertmann, D., & Jespersen, M. (2007). *Strategic Environmental Impact Assessment of hydrocarbon activities in the Disko West area*. NERI technical report No. 618. Aarhus: National Environmental Research Institute.

Normander, B. (2016). *Greenlandic seasons – nature and climate in the Disko Bay area*. Brønshøj, Denmark: Forlaget Natur & Miljø.

Petersen, H. C. (2002). *Fangstdyr og klimarytmer i Grønland – og det levendes brug af landet*. TemaNord 2002: 587. Copenhagen: Nordisk Ministerråd.

PISUNA-net. (2017). *Local Observations: PISUNA-net*. Retrieved May 15, 2017, from https://eloka-arctic.org/pisuna-net/en/

Poppel, B., Andersen, T., Beach, H., & Bernard, N. (2015). *SLiCA: Arctic living conditions: Living conditions and quality of life among Inuit, Saami and indigenous peoples of Chukotka and the Kola Peninsula*.TemaNord 2015:501. Copenhagen: Nordisk Ministerråd.

Qaasuitsup Municipality. (2014). *2014–26 Town Plan for Qaasuitsup Municipality*. Ilulissat: Qaasuitsup Municipality.

Rasmussen, R.O. (2003). Havfiskeri/kystfiskeri–magt og afmagt i Grønlands hovederhverv. In G. Winther (Ed.), *Demokrati og magt i Grønland*. (pp. 133–161). Aarhus: Århus Universitetsforlag.

Rysgaard, S., Nielsen, T.G., & Hansen, B. (1999). Seasonal variation in nutrients, pelagic primary production and grazing in a high-arctic marine ecosystem, Young Sound, Northeast Greenland. *Marine Ecology Progress Series 179*, 13–25.

Sejersen, F. (2003). *Grønlands Naturforvaltning – ressourcer og fangstrettigheder*. Copenhagen: Akademisk Forlag.

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S. *et al*. (2007). Marine Ecoregions of the World: a bioregionalization of coast and shelf areas. *BioScience* 57, 573–583.

Statistics Greenland. (2016). *Greenland in Figures 2016*. Nuuk: Statistics Greenland.

Taverniers, P. (2010). Weather Variability and Changing Sea Ice Use in Qeqertaq, West Greenland, 1987–2008. In Krupnik, I., Apota, S., Gearheard, S., Laidier, G.J., & Holm, L. K. (Eds). *SIKU: Knowing Our Ice: Documenting Inuit Sea Ice Knowledge and Use*. Dordrecht, Germany: Springer.

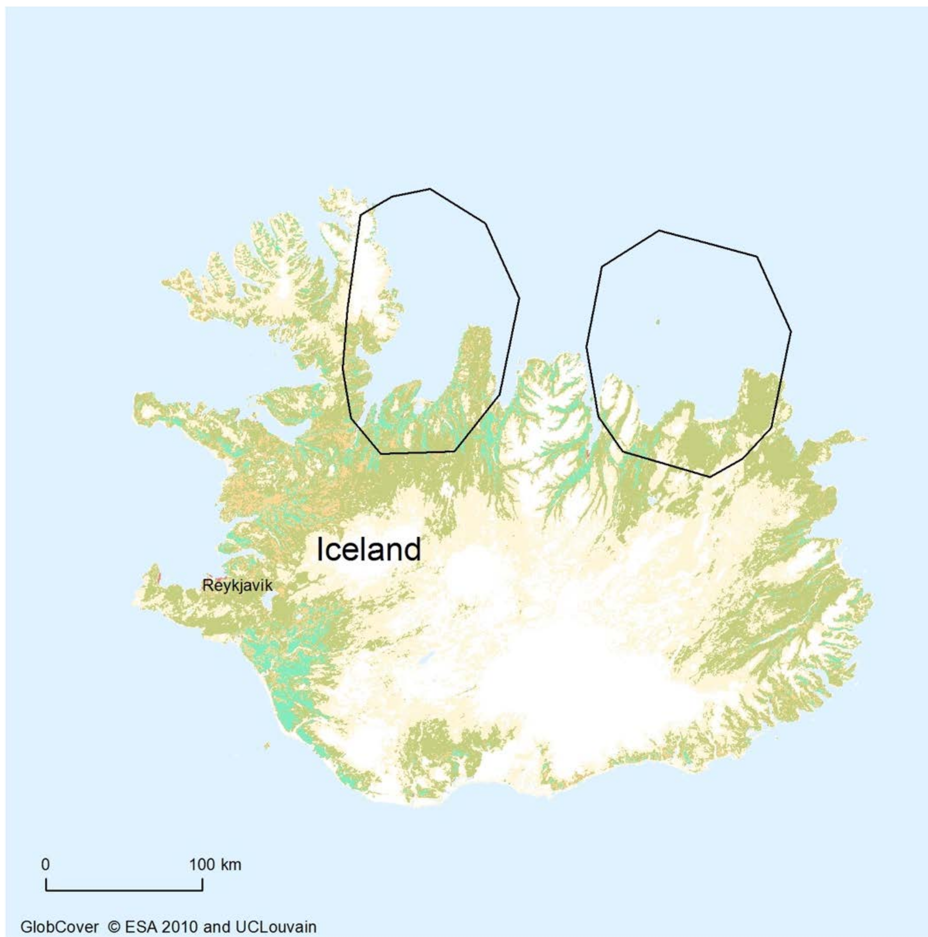
Wegeberg, S. & Boertmann, D. (Eds). (2016). *Disko Island and Nuussuaq Peninsula, West Greenland. A strategic environmental impact assessment of petroleum exploration and exploitation*. DCE report No. 199. Aarhus: Danish Centre for Environment and Energy.

Wenzel, G. (1991). *Animal Rights, Human Rights: Ecology, Economy and Ideology in the Canadian Arctic.* Toronto: University of Toronto Press.

Worm, B. & Myers, R. A. (2003). Meta-analysis of cod-shrimp interactions reveals top-down control in oceanic food webs. *Ecology 84*(1), 162–173.

# 10. Iceland

**Figure 98: The research locations Broddanes (NW corner) and Húsavík (NE corner) on a national map of Iceland**




Note: The eastern area is Húsavík and the westerna area is Broddanes region.

Source: ESA 2010 and UCLouvain.

## 10.1 Gendered Landscapes of Northern Icelandic Coasts and Rural Areas

*Tero Mustonen, Kaisu Mustonen, and Embla Oddsdottir*

**Figure 99: Ocean is the source of both food and culture for the Northeastern Icelandic communities**

Source: Snowchange 2005.

**Figure 100: Geothermal vents, geysirs and hot springs are central features of the landscape in the Húsavík region and surrounding inland areas**

Source: Snowchange 2005.

## 10.2 Introduction

The interconnectedness of places, animals, weather, birds, fish and people, and the gender specific bonds these form, defines the boundaries of a gendered socio-ecological system.

The Snowchange Cooperative[6] worked with a group of women from the coastal rural areas of Northern Iceland in 2004–2008. Following a scoping investigation with local stakeholders, ILK-holders were contacted and a research collaboration was initiated. The aim was to find those people still maintaining traditional sites, ways of life and culture in the Húsavík region in Iceland. The female co-researchers and knowledge holders in the project included Kristín Ketilsdóttir, Elín Stefanía Hólmfríður and Gunnhildur Ingólfsdóttir, who all were between 60 and 70 years of age at the time of the study. The information was collected as a part of the Snowchange Akureyri Oral History Project between 2004 and 2008. Specific field methods included interviews, field visits, participatory observation, casual conversations, art analysis, mapping of traditional land use and visual photography of the sites. The interviews have been reviewed by Kristín Ketilsdóttir, Elín Stefanía Hólmfríður and Gunnhildur Ingólfsdóttir and they have agreed to the use of the material. The original digital video and

[6] Snowchange is a non-profit, independent cultural and research organisation from Finland, but working across the Nordic space for 20 years.

audiotapes are available from the Snowchange Akureyri Oral History Project at www.snowchange.org. Since 2008, communication has been maintained between the Finnish and Icelandic members of the research team and the materials have been analyzed and translated into English. In this case we focus on indigenous and local knowledge (ILK), presenting excerpts from the womens' oral histories focusing on the following themes:

- their relationship with landscapes;
- oral histories of these women were documented to investigate their relationship with nature under northern climate change;
- traditional seasonal activities and calendar;
- weather knowledge;
- relationships with the "hidden people" and other spiritual-cultural elements of landscapes in northern Iceland.

By utilizing these authentic voices of Icelandic women from the Nordic periphery, research can reach out to the marginalised rural areas, which today often are sites maintaining traditional ILK systems.

### *10.2.1 Kristín Ketilsdóttir from Hallgilsstaðir*

Kristín was raised at Stafn, Reykjadalur in Þingeyjarsveit. Her home was on a farm with cows and sheep, situated on the moor. She had one sister, which was considered uncommon as there were usually many children in families some 65 years ago. Kristín moved to Hallgilsstaðir when she was 19.

Close to the Stafn farm, there were four other farms very close to each other on the same field. Everything outside the field was shared property. The four farms were owned by four brothers and their families. The shared use of these lands by the local people represents an important example of community commons that were and are partially still in use in Iceland. The community had a travelling teacher for the children who usually stayed at Kristíns house. The area is mostly hilly with snowy winters and "very good" summers.

Kristín described the migration out of community, saying that "everything is fading, there are only a few people left, particularly in the more remote places". This affects all European peripheries but is pronounced in northern Iceland.

#### Kristíns Reflections on Seasonal Calendars

Kristín reflects on the earlier and contemporary seasonal cycles of the land:

> "There was a lot of berry picking in those days and we still do that today, there is a lot of berries around here. Usually January and February were heavy for snow. We have only sheep here and we had to keep the animals alive and everything going. We don't use skiis much today, but in the old days, we skiid between farms. In regards to the cycle of work…in the winter people did handicrafts, knitting and carpentry in addition to the traditional animal care. As spring approached we started

> shovelling dung and preparing for the spring. Both in my younger years and after I came here to live, I was always very much involved with the work outside. [Using] all the machines, like snow-mobiles. I have never been very 'feminine' in my nature. In the spring the sheep give birth and as you know that involves a lot of work. You don't do very much else in the weeks when that is going on. And then it depends on the weather how you can get rid of the sheep. In the old days, they were just chased out of the field and it would scurry to the moors. After I came here they had to be taken to afrétt [assigned grazing land]. That is done in the spring or in June–July – it is usually not good enough before that time. And then there was the other spring work. There is the work with hay. If it goes well, maybe we go somewhere for a daytrip to see something. We have never taken a summer vacation, many days in a row away from home so [it means we mostly know our] immediate envrironment. We did go on a farmers' trip, many years ago, to Europe. I was so inexperienced that I got lost in a supermarket. I will never forget that, when you don't speak the language it is very uncomfortable."

In this oral history segment, Kristín explains some of the seasonal work, as well as changes that have taken place in the community due to modernisation. Skiis were used in the past to visit other farms, now machinery such as snowmobiles are part of the daily work. Sheep were the most commonly farmed animal. In the past, the communities could release the animals to open moor pastures, but in later periods, the government has assigned *afrétt,* designated grazing areas for the animals. Handicrafts and other essential work in the community reflected the seasons.

Specifically regarding the summer and autumn seasons Kristín explained that:

> "In the summer…there is the hay work. Then we go pick fjallagrös ['mountain grass', *Cetraria islandica*] at Flateyjardalur moor. There is a bit of a market for fjallagrös and we sell that a bit. They can be picked anytime the ground is empty, even during the wintertime. In the autumn there is harvesting of edible plants – we have had carrots and some potates to sell. A large portion of the autumn is used for that and following sheep endlessly. Then we make haggish in the autumn, for a long as I can remember. [This includes] all sorts of things made out of the meat, frozen, put in storage or salted like in the old days. Haggish, the sheepsheads [svið]. We still do this today. We can't take anything other than the sheepsheads from the slaughterhouse, but we always slaughter a little at home, the sheep that are not for the slaughterhouse, to use for minced meat and those kinds of things. Everything like that is done at home, fortunately those who have sheep can still do these things themselves. In many respects we are quite ancient, we have stuck quite firmly to utilising what we have at home. So there was hay work, harvesting and sheepherding, haggish making and food making, all this is often until November. The meat is smoked at home and that is usally not finished until the end of November. Of course we don't do all these things every day but it has to be done at the right time."

In this oral history by Kristín, we can see how harvesting mountain grass connects the highland ecosystems and farm life. Traditional dishes are reflective of the season and all parts of the sheep, including the heads are used. Kristín calls the life she leads "ancient", stressing the role of traditions and the close proximity to the surrounding ecosystems.

Kristín gathers the following flora:

- birch leaves;
- *Vallhumall*. English: yarrow (*Achillea millefolium);*
- *Ljónslöpp*, alpine lady's-mantle *(Alchemilla alpina);*
- *Maríustakkur*, Common lady's mantle, (*Alchemilla vulgaris).*

These plants are, for example, dried and then sold in a local market at Heilsuhorninu. The various plant leaves can be utilised for creams and oils according to Kristín. She says that this is done "to maintain knowledge of the plants and the children and grandchildren go with us and learn more about the plants."

### Traditional Weather Prediction

Icelandic northern areas are known for their shifting weather. Traditional knowledge and prediction skills regarding the winds, storms and seasonal weather were essential for carrying out the subsistence activities in the past. Now the knowledge on weather is a mix between traditions and modern science, as Kristín explains:

> "I always knock on the barometer. At Stafn, there was much less modern prediction then, everyone was always speculating about the clouds, the clouds on this mountain, this wind direction. There was Sellandafjall mountain, which we saw from Stafn. If the bunch of clouds looked this way or that, one could tell which direction the wind would blow from. There has always been, as far as I know, some belief in the influence of the moon, the bigger the moon, the more influence. There is a weather club at Dalvík, a senior citizen group. They alway make a month's prediction where the moon has a big role. And they are incredibly often right. They predict where it will light in the sky and what kind of moon."

Kristín herself does not often dream about things or weather, but knows that there are people that have been able to predict many things. There was a woman in Skagafjörður that used sheeps intestines to predict the winter's weather.

### Relationship with the Landscape

Kristín explains that she feels strongly about her right of ownership of land. Kristín spoke of the importance of the mountain behind her house, calling it "priceless". The mountain is a source of pleasure and one of her favorite places.

Two huge rocks on the mountain are for the *hidden people* [non-human beings of the landscape]. She considers these rocks to be sacred and no-one should touch them. It is alright to pick berries around them, but otherwise, these sites should not be disturbed in any way. People should not make any noise around them.

This relationship with the local mountain and the rocks presents some of the most remarkable features of the traditional knowledge in northern Iceland. Kristín explains that the landscape contains sacred areas and living spaces for the hidden people. She also went on to convey customary "rules of non-disturbance" around these sacres sites.

Raven is a central bird in the Icelandic and larger Scandinavian tapestry of traditions. It has a central role in the Saga literature and oral histories of Iceland. Kristín shared powerful oral histories of her relationship with raven, as well as songbirds:

> "I always put food out for the raven every autumn. When I have deboned my meat, I take it to the bottom of the hills and give it to the raven. He is quite intelligent. I always give something to the smaller birds too. I go to the bakery and buy what they call 'horsebread', old bread. Over the winter, we probably distribute about one bird-feeding bag a week and it completely disappears. Birds approach the window in groups and I think they know this by now. I really enjoy this – it connects me to the mountain. For a few years there have been three small birds that are very tame. This is a privilege that comes with living in the countryside, to be able to be in my home and enjoy this. In my childhood, the raven was popular and one should always feed him so he wouldn't take the sheep. This is still a part of me, there are so many things from childhood one takes along in life but when I came here everyone disliked the raven. He had taken some animal or something. He can't be shot though, he is protected. They sometimes took the ravens eggs here and I was completely against it."

Kristín lives in a reciprocal relationship with the raven and some of the songbirds from her local environment. According to her, this maintains the relationship between the mountain, birds and humans in her community. The raven is a mythical bird that has been seen both as a pestilence for the sheep economy, as well as a bird of knowledge in Iceland.

At the conclusion of the oral history work, Kristín reflected over changes in her life time and the world around her. The speed of these changes, along with modernisation and changes in nature have risen alarm in her world:

> "There were so many things in nature that constituted life itself… A part of daily life, a source of enjoyment. This past century everything has gone crazy all of a sudden, everything gets worse. I don't understand it. Thank God I am so old so I don't have to see all this, it all seems so dangerous to me."

### *10.2.2 Elín Stefanía Hólmfríður Baldvinsdóttir from Bárðardal*

Elín Stefanía Hólmfríður Baldvinsdóttir was born in Akureyri and lived there until she was five years old, then moved to Bárðardalur where her family lived for fourteen years. Then she moved to Arnarstaðir, which has been abandoned since approximately 1970. There is one family house and a small sheep house, currently being made into a summerhouse in the current residential area of Bárðardal.

**Figure 101: Elín Stefanía Hólmfríður Baldvinsdóttir has maintained traditional cultural heritage and buildings at her farm**

Photo: Snowchange, 2005.

The surroundings of Bárðardal are mostly heather moorlands of dwarf-shrub heath, in Icelandic *lyngmóar*, and some plain natural *grunðir* (ground). At the bottom of the slope there is a lava ridge, which is a common sight in the valley at the edge of the slope. This ridge came from a lavaflow hundreds or thousands of years ago. It is called *Bárdardalshraun* (hraun=lava). Elíns house was built on the ledge by the ridge, which was a traditional way of construction. The slope above is mostly a wooded area, but also has some heather moors with typical Icelandic wild flowers.

When Elín was growing up, there were no freezers and no fridges because there was no electricity. They just had oil lamps and gas kerosene lanterns. A cooker was initially heated with coals and later with oil. The communal food was mostly prepared in the autumn, the meat was either salted in barrels or smoked. That was the *hangikjöt* (hung meat), but that wasn't used much, Elín only remembers it around Christmas time.

Milk from cows was used all year round. They made sour *skyr*, butter and cream and it was always fresh. The farm also had hens that walked freely in nature and they used the eggs.

In the summer months the community fished. In the past, fishing could not be done in the winter, as there was so much snow. However, now Elín interprets that things are different. There is much less snow.

There weren't really proper roads. Today the roads are elevated but in those days they were dug in and became completely immersed in snow. Because of this, fresh food was rare.

Elín does not remember getting bored with the food though. In the fall they also made rolled sausage and *paté* to put on bread. The sausage was preserved in salt, like the meat, and it kept all year around. There were some cold storage spaces so it didn't go bad.

In the winter they would occasionally go to a lake that is located on the moor and icefish. Many people did this in late March and April. The lake is very big and called *Kálfborgarvatn* (literally *Calf city lake*). It is situated east of Lundarbrekka. People just went there and fished without asking the people who owned the land. The lake is so big that everyone thought it natural to go there. They would bring lots of trout (*Salmo trutta*) home in the evening and have a feast.

Nowadays they still use the traditional Icelandic food such at Svartárkot, simply because they like it. Storage of course is very different today. They make their own *hangkjöt* but smoke it less. Before it was smoked for maybe three-four weeks, today it is smoked for a week or ten days.

Elín, much like Kristín, has experienced a transformation of the rural economies and connections to the local ecosystems in her lifetime. Toponymic place names as *Bárðardalshraun* indicate knowledge of hundreds of years of living and building houses in the northern Icelandic landscape (in this case reflecting the volcanic landscape). Life without electricity meant that traditional food gathering, such as fisheries and preservation of meat and other food items, survived well into the 1900s. Modernisation brought better roads, freezers and fridges, transforming the food economy.

### Elíns Views on the Traditional Calendar

During the oral history work, Elín reflected the start of the year by saying that:

> "In the beginning of the year you first have to recover from Christmas and the Þorrablóts [traditional festivities]. This is usually the most quite time in the year. You basically tend the animals, feed the sheep, cook, bake and tidy the house. This is the best time to potter about with handicraft work, particularly if you don't have small children."

She belongs to the *Unmennafélag* (a community based youth activity society) and the *Kvenfélag* (a community based women's society). These kinds of societies are important for the social cohesion of the community. Especially the women's society has been very common in Iceland for a long time. Some people say that these women have been like glue for these rural communities. The work they do is based on the community spirit of helping the neighbour.

In her community, before the sheep start giving birth, Elín and others get trout to smoke because Tryggvi (husband) is involved in vermin control (mink and arctic fox) in the summer. Since he is responsible for the smokehouse they do not want to risk being out of trout in the summer and try to coordinate the timing of these actions to allow him to succeed in both tasks. They also sell the fish in the summer time.

The community buys farmed trout for smoking. The smoking can take from one to two weeks, depending on how much they buy. The smoking process takes a full week. They pick the trout up from Húsavík, take it home, clean it, hang it and smoke it. The volume is around 300–400 kilos at a time.

At the beginning of May, the sheep start giving birth and this goes on until the end of May-beginning of June. Sheep need tending until the middle of June, after which they are released to pastures around the farm or driven to more remote pastures.

The community hires also outside fishermen. Once the ice has left the local lake, the trout are harvested by these hired hands. The community sells new trout from the lake to the surrounding tourist businesses, such as *Kiðagil, Fosshóll, Narfastaðir* and individual customers. The fishery lasts until the end of August.

Summer is also the time for harvesting hay. Many guests and tourists arrive and require directions and information about the local mountains. All this takes a bit of time. Transitioning to autumn, the end of August / beginning of September brings the rounding up of sheep. Sheepherding keeps the community busy until mid October. And then it depends on the weather when the sheep have to go inside again.

When the animals are inside again, they have to be sheared, although Elín does not participate in this. They shear the sheep so the wool is in as good a condition as possible. The quality of the wool determines the price for the farmer. This is also done in March. Traditionally at Svartárkot, they slaughter some sheep at home. The slaughtered sheep are used for home-use in the following year – this is a lot of work.

On the day of slaughtering, there is cutting of fat, cleaning of stomachs, sowing, making haggish and making *pækill* (salty water) to preserve the meat that is to be smoked. Elín makes paté and rolled sausage. Then she boils *magálar*, which are hung and smoked a little (smoked lamb breast). This comes from the same part of the animal as the *rúllupylsa* (a cut meat dish prepared from pork side).

Elín and the community retain close relations with their surrounding ecosystems. They preserve fish using traditional smoking methods, maintain a sheep economy that dictates much of the seasonal activities and maintain the traditional festivities such as *Þorrablót. Kvenfélag*, the womens organisations in the rural areas are important engines of social cohesion, even though often ignored and invisible in mainstream decision-making in Iceland. They are important in maintaining both traditional and present-day neighbourhood networks and cooperative life in remote communities.

### Traditional Knowledge, Landscapes and Weather

Elín keeps a weather diary because she sends a "rain downfall report" to the authorities every month. This has to include descriptions on the weather. But she has not paid too much special attention to the changes in weather over the past decades.

Elín is aware of people with knowledge and abilities to see things in dreams.

For example, she says that there are local people that dream about weather and all sorts of other things, but she thinks there are very few of them. According to her, people who have animals and need to get food for them, as well as people who live in remote areas, need to think about the weather.

When she explained about her relationship with the landscape, Elín quoted a poem: "The landscape is worth little if doesn't have a name." The Icelandic place names serve very clear purposes according to her. For example, the place names for mountains can refer to people, a definition of a natural phenomenon or an event. Place names are those names that people start calling the place. As an example of that, she explains, are the elements of the place name *Kollótta dyngja* in front of Herðubreið. According to her, this refers to the mound (*Kollótta*=hornless, *dyngja* = shield volcano; lava dome) and has a volcanic hot spring inside it.

In Elín's oral histories, the traditions of remote Icelandic subsistence and farming community become visible. The seasonal use of animals and the nature based economy, such as fishing and collection of hay, determines the life of a village. She is aware of people who can see things in their dreams, bringing in the mythical dimension of living with nature. Elín explained and stressed that the Icelandic landscape is full of life and meaning, including very detailed place names that have formed over centuries of living in an oral culture that had close relations with the land and nature.

### *10.2.3 Gunnhildur Ingólfsdóttir from Ystafell*

Ystafell is the place where Gunnhildur Ingólfsdóttir was raised. It is situated in a narrow valley. There is a forest on the other side of a low mountain and a river. There are two rivers in the area. There are local fish, *bleikja* (Arctic char, *Salvelinus alpinus*) and *urriði* (trout, *Salmo trutta*). These fish were harvested in the community.

Gunnhildur has seven brothers and sisters. Her grandmother lived in the next house with two of her uncles. There were always a lot of people around the place, locals and strangers. This was mostly due to her father's repair shop. Traditional farming was not practised until later and had stopped completely when Gunnhildur left home.

Gunnhildur says that her home place is very different now. There used to be many people in the countryside. Nowadays there are only empty houses. Agriculture has diminished very much. The landscape changes too. There are now more trees and she has also noticed increased soil formation. It is higher now and renews itself, according to her.

#### Exploring Gender Roles

Gunnhildur reflected on the role of women in more traditional times. She does not remember the roles being particularly gender-divided and finds them more divided today. Before people did things together. Women did however, take care of the cooking and the home. Her mother and grandmother did, as did girls hired to help around the house. Her everyday activities today include cleaning, cooking, washing and she also does a lot of handicrafts such as knitting.

In Gunnhildurs oral histories, the gender roles shift through time, but sometimes in surprising directions. In traditional times, the division of men and women's work was more marked. Now as the economy and social structure of the villages has shifted, so has the work times and roles. This can partly be explained by thinking about the social cohesion of the rural communities. The shared activities kept everybody involved, but in modern times, stress results in more gender divisions and gaps in the activities that people conduct.

### Gunnhildurs Traditional Calendar

According to Gunnhildur, the daily routine has changed very much since they gave up the traditional farming and took up tree farming. In the 2000s they wondered how many trees to plant each year. The location of tree plantations has to be applied for from the authorities. The local people cannot decide themselves.

Trees are planted in the spring and early summer. This should be concluded by the 17th of June. Another planting can take place in the fall. Food preparation is no longer connected to a specific time according to Gunnhildur. It is always done alongside other activities.

When they had sheep and particularly cows, their routine was very much determined by their needs, now it is more determined by her husband's work. She used to tend the cows and the sheep. The spring sheep activities and hay harvesting were the most difficult. Around 1982–1983 they got rid of the cows.

October, November and December was less busy. In August Gunnhildur picks berries and herbs. This is traditionally considered a woman's activity. The collected species include:

- *Blóðberg*, wild thyme (*Thymus praecox*), which should be collected before mid July since it is best to pick before it blooms;
- *Ljónslappi*, Alpine lady's-mantle (*Alchemilla alpina*), which she also uses for tea;
- S*ortulyng*, kinnikinnick (*Arctostaphylos uva-ursi*);
- *Fjallagrös,* Iceland moss (*Cetraria islandica*) is harvested in late summer and fall;
- *Birki*, birch (*Betula pubescens*) leafs, particularly the annual growth. She picks them in late summer and uses for tea, spices and bread;
- *Skessujurt*, lovage (*Levisticum officinale) which she uses most of all as a spice;*
- *Rabarbari (rhubarb, Rheum rhabarbarum) she has used for wine making, but she has not used Fífill (dandelion, Taraxacum), that is used by some;*
- *Hrútaber, stone bramble* (*Rubus saxatilis*);
- *Sólber, black currant* (*Ribes nigrum*);
- *Stikilsber, gooseberry* (*Ribes uva-crispa*).

The maintaining of the uses of berries and herbs provides a mostly female relationship with the plant ecosystems and traditional uses in the area. This plant knowledge was often translated from mother to daughter. However, modern knowledge production has affected this process. Gunnhildur is one of the women who has been able to maintain this gender-linked knowledge of the land.

Gunnhildur has seen the shift from a farming life to a new economy of planting trees in Iceland for commercial purposes. The rhythms of tree planting determine some of the seasonal activities for her community today. Gunnhildur maintains a rather extensive knowledge of uses of plants, berries and herbs that she harvests through the year and uses for many different purposes. This connection reflects one of the ways she and her community maintain the socio-ecological systems of Ystafell.

**Figure 102: Gunnhildur Ingólfsdóttir has maintained the art of traditional Christmas laufabrauð, leaf breads, each reflecting a regional patterns and symbols**

Photo: Snowchange.

## Cultural Relations with Nature: Hidden People, Sacred Rocks, Birds, Starlore

Gunnhildur has grown up immersed in the northern Icelandic traditions. She has preserved many of these traditions. For example, during the oral history work when asked about *the hidden people* her first reply was that they "definitely" exist. She then proceeded to describe a couple of rocks around Staðarfell.

When asked how community people know that there are elves or hidden people in the rock, she said she does not really know more specifically. Gunnhildur remembered a story of a rock of *grágrýti* (dolerite) that is situated close by. There is an old oral story (*munnmæli*) that says this one got blown from *Kross* (a farm situated close to the crossroads Húsavík/Mývatn, just by Ljósavatn): "A man was on top of it and it landed on the hillside."

Figure 103: Gunnhildur Ingólfsdóttir and the home rock of the hidden people

Photo: Snowchange, 2005.

Gunnhildur and her community maintain reciprocal relations with the natural world. For example, she reflected that there is a lot of communication with the animals around her. Ptarmigans are their friends. They hang around the home area and the house and do not fly away when people move around.

Gunnhildur thinks this can be dangerous for the birds. Being so at ease with humans makes them easy prey when the hunting season starts. Other birds in the area include:

- *Skógarþrösturinn*, redwing (*Turdus iliacus*), which used to migrate from Iceland, but according to Gunnhildur, they now overwinter in Iceland – perhaps a sign of warming winters;
- *Snjótittlingurinn*, snow bunting (*Plectrophenax nivalis*), stays in the area during winter;
- according to Gunnhildur, ravens are plentiful. She says there is a belief that you cannot touch or mess with the raven. That will bring no good. The raven, Gunnhildur says, is a very, very wise creature.

To Gunnhildur, dreams are an important source of information. She had dreamt about her brother becoming paralyzed. Events from a dream came true later when her brother fell ill. She used to be scared of the skill of predicting things, but nowadays she takes more notice of it and very often experiences a reality that she has previously dreamt.

Icelandic starlore was still part of the traditions in Gunnhildur's childhood. She says that after looking at the stars enough, it is easy to imagine navigating by them. She talks of the *Sjöstirni*, (the Pleiades constellation) and the fact that she can no longer see it. The Northern lights have been one of the themes in her paintings.

### 10.2.4 Conclusions – Wisdom Sits in the Margins in Northern Iceland

This case study has explored the oral histories and traditional knowledge of three women, Kristín Ketilsdóttir, Elín Stefanía Hólmfríður and Gunnhildur Ingólfsdóttir from northern coastal areas of Iceland. In the voices of the women we learn about change and persistence, close relations with the landscapes, weather and animals of this remote Nordic region. Traditional ways of life are still clearly remembered and partly maintained. Of particular value is the knowledge on herbs, berries and plants these women possess. The gendered knowledge of biodiversity is embedded in the seasonal work on the farms and in nature. The knowledge may be hidden at first, but contains significant cultural statements building on centuries of life in the sub-Arctic Atlantic communities.

Of greatest value are the statements regarding maintaining customary, endemic relations with the special features of the landscapes. For example, Kristín Ketilsdóttirs accounts of sacred rocks for the hidden people and the cultural guidelines of how humans should behave around such locations, point to the necessity of listening and paying special attention to the subtle signs and hidden quiet messages of these knowledgeable women.

## 10.3 "We're not the Enemies of the Seal": Seal Hunters of Iceland

*Tero Mustonen*[7]

**Figure 104: The sealing team**

Photo: Snowchange 2008.

### *10.3.1 Introduction*

Seals have been hunted for a long time along the coasts of Iceland (Pálsson, 1991). Many local place names tell of hundred-year-old traditions in the Atlantic maritime communities of Iceland. Even though local people no longer depend on seals for their survival, the community-based harvesting of seals remains an important element in the life of certain families and farms. In 2003–2008, the Snowchange Cooperative conducted oral history work and local interviews with seal hunters of Broddanes in Westfjords (Mäkinen & Mustonen, 2003) and in the Húsavík area, Iceland (Mustonen, 2008). The participants spoke of their traditions, hunting methods, observations of environmental change and cultural opinions. The main messages of the oral history work and indigenous and local knowledge (ILK) aspects are presented in this case study.

[7] With inputs from the research team 2004–2005: Andrea Hjálmsdóttir, Birna Rún Arnarsdóttir, Embla Eir Oddsdóttir, Jóhann Ásmundsson, and Linda Björk Guðrúnardóttir.

### *10.3.2 Broddanes, West Fjords*

Broddanes is a small farm and a village settlement on the way to Westfjords in northwestern Iceland. For as long as the local people remember, harbour seal has been harvested in the community. A specific feature of the hunt is the sealing nets. The seasonal hunters of the community shared their oral histories on the hunt, environmental change, traditions and other aspects of life in Broddanes between 2003 and 2008 (see Mäkinen & Mustonen, 2003). In the 2010s the community has taken a strategic break from the hunt to investigate other avenues of income for the summer, including tourism.

Eysteinn Einarsson, the main hunter, is a structure and earthquake engineer. He grew up in Broddanes, Iceland. He has also lived in the United States of America. His parents live in the community and they are sheep farmers. Eysteinn lived here until about 1980, when he moved to Reykjavik. During most summers he goes back home. He says:

> "I go seal hunting here every June, at least when I can. Today it is definitely not a professional activity. It's not something that the people or the farmers need to do. They're not by any means dependent on seal hunting or the money that you can get from it. Today there's really no money in it. You still do get some money from the skin, but it's very little. So it's more recreational and to maintain the tradition. I am very much interested in keeping this tradition, at least hunting the seals, even though we don't actually do the same things with the skins as we used to. Hopefully I can continue this for as long as I live and maybe pass it on to my son and maybe to other generations. I'm interested in it. It would be very sad if this would be lost completely and nobody would continue doing it. I would find it pretty sad. Even though seal hunting has never been a big part of this nation's history, it still has through the ages been a part of it. And for those farmers who had the opportunity to hunt seals it was an important supplement to the diet. So, I would find it pretty sad if seals would only be hunted by some fishermen, just shooting the seal and not telling anybody about it. Just shooting the seal to kill it, and throw it away, so that it wouldn't eat the fish. That would be pretty sad."

Sigvaldi Thorðarson is Eysteinns partner in hunting seals. He works at *Orkurstofnun*, the National Energy Authority of Iceland, but has been hunting seals in northern Iceland before participating in the hunts in Broddanes. He started going on regular seal hunting trips when he was about fourteen. He says:

> "I've been doing this for 25 or 26 years. My father moved to a farm when he was 21 and he lived there, at least in the summer, in the last part of his life, until he was 80. My dad retired when he was 81. Good 60 years. That's the way I learned, both from him and there was always another man, at least in the beginning, there was always the same man who came to help us. My father came from a farm from the inland, nowhere near the sea, so he had no experience in seal hunting when he came there. So he had to learn everything. He learned from those people who had been working on this farm before, sort of helpers who came there to hunt the seal and they carried on when he came to the farm. So he learned from them, both how to hunt and how to utilise everything. The person who taught my father was from a farm near by. They didn't hunt there, but his father had hunted seal at my father's farm before him and he carried the tradition on. He had probably been hunting on this farm for 40 years or so and he had a great experience, and so they sort of learned from each other, and sort of over lapped the generations."

## Method of Seal Hunting in Broddanes

**Figure 105: Harbour seals at Broddanes**

Photo: Snowchange, 2008.

### Use of Nets

The primary seal harvesting method in Broddanes is with nets. Once the seal is caught in the net, a sturdy club is used to stun the animal. Then it is lifted in to the boat. Nets are held in place with anchors. Net locations are around the *sker,* small islands close to the shore. Nets are cleaned and untangled on the island and set again. Unlike usual standing net harvests, the sealers monitor and check the nets every 6 hours to make sure the harm to the animals is minimalised. Eysteinn reflected on the harvest:

> "Seals have almost always been caught in nets and it's the landowners who have done that. Nobody else is allowed to go there to hunt the seals like we do. It's only the owners or someone who has their permission that can go there. The fishermen, they don't go out specifically to catch seals in the net. Of course sometimes they will get seals in their nets too, but that's a part of fishing, it's not their intention. It's typically done around the 20th of June. But that's approximate. If there's a bad year, we might do it slightly later, if it's a good year, we might start slightly earlier. We do it in the weekends. June 17th is our national holiday, and sometimes if there's a long weekend associated with June 17th, we show up here. It's just convenient for us, because all of us who participate in this hunt live in the city, and we just try to come on weekends or on three-day weekend. Typically we arrive on Thursday night and leave on Sunday night."

Sigvaldi reflects on the timing of the hunt:

> "All activities are done when the female is trying to get rid of the young seals, three-four weeks after they have been born. Where I come from, we always start on the same day, on the 24th of June. Then we put the nets out and we come and check the nets everyday if we can. Everything has its time. This just happens to be the right time at this place for the pup to leave the mother. In other places it happens sooner – perhaps especially if you go further south it will be sooner, so it's just the way things work. Recently we only visit the nets three or four times before we take them out from the sea again. Earlier they did this for a longer period, since the prices of skins were higher

and the nets weren't as good. It was more difficult for them to get the numbers and they also did hunt more seals."

Eysteinn continues:

"Our season is typically three, maybe four days. We have special nets for seals – they're stronger and the size of the grid mesh is a bit bigger (about 100 mm), just to fit. What we do typically is that we arrive here, the nets are stored here in the community over winter. We arrive and bring the nets into the boat. We have a small boat that can take four of five people; we have a motor on it. We just go there, to the same places year after year, and put out the nets. Experience tells us, and the experience of our forefathers tells us, that this is the best chance to catch seals."

Sigvaldi discussed the nets in detail:

"Traditionally they were prepared by the hunters. They bought the basic material for them but they had to work on them as well. And they have changed a lot in the last century. Nowadays we have nets that have a sort of lead in the bottom rope and something that floats on the top rope, so that it keeps open. And you don't really need to weigh it down or put cork or anything to hold it up, so they are very easy to handle. Previously they only used to have a rope at the top and they attached some cork or something that floated on that and some stones at the bottom. When you get a seal in it, it was very difficult to get the net out, and it could tangle pretty badly and all the things you attach to the net makes it more difficult to handle, so they could tear up when you took them out of the water. But nowadays they are from nylon so you can pull the seal in the net and put into the boat, get it loose there, it's much easier nowadays."

Selection of seal hunting places is very important. Eysteinn discussed the selection of places:

"Sometimes we have tried to put the nets into new places. Sometimes it is successful, sometimes not. But typically we go to the sker, [above water reef in the coastal bay] to the rocks, and we tie one end of the net onto the sker and then normally we stretch the net directly out from it, or occasionally sometimes parallel to it, but typically almost directly out from it."

**Figure 106: Checking the nets**

Photo: Snowchange, 2005.

Sigvaldi agrees. He points out that

> "One year this island is very good, the next year some other island might be good. It shifts through the years."

Eysteinn continues:

> "Sometimes we put just one net, sometimes two, in a row. It depends on how many places we intend to put nets at, and how many nets we have available. Typically just one net, almost directly out from it. We bring maybe 6 or 8 nets with us, and during the same trip, check them immediately. Very often we have already caught some seals by this way. So, during our first trip when we actually put the nets into the sea, we bring back three to five seals. It depends, but often we do. We try to go out the next time about 12 hours later and again 12 hours later, then after 24 hours. The third day, maybe we just get the nets or on the fourth day we go and collect the nets. And that's the end of our season. Back in the old days they used to continue this over a two week periods at least. They would of course catch more seals, but today we catch somewhere between 10 and 40 seals. The seals that are caught in the net, roughly half of them drown; and about half of them are alive when we come to the nets. It depends whether it's shallow water, if it is shallow water, seals can go up to the surface and breath, or sometimes if it's a low tide, they might still be alive when we come there. If they're alive we club them, we have a club or a wooden stick and we just hit them

in the head, and the seals we club, those are the seals we eat some of the meat from, and it's always from the seal we club, so we can let it bleed out a little bit."

**Figure 107: A successful hunt! Releasing a seal from the nets**

Note: This one was clubbed and will be used for food.

Photo: Snowchange, 2008.

## Weather Knowledge and Cultural Change

Sigvaldi illustrated the prevailing conditions in Broddanes in the following way:

> "There is always some wind; there is almost never no wind. I remember maybe two or three days in my whole life when it was calm the whole day. You always get the wind from the sea. Strong winds from the sea or from the land. If I measure this now in meters, it's probably maybe 5 to 10 meters per second. It's normal."

Eysteinn further discussed the impact of winds and weather on the hunt:

> "There are some places where the hunt depends on the wind, whether it's blowing from the south or from the north [that influences where we actually put the net]. In most places we try to put it regardless of the wind. However, when we are putting out the net, the line might not be perfect because of the wind. Nowadays we have this plastic boat, instead of the wooden boat we used to have. So we have a harder time controlling it, especially if it's blowing. There are some places where it is dependent on the wind, how we put the nets and where we put them. It appears that back from 1930 until 1965 there was a warmer period with of course occasional exceptions, but from 1965 to 1990 it was quite a bit colder. There was more snow than the decades before, but now it seems, from 1995 to now, it has warmed up again and according to my father the weather is somewhat similar to the years in the previous warm periods. So we might be seeing a warmer period or a cycle, I don't know, we have to see. Of course there are occasional exceptions to this, some years and some months maybe, but what I find most interesting is that the autumns are a lot

> warmer now than they used to be, and it's warm until the beginning of November, it's hard to see any snow until January. You can forget about skiing in Iceland, which is strange to some people, but that's just the way it is. The lambs are typically born in May and when there's good grazing in the fields we just simply let them go freely in the mountains. They grow wild. In September, late September, or early October we go up to the mountains and catch them. We herd the sheep down, this is called "rettir". I remember before this warmer period started, that it was much easier to herd the sheep because it became quite a bit colder in the autumn and the sheep were more willing to come down. In the past three-four years it's been exceptionally warm and it's almost impossible to get them down. If you don't have a good sheep dog, you just don't stand a chance with them. They are just not willing to obey your order. So that's a big change. My feeling is that the tide is getting higher and lower than it used to be. But that might also be my own impression. This area, Broddanes, is interesting geologically. In this area, it's a very small area here, it's still rising, the land is still rising from the Ice Age. When there is a low tide, there are sker, rocks in the sea, they are appearing now. My mother never saw them when she was a child. Obviously during low tide you can see that the water level is significantly lower. It's definitely got to do with the rising of the land here. Maybe as well with the increased fluctuation on the tide, I am not sure. But one thing is for sure, it's lower during the low tide. Whether the water level is rising due to global warming and melting of the glaciers, and the ice cap in the North Pole, I don't know, it's hard to tell here, because the benchmark is moving. You can't tell."

Sigvaldi agrees:

> "The sea seems to be changing its level a little bit in the north, so it's a little bit lower. At least that's the feeling you get, because some of the sker are more prominent. Sker is a small, really small island that hardly gets out of the sea. They are more prominent now it seems."

Seal hunters of Broddanes have used their traditional knowledge to reflect on weather changes, including reflections from the older generation and changes in their own lives and farm activities, including the sheep economy. The postglacial rebound, according to the community members, is affecting the sea levels too.

Eysteinn continued on reflections changes in weather:

> "There is a definite trend. I don't think it is in any relationship with global warming or the climate change. It's just a cycle, we don't know for sure. The older generations have seen weather patterns like this before, so that's just the way it is."

The old weather prediction and wave knowledge skills are disappearing.

"I think it's been pretty much forgotten", says Eysteinn:

> "Because this is more recreational for us and we don't care all that much if we catch ten seals or forty, that's not really the most important issue. We would like to catch 40, but if that doesn't happen it's ok."

Sigvaldi continues:

> "I'm not able to predict it but this is something the old farmers in Iceland tried to do, predict weather. Since it was very important to them. I'm sure they could predict a little bit, by seeing if the clouds would be coming in. Because of the way we hunt the seals, that doesn't have very much effect on the hunting, we only have to get out to the sea. Sometimes we don't. There have been years that the weather was so bad that we couldn't hunt any seal. Then that's just off. So as long as we can go out and put the nets out, the seals are more or less there."

**Figure 108: Untangling the nets after a hunt**


Photo: Snowchange, 2008.

## Use of Meat and Blubber

**Figure 109: Skinning the seal is done according to age-old rules**

Photo: Snowchange, 2005.

Eysteinn reflects on the use of seal meat and blubber:

> "It's been a tradition to give away a few seals to the neighbours if they want to have them. What we do when we get the seals to the shore, is that we take the skin off. We always keep the skin even though we give away the seal. Some people maybe get one or two seals. They come and they will actually do all the cutting of the meat and in which way they want to have it. We take some of the meat for ourselves of the remaining seals, not very much, take the flippers, the back flippers. Some of the meat we cut and feed to the dog. But when there's a lot of meat, or a lot of seals, some of the meat actually gets buried in a hole. It depends on how many we catch. If we catch very few, we try to use most of the meat. Occasionally people want to get blubber and salt it, but that's extremely rare. We don't do this ourselves."

**Figure 110: Skins are used and most of the clubbed seals eaten**

Photo: Snowchange, 2005.

## Traditional Ways and the Future

Eysteinn thought about the importance of passing the skills and traditions to younger generations:

> "In general, I think most younger people are not interested or they don't know much about it, they don't care. In general, they don't oppose it like in some other countries, they're aware that this is happening, they don't oppose it, but they don't really take much interest in it. I think if this would be introduced more to the public there might be some more people taking interest in it, but today the way we do it we're only maybe introducing it to our relatives or friends, but nothing more, so there it's an ever-decreasing number of people who are doing this, or even know the skill. Just how to cut off the skin of the seal is a bit tricky. If you're selling it, you can't just cut a hole into the skin, it would be ruined and worthless. It's something my father does really well. I learned it when I was younger, but I've never been good at it. I'm not even sure if I could pass it on to someone else. But I mean, people haven't done anything to promote this at all. I grew up with this, going out when I was little. To me it is a normal thing to do. In a way I enjoy it. I'm not saying I enjoy killing an animal but I enjoy the hunt and I try to do it as mercifully, I try to do it quickly and kill the prey. I get excited, I go there and catch some seals and I do get excited. Just like when I go shooting some ptarmigans or goose. We only caught about 290 seals in the whole country in 2002 so it's a dying tradition. We ourselves caught 40 seals last year, so I don't know what's going to happen to this, I really don't know. We sell our skins to a person who makes fur coats. Maybe he will not buy from us in the near future. What do we do then? Then we just catch the seals to get the taste of it, the meat and the flippers. What happened some years ago, when I was a kid, we would get a big price for the skin. Then Brigitte Bardot and other environmentalists started acting against us and then there was no market for it. So what happened, for some years, there was no seal hunt at all out here. I don't

> know for how many years it was, maybe five or six years. Then what happened was that they started put up, growing foxes, you know, and seal meat was considered pretty good for the foxes, mixed with some other ingredients to make food for the foxes, so then there came a market for the meat, so we started hunting seals again, but this time we didn't even bother to take the skin off, there was no market for it. So it was taken directly to this factory, where they grinded it up for food for the foxes. Then, maybe around 1999, a small market started again for the skins and people started making seal skin clothing and furs and even one of our ministers used to wear them quite a bit, our foreign minister. So that's how it went."

Sigvaldi commented:

> "I think it's either 5 or 10 thousand kronor [EUR 40–80] for a skin. I think 5,000. 5–6,000 [EUR 40–50]. It's not much more than that, but I'm not sure. They might get a little bit from the fisheries, I'm not sure. But it's not enough really to keep this alive in the way it used to be, so it becomes a side project. And also not in all the places where they used to hunt."

The local knowledge of waves, ocean, currents and the ecosystem, known as "wave knowledge", was important, particularly historically during the hunt. Sigvaldi reflected:

> "It is important when you try to get to the places, because the currents, especially in the old days when you had to row, it's important that you didn't row against the current, so I'm sure that they tried to know the waves. Also the nets are going to be affected by the currents in a sort of fluctuating way. So I'm sure this was something they had to think about and they certainly knew the currents. I'm sure about that. And there is also one thing you should keep in mind. All the seal hunters are sort of farmers, they are not fishermen, since seal hunting always belongs to a certain farm. Where the young ones are born that's where you can hunt them and that's tied to a farm. It's not fishermen per se, even though many of them also go fishing, because obviously all the farms are by the sea side and there are some you can fish near by. I'm very much against a Norwegian-style industrial seal hunting. I think seals should be utilised by the people who live with them and it should be a by-product and something they can use. Local people understand the way the seal lives and they don't want to destroy it, they just want to utilise it, make use of it in a way that is proper. I certainly respect the seal very much, I think it's a wonderful animal and I would never want to make it go extinct. I take great care not to do that. I think almost all the seal hunters here would feel the same way. We're not the enemies of the seal."

Eysteinn continued:

> "So I don't know what will happen if we can't sell the skins, even though we don't get too much money for it. Then we might just go for one day, come here with the nets and next day pick them up, to get just some meat. And maybe in ten years nobody will be interested in it. Hopefully not."

### Story-telling

In the rural areas of Iceland people still keep traditions alive and story telling and folklore play a part in people's every day life. "It's I think the "small people" and spirits and ghosts and everything is common" says Eysteinn. "Everybody sort of talks about it. Of course not everybody believes in it, but that's a big part of history in Iceland."

Sigvaldi commented on dreaming, seal stories and stories of the hunters:

"There are not so many stories about the seal, but about the people who were involved in the hunt and how it sort of proceeded. Because in the old days it was the first fresh meat you got in the spring. So, people came and they got some meat and they really looked forward to this. Use of dreams is just a normal thing with Icelanders. Maybe not myself, but especially with the elders. They would dream about anything. That would sort of predict what they would be going to hunt or what ever. They would interpret the dreams according to whatever they were doing. So certainly some of them used dreams or maybe not used them, but they thought they were going to see what's going to happen. But that's just kind of an Icelandic thing, not a specific seal-hunting thing. It's difficult to say. The future depends on whether you are going to get the next generations interested in seal hunting. It's not to everybody's taste. And people are becoming more 'environmentally friendly', they kind of misunderstand this activity. They look at it as just being a cruel thing. They don't see it as preserving a way of life. Maybe they have a point, at least in Iceland it's not necessary for anyone, your life doesn't depend on it in anyway. So you can take it as more of a hobby. Even though my view would be different. It's difficult to explain, how you look at this. I wish other seal hunters in the north keep up with the traditions and certainly don't try to industrialise it too much, I don't think it's a good thing. It should be kept as a tradition. I hope they do that."

**Figure 111: The Húsavík coast**

Photo: Snowchange, 2008.

### *10.3.3 Húsavík Seal Hunting*

Húsavík is a town with 2,500 people located in the southern part of the county of Þingeyjarssla on the northern coast of Iceland. The town was founded in the year 1930. The story is, that a Swedish man by the name of Gardar Svavarsson, came sailing from Sweden, bringing with him a bondwoman and a slave called *Náttfari* (Nightwalker).

Svavarsson sailed around the country and realised it was an island. He sailed ashore in a small cove at the foot of the Kinn Mountains directly across from Húsavík. Reportedly, Svavarsson sailed away from the cove in the night, leaving the slave and the bondswoman. The cove in which he left them is called *Náttfaravík* (Nightwalker cove) (Saga Húsavíkur, 2001).

**Figure 112: Húsavík harbour**

Photo: Snowchange 2008.

Traditional ways of life persisted in to 1960 in the region, as is described by Sigurður Gunnarsson in one of his oral histories from 2004:

> "There were a few turf houses in the Húsavík area. I do remember them, one, two, three, four, at least five. At least when I was a small kid (in the 1930s). The one that was lived in the longest was lived in until after 1950. In one of the turf houses, people lived until almost 1960."

This chapter focuses on Húsavík sealing as an example of an Icelandic socio-ecological human-sea system that has been little-explored before in an international context. Materials presented here centre around oral histories of the sealers themselves and builds on research between 2003–2008, along with community reviews, translations and analyses from 2009–2018.

### Harvested Seal Species

The six most common seals around Iceland are as follows:

- *Landselur*, Common (harbour) seal (*Phoca vitulina*), grows to around two metres long and can become 34 years old. Their mating season is in August and

September and they mate in the ocean. The females give birth in May and June. In 1980, the population of the common seal around the coast of Iceland was approximately 33,000, but in 1995 the estimated population was around 14,000, showing a downward trend;

- *Útselur*, Grey seal (*Halichoerus grypus*), grows to about three meters long and can live for up to 40 years old. The grey seal mostly stays out in the open waters away from human presence. They give birth from the middle of September until January, and their mating season starts as soon as birth is completed. Mating takes place on land and by the ocean;
- *Vöðuselur*, Harp seal (*Phoca groenlandicus*), grows up to around two metres long and lives for 15–20 years. They stay in groups. Birthing season is in February and March, but they then migrate from further south to Iceland on drift ice to look for food. Their choice in food varies according to waters, seasons and years. Mating takes place in the ocean 10–12 days after birth. There is not much interest in hunting harp seal among seal hunters in Iceland. The people in the county of Thingeyjarsveit define the harp seal according to age: *dropaselur* (drop seal) is a one-year-old harp seal, next there is *gráskjóttur* (greyish skewbald) and the oldest is *brúnskjóttur* (brownish skewbald);
- *Blöðruselur,* Hooded seal (*Cystophora cristata*) becomes around 2–2.6 m long and can live up to 30 years. This seal travels extensively looking for food, it very seldom moves close to the shore and mostly stays on drift ice. The females start mating at three years of age and give birth at four years of age. They give birth on icebergs. They choose a big one and lie very close to each other;
- *Hringanóri*, ringed seal (*Pusa hispida*) becomes 1.5–1.7 metres long and can live for 15–20 years. They live in the Arctic Ocean and can be seen around Iceland from April to December. They give birth on ice and must always be on the lookout for polar bears. The ringed seal reaches puberty around the age of 8–11 years old and their mating season immediately follows the birthing season that is in March/April or May/June;
- *Kampselur,* Bearded seal (*Erignathus barbatus*) becomes around 2.5 metres long and can live for about 30 years. The females reach puberty at the age of 5–7 years, they give birth in May or June and the mating season starts right away. They give birth on drift ice from March until May, and then the seals move up north on drift ice when birthing is finished (Íslensk spendir, 2004);
- Migrating seals are: *Blöðruselur* hooded seal (*Cystophorae cristata*), *hringanóri,* ringed seal (*Pusa hispida*), *kampselur*, bearded seal (*Erignathus barbatus*) and *völuselur*, Harp seal (*Phoca groenlandicus*).

In the 18th century, most of the seal hunting in the north of Iceland was in the county of Þingeyjarsla. 31 out of 70 farms were involved in the hunt. Flocks of seal moved into the Skjálfandi bay and the fjord Axarfjördur every year. The most common seal was the harp seal, which was around Iceland from the time of December until May.

According to Björn Guðmundsson, a farmer at Lón in Axarfjörður, the harp seal is the cleverest swimmer, has the most skilfull and beautiful movements. It swims on its back or chest and jumps easily out of the ocean, like a dolphin. The harp seal is a very social creature and travels in groups. If it gets scared, it gushes loudly under water, warning other seals to remain below the surface. But the harp seals also play loudly, gushing and splashing. Other seals seem to be able to distinguish these two separate, but similar, behavious and ignore it when appropriate, i.e. when the harp seal is paying (Íslenskir sjávarhættir, 1980).

Today seal meat is eaten, but it is also used as bait for shark. Prior to the EU ban on export on seal products in 2009, the skins were also sold internationally. Today one has to rely on the domestic market.

Icelandic ILK on seals, including the rich vocabulary such as that presented on harp seals above, exists across all seal species.

### The Historical Context of Húsavík Sealing

It is believed that seal hunting has been practiced for as long as there have been inhabitants in Iceland. However, the first documentation of seal hunting originates in the Middle Ages, where it is clear that seal was used for both food and gifts. In the Húsavík area the three most common methods of killing the seal were: nets, clubbing on ice or skerries and by shooting, mostly off boats. Until 1905, Húsavík only had rowing boats and people only hunted or fished in shallow waters. After 1905 they started bringing in motors for the boats and around 1930, the rowing boat fishery ended in Húsavík and boats that had gasoline propellered motors took over (Íslenskir sjávarhættir, 1980).

Hunting by harpoon was restricted to the harp seal and practiced quite a bit at the Skjálfandi bay in the 19th century. The oldest documentation found on hunting seal with nets on Iceland is from 1605, where they speak of a kind of hunting license owned by the church. The priest at Húsavík was often a fisherman himself and he allowed people to use the hunting licenses with him for a charge.

Until the 20th century the income from these licenses went to the church. Hunting with nets increased in the 19th century at the expense of the harpoon. The nets were difficult to use; the hunting took place in the wintertime through to spring and at least six strong men were needed for each net. Additionally, the precarious weather made it a particularly dangerous hunting method.

Men hunted from Bangsastaðir and stayed there for days or weeks on end. Each crew had a primus for heating coffee and cooking their porridge, but otherwise they lived on food they brought with them. Occasionally the men went home, got rid of the catch and picked up some food, but between those trips the seals were gutted, filled with ice and buried in the snow (Saga Húsavíkur, 2001).

The people at Húsavík attracted the seals with smoke. They hunted the seal in nets and had a box of old grass, *moð*, at each end of their camping location. Around noon they lit the old grass, producing smoke. The harp seal was attracted to the smoke and got caught in the net. Every possible part of the seal was used, the most important parts being the fat, the meat, the head and the skin. Seal fat was used for human food and was as valuable as dried fish for a long time. The older and greener it was, the better it tasted. Around 1900 a pound of fat was equal to a pot of milk in Húsavík. The meat was eaten fresh, salted, boiled and smoked and was also boiled for soup. The head, flippers and tail were soured. The stomach was used to transport liver oil (Íslenskir sjávarhættir, 1980).

In northern Iceland it was common to make painting for houses from a mixture of the seal liver oil and dyes. The skin was used for clothing and for book covers, as well for receptacles and straps. Shoes made from sealskin, particularly skin from the bearded seal, were popular among the ptarmigan hunters. The seal was a great asset and those who had nothing but seal meat for Christmas, ate it smoked. The blood was sometimes taken when possible and if times were hard. Jón Ósmann, a ferryman at Hérasvötn, reportedly drank the blood. When he had shot the seal he would open a vein in the throat, put his mouth against it and drink all he could from the warm blood of the seal (Íslenskir sjávarhættir, 1980).

Around the middle of the 20th century, rowing for seal became less and less common. In the last decades, harp seal has hardly ever been seen in the bay and other species have also become extremely rare. Seal are not usually considered food for humans anymore, but have been used to feed foxes at fox farms. Even the skin of the seal has lost its value (Saga Húsavíkur, 2001).

**Figure 113: Helgi Hélginsson at his fish base, Húsavík**

Photo: Snowchange, 2008.

### Helgi Hélginsson and Sigurður Gunnarsson – Keepers of Tradition

Helgi was born in Húsavík on the 31.12.1928 and was raised in Husavik. He is the son of a farmer who harvested the ocean. Helgi has been fishing and hunting since the age of fourteen. He hunts and fishes just about everything that the sea gives: fish, birds, shark and seal. He is a keeper of tradition:

> "My grandfather hunted seal. He was born around 1870 and my father, he was born on the 18th December 1899 and got a gun as tooth money (a present given as a reward to a baby for its first tooth). But he did not start to use the gun until he was ten, I think. Overall people that lived here in Húsavík, they were farmer-fishermen. They kept animals and then they went to sea. In the 1920s and 1930s, men hunted seal east of Axarfjörður. They kept their base at Bangastaðir. Men would go there with rowing boats and celebrated the 1st of April and even the first day of summer while hunting for harp seal."

Sigurður was born on 24.05.1931 at Arnanes in Kelduhverfi and he was the son of farmers who, like Helgi's ancestors, harvested the ocean:

> "My maternal grandfather, he did a lot of hunting, seal hunting. He lived in Lón here in Kelduhverfi. He hunted seal a lot while he was in his prime, and he started hunting seal just before or about the turn of the century (1800/1900). He hunted seal the next thirty years or even longer, but then his son Guðmundur was an adult and had taken over. He was my uncle on my mother's side, and he taught me how to hunt seal when I was a teenager."

Sigurður lived in Húsavík for over 50 years, fishing on his own all his life. Sigurður began the hunt when he was 14 but did not hunted seal since 1957. Sigurður passed away in 2008.

**Figure 114: Sigurður Gunnarsson at home in Húsavík in 2004**

Photo: Snowchange.

## Seal Hunting Oral Histories

Sigurður recalls the hunts from 1930s and 1940s: "I cannot remember catching more than six seals" at one time. This implies the numbers caught per boat crew remained relatively low in the earlier part of 1900s. Spring and autumn were the times of the harvests:

> "Often in October and then again in March and April. Those were the main months. In those days the pup skins were prepared and sold. You could get a good sum of money for them until 1930. Skins were used for shoemaking – I only remember having that kind of shoes on as a kid. That was during the war, then it was a big problem here, we were lacking all kinds of things and there were strict rations."

## Role of Seal in Food and the Domestic Economy

Seal meat was a much-needed addition to local diets and the skins were utilised for both domestic consumption and for earning extra income. According to Helgi:

> "seal was very valuable because you did not have to store it (in the cold). It was only salted and soured. There were no other storage forms".

He recalled how the meat and fish was distributed in the community after a successful trip:

> "We were so lucky to see a hooded seal and get it, we rowed with it straight to shore and it was distributed between houses. It was like this in the olden days when men were rowing on the rowing boats for food. There were no icehouses or fish factories to take care of and handle the catch. Catch was distributed. It was often three men that rowed together. The catch ranged between 100–200 kg. There were many fish divided into three piles. Catch was thrown into these piles, the different species of fish distributed evenly between the piles and then one would turn around and say who would get which pile. In this way the catch was distributed, this was their take. Then they could sell their catch if they wanted or give it away."

## Numbers of Seals in the Early Part of 1900s

According to Sigurðurs observations: "There was a lot of harp seal in the olden days." Helgi agreed:

> "There were quite a lot of ringed seal. Bearded seals are the smallest in numbers although they can be seen in most years. Usually there was a considerable amount of ringed seal. You could shoot five to seven ringed seals at best, and it was usually alongside the shore. This was before men would go out on the bay and hunt the seal there."

Some of the older traditions were still present in Sigurðurs youth:

> "My father hunted seal, cut it and drank the blood of the animal. He just thought it tasted excellent. I only knew of one other man that did this. The old man was always offering me to drink, that this was so good, you would blóðhitna (means warms you up, warms up your blood) by drinking it. No, but I could never get myself to drink it."

**Figure 115: Helgi Hélginsson demonstrates a seal hunting harpoon tip, Húsavík in 2004**

Photo: Snowchange.

### Observed Seal Behaviour

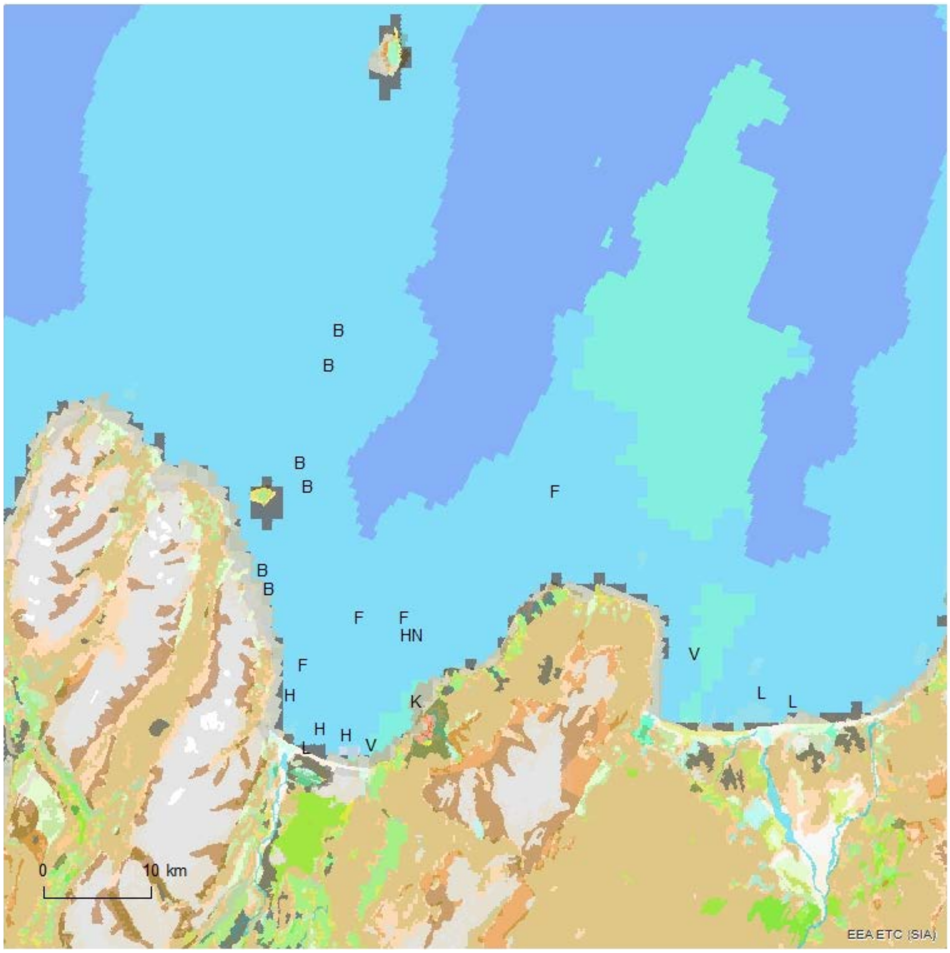
According to Helgi various seals behaviour is closely related to the seasons of the ocean:

> "Harp seal is more there in Axarfjörður and of course somewhat in Eyjafjörður and then here. This was the seal that people wanted to catch, there was so much of it. I remember when I was a kid, then I would go to the shore when there was good weather, then there were many people fishing in rowing boats hunting for seals. Then one would wait to see what they got, watch the shore, waiting for when they came ashore to see the catch. Hunters would venture out north of Grímsey and perhaps they would come with nineteen hooded seals in one tour.. Blubber was salted. This is all bound to the seasons, both in connection with the catch and also with the seal."

Both hunters confirm the seals are clever and they have excellent hearing according to Helgi:

> "They hear well. It doesn't pay off just to let the boat drift, the engine running. When you do that there comes a sound change to the engine. You must be still while the seal is on the sker but if you come too close to it, it will dive into the sea."

**Figure 116: Seal hunting and fishing map over the Húsavík Bay area based on the experiences of Sigurður Gunnarsson (b. 1931) and Helgi Hélginsson (b. 1928)**




Note: B = *Blöðruselur* hooded seal (*Cystophorae cristata*), F = *Fiskur* fish, H = *hringanóri*, ringed seal (*Pusa hispida*), HN = *Hnísa* harbour porpoise (*Phocoena phocoena*), K = *kampselur*, bearded seal (*Erignathus barbatus*), L = *Landselur*, common (harbour) seal (*Phoca vitulina*), V = *vöðuselur*, harp seal (*Phoca groenlandicus*).

## Hunting Seals

Navigation on seal hunting trips required significant skills to read the sea, waves and the bottom. Hunters would use line to measure depth to determine various features of the bottom. Currents had to be considered when travelling with small boats. Helgi explained that a combination of currents and waves determined good navigation:

> "then you just looked around and positioned yourself. There was the current and either it overpowered you and you would miss the spot of sealing or fishing, if it was kind of a small spot. You can't see it from the way the sea is because you cannot see anything from the way the sea is until there is surf. Then you can start to read into it and if there is a lot of surf, the undercurrent comes from far away."

According to both hunters, calm weather was essential for a successful hunt or as Helgi put it:

> "There was no use going except if there was still weather. Calm wind or without wind. Especially if you went from shore." Tides also play a role according to him: "It is such an amazing species. Seal can protect itself in shallows where I cannot get to it. Even though I could shoot it, I wouldn't be able to fish up. So, in this case you would skip the whole thing. If you want to shoot a seal that lies on the sker, then that should always be on the high tide."

Sigurður explained that the hunting time is called:

> "ládautt (the sea is so calm that not a ripple can be seen on the sea surface). It was like the sea was dead. In January it was often not possible to leave, but sometimes there were days and then of course you would go out to sea, it was so important in those days to get fresh food."

He recalled a hunting trip in January 1946 where the conditions shifted in a split second:

> "there was good weather around noon or just after noon, then a seal comes in a hunting distance. We get it but then just in a split second the weather changes and becomes completely crazy with a westerly storm. There was nothing else to do but to try to get over the Jökulsá river delta or to row to (safety)."

The hunters mastered several local weather and wind concepts, including *snepplótt*, meaning that the clouds are forming in an upright but tilted way showing the direction of the wind and whether it will turn or not. These skills and concepts could be utilised to safely predict the short-term weather for hunts. According to Helgi, the weather has changed in his lifetime:

> "The snow melts away fast. When I was younger, the snow stayed. Then when it snowed during winter there were frost stills, with a lot of frost and calm weather in the afternoon and night, with cold mornings. In the night the sea froze to land. In the 1970s this ice caused a lot of damage to boats."

High tide is important for a successful harvest:

> "You need high tide to be able to follow the seal and have a chance of catching it. If it is not curious and comes closer to you, then you need to go to it and try to corner and trick it. It's good to be out at high tide so you can freely steer the boat – I have often ended up being stranded at low tides."

Both hunters also utilised porpoises for food. For example, Helgi once got thirteen animals in one hunting trip. Sigurður complemented the meat quality of porpoise, but said that this harvest has been discontinued due to the whale watching out of Húsavík in modern times.

### Seal Stocks of Today and Shifts in Nature

According to Sigurður the two main:

> "seal populations here at Iceland are grey seal and common seal. Their populations tend to fluctuate in waves like the rock ptarmigan. I have no explanation for this, but grey seal and the common seal have, for example, decreased considerably. It is not being hunted very much, not at all as much as it was hunted in the olden days."

He links the population fluctuations to fluctuations in lumpfish harvest, but he cannot confirm this:

> "There is something else that is affecting the population, something that plays a part, something in the nature. To a certain extent it might have to do with net fishing on lumpfish, but I am not sure that that is very likely."

He has observed only a few seals in poor condition:

> "I only remember once in my lifetime getting a grown common seal in my nets and it was blind. It's lenses were white as snow and it had become so skinny and was weak."

Helgi paid special attention to the link between shark diets and seals: "The shark is a deep water fish that can wander to the shallow waters. It is by no mistake that a shark catches an Icelandic seal, gray seal or harbor seal."

In the 1990s and 2000s, seal meat has also been used as shark bait.

Helgi summarised his observations:

> "there is a considerable change When I was young, I could only catch harp seal during spring, but after that it soon disappeared. There has been an increase in hooded seal for a few years now, but it had disappeared completely for a while. It is here during spring when the spring fish appear just before June. At least here in Skjálfandi. It then goes out to the ice to change its fur and comes back skinny – let's say around then end of July and beginning of August. But it looks like it is reducing in numbers. It has been quite noticeable the last ten-twelve years (1992–2004). It looks like the harp seal comes nowadays when the capelin is coming through."

Increased parasites and diseases in sealife have been observed in the region since the 1960s. Sigurður has had great concern for what he calls "roundworms" (nematode) in seals:

> "Then there is something else that is bad with the seal, specially the grey seal. It is a host for the roundworm. The eggs come from the seal. There are little crustaceans in seaweed, very small crustaceans, that eat the eggs and then the offspring comes to live in these crustaceans. Then the cod comes, specially the small cod, it eats the crustaceans and then the worm really comes alive. It crawls out to the flesh and in some fish, there are incredible numbers of the worm in the flesh. You cut open the fish and there it is, everywhere. These are the same worms as the ones in seals, worms that curl into a circle. They come into existence inside the seal's stomach. There the eggs drop down and they fall down from the seal."

During the oral history work Helgi expressed great concern for the changes he sees out in the ocean. According to him, zooplankton such as *Calanus*, has been diminishing in the ocean. This has affected the food chain. For example, numbers of tern, black-legged kittiwake and fulmar have been negatively affected.

One of the most interesting observations both hunters also reported were shifts in ocean currents. For example, Helgi reported that:

> "a sign of increasing sea currents is when the moon is rising and it is full. Perhaps the ocean has more salt in it. Then there is movement with the fish in the sea. A good example is the capelin, which is found in high numbers during spring here in Skjálfandi. I just think that the current has changed and perhaps several other things. The temperature in the sea and the changed current, there is much that has changed. Usually approximately twice a year, in the spring as well in July and August, there would be a lot of sea weed – bladder wrack that floats. There was a lot of it due to strong ocean currents that also brought driftwood. That has disappeared."

Sigurður lived all of his life in very close proximity to the ocean and nature. He spent much time worrying about the impacts of pollution: "This is of course a very serious matter, when men (humans) pollute nature so much."

According to him there exists a natural law. A system of existence that is present in nature and in all of its manifestations. One of the most powerful moments of the oral history work was when Sigurður concluded his observations by saying:

> "Nature is an incredible thing. All of this, all of this is incredible. And it is a shame that we do not protect it better, better than we do. I find it especially horrible that we pump all this poison in to the nature and think that the sea can take it all. Here in our neighbouring country, in Greenland, PCBs can be found in women's breast milk. We believe in mother earth… here in Iceland."

**Figure 117: Helgi Hélginsson with a seal, 1980s**

Photo: Snowchange, 2005.

## 10.4 Conclusions

The seal hunters of Iceland occupy a very specific coastal hunting economy and a niche that has survived in to the 2000s. Being a strong ILK system and a socio-ecological complex, the practice has been closely associated with traditional food security of coastal and northern Iceland. This is reflected in the intimate knowledge surrounding the seal harvests, including net locations in the *skers*, as well as cultural readings of the land and seascapes.

In the oral histories of the seal hunters from Broddanes and Húsavík, reflections on food security, self-limitation of harvests and endemic hunting methods, such as the use of *moð* boxes (containers to burn hay in to produce smoke to lure the seals) are present. Hunters are aware of more recent changes to the coastal ecosystems, including changes in weather, ocean currents and changes in fish distribution and abundance. The seal hunters of Iceland provide a deeper understanding of a marginalised practice and culture from a North Atlantic coast.

## 10.5 References and further reading

Oral histories of Sigurður Gunnarsson and Helgi Hélginsson, as well as sela hunters of Broddanes. Data stored on tapes in the Snowchange Husavik and Broddanes Oral History Archive 2004–2018. Available on request.

### *10.5.1 Written references*


Gunnarsson, K., Jónsson, G., & Karvel Pálsson, Ó. (1998). *Sjávarnytjar vid Ísland*. Reykjavík: Mál og Menning.

Huntington, H. P. (1997). Observation on the Utility of the Semi-directive Interview for Documenting Traditional Ecological Knowledge. In: *Arctic. Journal of the Arctic Institute of North America*. *51*,3(sept. 1998), 237–242.

*Íslensk spendðr*. (2004). Páll Hersteinsson (Ed.). Reykjavík: Vaka Helgafell.

Jónsson, B. H., & Rögnvaldsson, S. (2001). *Saga Húsavíkur* IV Bindi. Húsavík: Húsavíkurkaupstadur.

Landmælingar Íslands. License-number L04120005

Kristjánsson, L. (1980). *Íslenskir Sjávarhættir I*. Reykjavík: Bókaútgáfa menningarsjós.

Mustonen, T. (2008). *Report from the ILK Documentation of Husávik Sealers*. Unpublished Work Report. Available from the Snowchange Cooperative.

Mäkinen, A., & Mustonen, T. (2004). *Pitkät hylkeenpyyntimatkat ja muita kertomuksia hylkeenpyynnistä*. Tampere: University of Applied Sciences Tampere.

Ormond, A., Cram, F, & Carter, L. (2006). Researching Our Relations: Reflections on Ethics and Marginalisation. *ALTER*NATIVE, *2*(1), 174–192.

Pálsson, G. (1991). *Coastal Economies, Cultural Accounts – Human Ecology and Icelandic Discourse*. Manchester: Manchester University Press. ISBN 0-7190-3543-0.

www.husavik.is. Taken from the world wide web on the 8.12.2004 http://www.husavik.is/page.asp?id=539

# Sammanfattning

Denna rapport ingår i bakgrundsmaterialet till en nordisk IPBES-liknande utvärdering av biologisk mångfald och ekosystemtjänster och utgår från tio fallstudieområden runt om i de nordiska länderna (Danmark, Finland, Island, Norge och Sverige and Sweden), inklusive de autonoma områdena Färöarna, Grönland och Åland. Avsikten är att utgå från den lokala situationen för ekosystemtjänster (naturens bidrag till människor), bl.a. status och trender, orsaker till förändringar, förvaltningspraxis och vilken framtid vi kan förvänta oss. De tio fallstudieområdena beskriver situationen i Näätämö-avrinningsområde (FI), Kalixskärgård (SE), Kvarken (FI/SE), Puruvesi (FI), Lumparn (ÅL/FI), Öresund (SE/DK), Helgelandsskärgård (NOR), Färöarna (DK), Diskobukten (Grönland/DK) och Islands norra kust (ISL). Följaktligen består dessa områden av allt från sötvatten till högmarina Atlantområden och från urbaniserade områden med stort samlat tryck på ekosystemen, t.ex. Öresund, till glesbefolkade områden som Grönland. I de olika fallstudieområdena har huvuddelen av fokus lagts på situationen i havet och betydligt mindre på de kustnära landområdena.

Fallstudieområdena har sedan studerats utifrån befintliga data för att ge en översiktlig bild över statusen för de lokala ekosystemen och hur nyttjandet av ekosystemtjänster sker samt vilken utveckling man kan förvänta sig. Författargrupperna har även identifierat drivkrafter för positiv eller negativ utveckling. Generellt kan man konstatera att biologiska resurser av alla slag och själva upplevelsen av landskapet har stor betydelse för lokalbefolkningen livskvalitet. Det är också en avgörande orsak till varför andra människor besöker områdena. Den biologiska mångfalden och nyttjandet av olika ekosystemtjänster utgör även väsentliga delar till platsens kulturella och historiska utveckling och spelar en betydande roll för vilken kulturell identitet som finns i ett område. Praktiskt taget alla olika kategorier av ekosystemtjänster har betydelse. Även i urbaniserade områden där det direkta beroendet av de lokala resurserna för människors överlevnad mer eller mindre upplevs ha upphört, anses en någorlunda välmående natur som viktig och många fritidsaktiviteter är kopplade till kvarvarande naturområden. Mycket av den negativa påverkan på biologisk mångfald och ekosystemtjänster har sitt ursprung i urbanisering, övergödning, föroreningar och överutnyttjande av resurser, inte minst i kustnära områden. Ofta finns även en geografisk skalproblematik som gör att problem inte har en lokal lösning. Det mest uppenbara exemplet på detta är klimatpåverkan, vilken dessutom kan förväntas påverka nordiska länder i än högre grad. I de nordiska länderna finns visserligen en relativt stor miljömedvetenhet och en väl fungerande naturvård men på grund av livsstil, produktionsformer, konsumtionsmönster och befolkningsantal är trycket och hotet fortsatt stort på den omgivande miljön och den biologiska mångfalden eller genom globalisering förflyttat till andra delar av världen.

Fallstudieområdena har olika system för förvaltning av ekosystem och biologiska resurser. Flera av fallstudierna understryker vikten av lokal delaktighet i förvaltningen av områdenas biologiska mångfald och ett ökat tillvaratagande av lokal kunskap om status och trender hos ekosystemen.

# Annex

## List of editors, co-chairs, authors and reviewers

### *Editors*

*Andrea Belgrano*
Swedish University of Agricultural Sciences
Sweden
Swedish Institute for the Marine Environment
Sweden

*Gunilla Ejdung*
Swedish Environmental Protection Agency
Sweden

*Cecilia Lindblad*
Swedish Environmental Protection Agency
Sweden

*Håkan Tunón*
Swedish Biodiversity Centre, Swedish University of Agricultural Sciences
Sweden

### *Co-chairs*

*Andrea Belgrano*
Address – see Editors

*Anna-Stiina Heiskanen*
Finnish Environment Institute
Finland

*Eva Roth*
University of Southern Denmark
Denmark

### *Project leaders*

*Gunilla Ejdung*
Address – see Editors

*Britta Skagerfält*
Swedish Environmental Protection Agency
Sweden

## Volume 2 Geographical case studies

### *Authors*

#### Case Neiden/Näätämö

*Tero Mustonen*
Snowchange Cooperative
Finland

#### Case Kalix archipelago

*Marie Kvarnström*
Swedish Biodiversity Centre, Swedish University of Agricultural Sciences
Sweden

*Joakim Boström*
Kustringen, Kalix
Sweden

#### Case Kvarken – The Quark

*Hannele Ilvessalo-Lax*
Centre for Economic Development, Transport and the Environment for South Ostrobothnia
Finland

*Johnny Berglund*
County Administrative Board of Västerbotten
Sweden

*Hans-Göran Lax*
Centre for Economic Development, Transport and the Environment for South Ostrobothnia
Finland

*Tero Mustonen*
Address – see Case Neiden/Näätämö

### Case Lake Puruvesi

*Tero Mustonen*
Address – see Case Neiden/Näätämö

### Case Lumparn area

*Susanne Vävare*
Government of Åland
Åland

*Maija Häggblom*
Government of Åland
Åland

### Case The Sound

*Anders Højgård Petersen*
University of Copenhagen
Denmark

*Preben Clausen*
Aarhus University
Denmark

*Lars Gamfeldt*
Swedish Agency for Marine and Water Management
Sweden

*Jørgen L.S. Hansen*
Aarhus University
Denmark

*Pia Norling*
Swedish Agency for Marine and Water Management
Sweden

*Eva Roth*
The University of Southern Denmark
Denmark

*Henrik Svedäng*
Swedish institute for the Marine Environment
Sweden

*Håkan Tunón*
Address – see Editors

### Case Helgeland

*Kasper Hancke*
Norwegian Institute for Water Research
Norway

*Hege Gundersen*
Norwegian Institute for Water Research
Norway

*Kristin Magnussen*
Menon Centre for Environmental and Resource Economics
Norway

*Egil Postmyr*
The Norwegian Environment Agency
Norway

*Guri Sogn Andersen*
Norwegian Institute for Water Research
Norway

*Karl-Otto Jacobsen*
Norwegian Institute for Nature Research
Norway

*Håkan Tunón*
Address – see Editors

### Case Faroe Islands (Føroyar)

*Jan Sørensen*
Natural History Museum
Faroe Islands

*Johanna Roto*
Snowchange Cooperative
Finland

*Håkan Tunón*
Address – see Editors

### Case Disko Bay

*Michael Køie Poulsen*
Nordic Agency for Development and Ecology
Denmark

### Case Iceland

*Tero Mustonen*
Address – see Case Neiden/Näätämö

*Kaisu Mustonen*
Snowchange Cooperative
Finland

*Embla Oddsdottir*
Snowchange Cooperative
Finland

## Reviewer – Volume 2 Geographical case studies

*Ulf Molau*
University of Gothenburg
Sweden

*Stine Rybraten*
Norwegian Institute for Nature Research
Norway

*Sebastian Villasante*
University of Santiago de Compostela
Spain

*Nanna Granlie Vansteelant*
Independent consultant
Denmark

## Steering group

*Inkeri Ahonen*
Government of Åland
Åland
Present address: Swedish Environmental Protection Agency
Sweden

*Suvi Borgstöm*
Finnish Ministry of the Environment
Finland

*Mette Gervin Damsgaard*
Ministry of Environment and Food
Denmark

*Maija Häggblom*
Address – see Case Lumparn area

*Mark Marissink (Chair)*
Swedish Environmental Protection Agency
Sweden

*Helle Pilsgaard*
Danish Agency for Environmental Protection
Denmark

*Bjarte Rambjør Heide*
Norwegian Environmental Agency
Norway

**Nordic Council of Ministers**
**Nordens Hus**
**Ved Stranden 18**
**DK-1061 Copenhagen K**
**www.norden.org**

**Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment Volume 2. The geographical case studies**

This report contributes to a Nordic IPBES-like assessment of biodiversity and ecosystem services in Nordic coastal areas. It is based on ten geographical cases in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) and Faroe Islands, Greenland, and Åland. The purpose is to reflect upon local biodiversity and ecosystem services, e.g. status and trends, drivers of change and policies for governance, and what future we are to expect. The cases describe the situation in the Näätämö area, Kalix archipelago, Quark, Lake Puruvesi, Bay of Lumparn, Öresund, Helgeland archipelago, Faroe Islands, the northern coastline of Iceland, and Disko Bay. It stretches from fresh water areas to ecosystems in the Atlantic Ocean and from urbanised areas with heavy pressures on the environment, e.g. Öresund, to sparsely populated areas, like Greenland with a population of around 0.03 habitants/$km^2$.

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