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Nordic Seals:

Seal populations in the North-Atlantic, Arctic Ocean and adjacent waters

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Title	**Nordic Seals:** ***Seal populations in the North-Atlantic, Acrtic Ocean and adjacent waters***		
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Summary:	This report is a part of the Nordic networking project Nordic Seals, which is supported by the Nordic Council of Ministers Working Group for Fisheries (AG Fisk). The project's objectives are to gather, analyse and disseminate information on the populations of seals in the North-Atlantic, Arctic, and adjacent waters, and their environmental, social, and economic impacts. As several seal populations have grown in the North Atlantic, Arctic, and adjacent waters, they have become a controversial topic with fishermen and other stakeholders within seafood value chains who claim that they negatively affect commercial fish stocks, catch, product quality and economic viability of the fisheries. Many scientists and conservationists have on the other hand pointed out the lack of understanding of the functioning of seals in the ecosystem. Although seals are known to feed on commercial fish species, research on their effect on fish size and age distribution of prey populations, as well as stock size, is incomplete. More knowledge on the role and effects of seals in the ecosystem is needed. As some seal populations still suffer from hunting that took place in the past, decisions on seal management must be well founded. Bycatch of seals is today the main threat to seal populations in many areas, which must be taken seriously. Depredations and damage to fishing gear and fish farms caused by some species of seals is well documented. The exact ecological and economic impact of these is however largely unknown. There are ongoing initiatives that aim to fill in these knowledge gaps, but results are largely lacking. The issue of nematode roundworms that are parasites causing quality defects in commercial fisheries, which seals play a major role in distributing as hosts, has been a major concern for fishermen. Controlling seal populations was in the past believed to be important to limit nematode distribution and therefore considered vital to safeguard the economic viability of the seafood industries in the North Atlantic. Seals have a long history as an important food source. Seal meat is nutritious and full of important amino acids, vitamins, and minerals. But they also contain food safety threats, such as nematode ringworm parasites, and bioaccumulated trace elements. The import bans on seal products imposed by the US and EU have made any kind of trade in seal products difficult. But as some seal populations grow in certain areas, the question on potential utilisation becomes more pressing. To answer that question there is a need for more research to better understand the role of seals in the ecosystem, and on how to produce sustainable, safe and stable food or feed ingredients from seals.		
keywords:	*Sealing, seal hunting, seal management, seal predation, seal depredation.*		

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List of Acronyms

ADD – Acoustic Deterrent Device

DHA – Docosahexanoic Acid

DPA – Docosapentaenoic Acid

EPA – Eicosapentaenoic Acid

ICES – The International Council for Exploration of the Sea

IUCN – The International Union for Conservation of Nature

MSE – Management Strategy Evaluation

MSY – Maximum Sustainable Yield

NAMMCO – North Atlantic Marine Mammal Commission

NE-Arctic – Northeast Arctic

NOAA – National Oceanic and Atmospheric Administration in the USA

SwAM – The Swedish Agency for Marine and Water Management

WGSAM – Working Groups on Multispecies Assessment Methods

WGMME – Working Groupon Marine Mammal Ecology

Introduction

This report is a part of the Nordic networking project Nordic Seals, which is supported by the Nordic Council of Ministers Working Group for Fisheries (AG Fisk). The project's objectives are to gather, analyse and disseminate information on the populations of seals in the North-Atlantic, Arctic and adjacent waters, and their environmental, social and economic impacts.

This report is meant to serve as an introduction for industry professionals and other interested stakeholders to the key issues relating to fishery-seal interactions. The report is not intended to solve these issues, but to spark conversation between opposing viewpoints and encourage co-operation. Co-operation between the scientific community, the commercial fisheries sector and the relevant authorities is crucial for successful policy making in matters relating to seal-fishery interactions. Furthermore, the Nordic Seals project aims to support and encourage Nordic partnerships and co-operation from scientific and commercial partners with interests in seal population dynamics in the North-Atlantic, Arctic, and adjacent waters.

Seals have been considered an important resource through utilization and for tourism entrepreneurs at best, and a destructive force on commercially important fish species at worst. Earlier culling efforts in the 19th and early 20th century saw some populations plummet close to extinction, and some areas are still experiencing historically low population levels [1, 2]. Moratoriums in other areas have led to dramatic rises in numbers for multiple seal populations [3, 4]. This has led to increased fishermen-seal encounters and has renewed questions whether, and how, fisheries are affected by the presence and predation of seals.

The interaction between the seal populations and the fishing industry is generally more frequently pertaining to small-scale or coastal fisheries, as line, jig, net and trapping boats spatially overlap with seal feeding grounds, whilst trawling and seine fisheries are generally further offshore where confrontations with seals are less common [5]. The nature of stationary fishing gear, trapping the fish in one place for longer periods of time provides greater opportunity for predation by seals. Frequent fishing locations also offer opportunities for conditional learning as individual seals remember common locations of fishing gear and have been shown to return regularly to such locations.

Seal populations in the North-Atlantic, Arctic & adjacent waters

Seal populations are widely distributed throughout the North-Atlantic and Arctic Ocean. Seven seal (pinniped) species are found in the area, five of which live primarily on the sea ice, and are therefore often called “ice seals”, and two that live near the coast and are referred to as “coastal seals”. The coastal seals are grey seals and harbour seals; and the ice seals are harp seals, ringed seals, hooded seals, bearded seals, and walruses.

Distribution and population

Grey Seals – *Halichoerus grypus*

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Grey seals are found widely on both sides of the North Atlantic Ocean. Two subspecies are recognized, *Halichoerus grypus grypus* and *Halichoerus grypus atlantica. H. grypus grypus* are local to the Baltic Sea while *H. grypus grypus* can be separated into two populations: the western North Atlantic stock (eastern Canada to NE-USA), and the eastern North Atlantic population (Iceland, Norway, Denmark, Great Britain, the Faroe Islands and Russia), as shown in figure 1 [6].

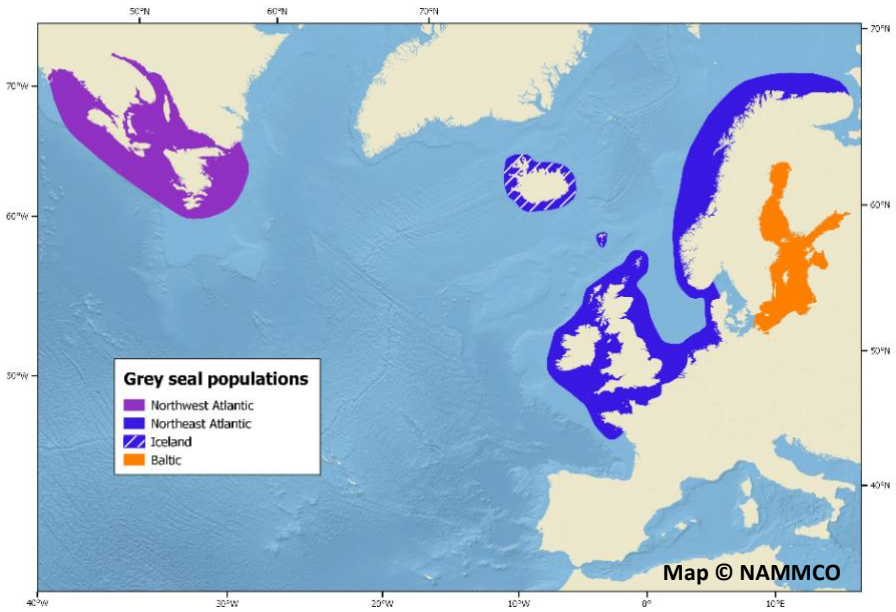

Figure 1 - Distribution of grey seals

The population of grey seals is estimated to be approximately 650.000 animals globally [7]. In 2016 the IUCN red list of threatened species estimated the stock to consist of 316.000 mature animals and increasing, with a total population of 632.000 individuals [8], giving them an assessment of “least concern”. Another stock assessment from the National Oceanic and Atmospheric Administration in the U.S.A (NOAA) estimates that there are approx. 450.000 grey seals in the US and Canada [9]. However, the status of grey seal populations varies between areas. As an example, the status of the Icelandic grey seal population is classified as “vulnerable” on the Icelandic national red list for threatened populations [10].

Grey seals are relatively large seals weighing 250-400kg and being 2-3m long, female being smaller than the male. They have an estimated life span of 25-30 years [11]. An adult grey seal eats about 5% of its total body weight per day. Grey seals are generalist predators, consuming a wide variety of species that are largely demersal or benthic feeders, such as sandeel, redfish, cod, haddock, catfish, saithe, and lumpsucker [12]. There is ongoing debate about the possible negative impacts of seal predation on certain groundfish populations. One factor contributing to this debate is the growth in grey seal populations in eastern Canadian waters over the past five decades and the concurrent decline, or in some cases collapse, of several groundfish populations, however these collapses were largely due to overfishing and recovery of the populations are most likely prevented due to high natural mortality, and reduced recruitment rates, while in some cases continued fishing in directed and bycatch fisheries is also an important factor [13]. Grey seals are prominent in the scientific literature available on seals, and the Baltic population has been especially well studied, partly due to the numerous research related to seal-fisheries interaction.

Grey seals were commercially hunted in most countries around the North Atlantic and the Arctic Ocean in the past, although not in Greenland where they have only exceptionally been observed. However, hunting of grey seals has decreased substantially in recent years, and the species has become protected in several countries. In 2019, Iceland introduced a general ban on seal hunting with an exception under special licences for subsistence use. Faroe Islands and Norway also banned the practice of killing grey seals interacting with fish farming installations in 2020. Norway, Canada, and UK all have implemented management plans of grey seals hunting in their area. In 2023, reported catches of grey seals numbered 133 in Norway and 1 in Iceland [14].

The size of the grey seal populations and their spatial overlap with commercial fishing grounds make it an ideal case study for the analysis of fisheries-seal interaction. Along with harbour seals, the grey seals, seem to be of most interest for the scope of this report, as literature and other evidence show frequent interactions between fishers and grey seals.

Harbour Seals – *Phoca vitulina*

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Harbour Seals are widely distributed in the Northern hemisphere. Three subspecies are currently recognised, the Atlantic harbour seal (*P.vitulina vitulina*) which is the only subspecies found in the NAMMCO area, the Pacific harbour seal (*P.vitulina richardii*) found in western North America, and the Ungava harbour seal (*P. vitulina mellonae*) which is landlocked and endemic to the freshwater lake system draining into Hudson Bay on the Ungava Peninsula in Northern Quebec [15]. In the North Atlantic there are estimates of approximately 200.000 harbour seals, with distribution as shown in figure 2 [16], and the world population is estimated at 600.000 animals [17]. The species is listed as being of "Least concern" on the global IUCN Red List, however population trends do vary between locations. As an example, the Icelandic and Greenlandic populations are listed as "critically endangered", and in Svalbard, it is "vulnerable", while in Norway it is listed as "least concern" [18].

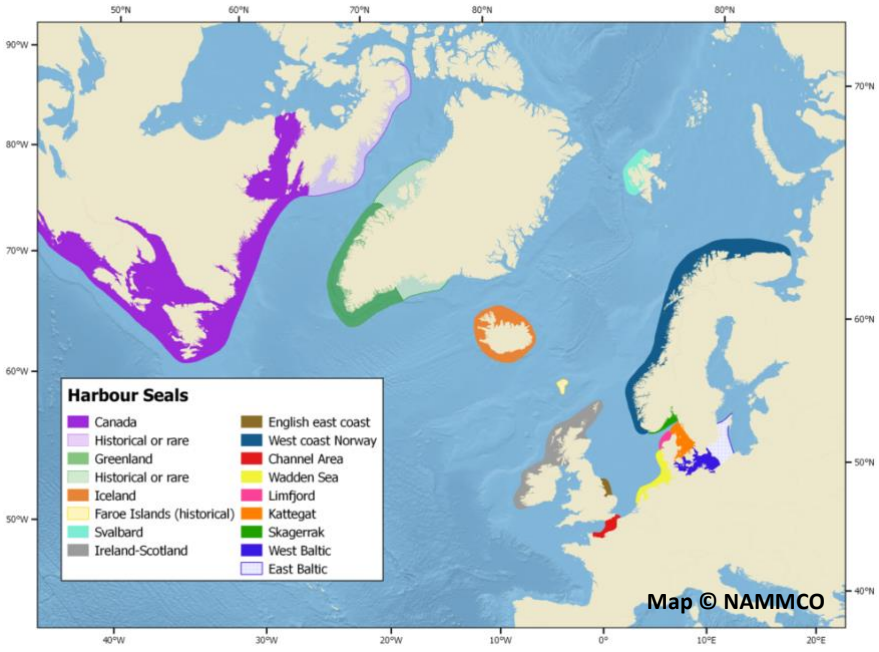

Figure 2 - Harbour seals distribution

Harbour seals reach lengths of 1,5-1,8 m and weights of 80-130kg, with males slightly larger than the females. Harbour seals have a lifespan of 25–30-year [19]. An adult harbour seal eats about 5% of its total body weight per day. They are generalist predators, with an overall preference for small to medium sized fish including cod- and flatfishes, herring, sculpins and sandeels [20].

There has been very little commercial hunting and culling of harbour seals in recent years. They occupy coastal habitats in close proximity to human populations and are therefore, much like grey seals, often interacting with human activities, including fisheries and aquaculture, coastal development, agricultural runoff and pollution, seal watching and other recreational activities.

Harp Seals – *Pagophilus groenlandicus*

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Harp seals are the most abundant pinniped in the North Atlantic and Arctic and consists of three populations, as sown in figure 3, with a combined abundance in excess of 9 million animals [21]. The Northwest Atlantic population is by far the largest, consisting of 7,4 million animals, from which an average of around 63.000 seals/year have been harvested. The harp seal has been commercially hunted for thousands of years. In recent years however there has been significant decline in harvests due to poor market conditions, the seal bans, as well as unfavourable ice conditions for hunting. Total catches at the turn of the century were just short of 300.000 animals per year but have decreased since then by 90% [22]. The second largest population is in the Barents Sea / White Sea estimated at 1,49 million, and the remaining population is in the Greenland Sea, estimated at 426.800 animals. In 2016, IUCN assessed their mature population as 4,5 million individuals and increasing, listing them as "Least concern ". This stock is thought to be relatively stable, showing little change between surveys, however climate change and evidence of high pup mortality poses a serious threat to this ice-associated species and populations should be reassessed every few years [23].

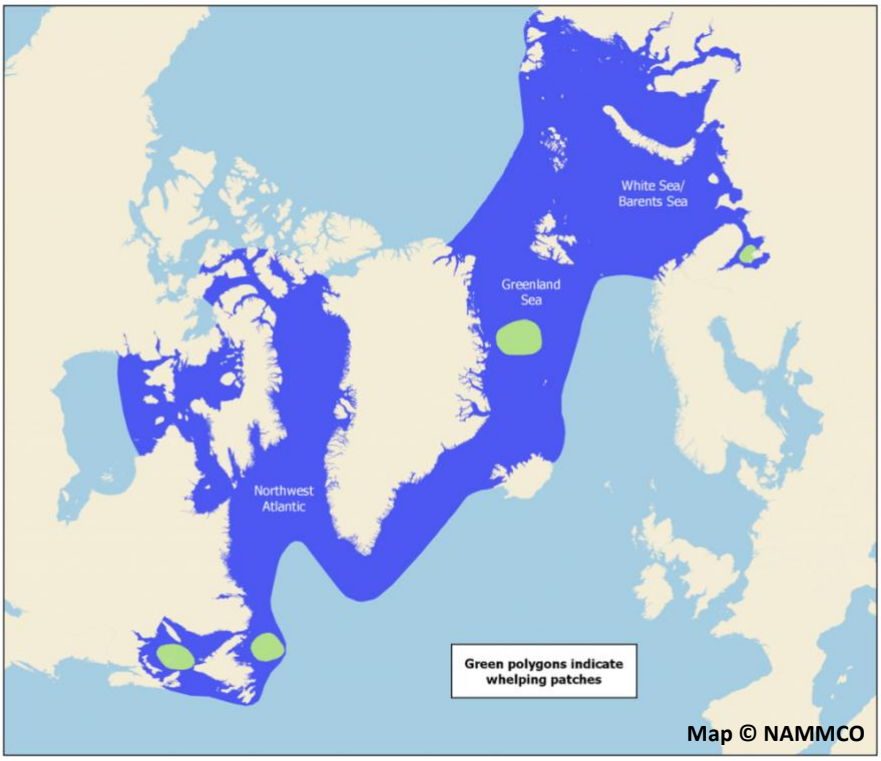

Figure 3 - Distribution of harp seals

Harp seals are medium-sized with males and females having similar size of up to 1,95 m long and weighing up to 180 kg, averaging at 1,6 m long and 130 kg [24]. The maximum lifespan of a harp seal is around 30 years. An adult harp seal eats 6-7% of its total body weight per day. They are opportunistic feeders and take many different species of fish, with capelin and polar cod being the most important species.

Ringed seal – *Phoca hispida*

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The ringed seal (*Phoca hispida*) is the smallest of all living seal species and the most common species in the Arctic. Ringed seals are divided into five subspecies based on geographical isolation, *P.h. hispida* in the Arctic Ocean (the Arctic ringed seal), *P. h. ochotensis* of the Sea of Okhotsk and northern Japan, *P.h. botnica* of the Baltic Sea and two living in freshwater lakes, *P.h. ladogensis* of Lake Ladoga in Russia and *P.h. saimensis* of Lake Saimaa in Finland [18]. The total number of ringed seals is estimated to be

around 5 million animals, with animals distributed throughout the Arctic, including the North Pole and the subarctic, and also range widely into adjacent seas [25]. Population estimates assume mature individuals to be around 1,5 million and they have an IUCN red list status of “Least Concern” although some subspecies are considered endangered [26]. Ringed seals have a north circumpolar distribution and are strongly ice-adapted, as shown in figure 4 [27].

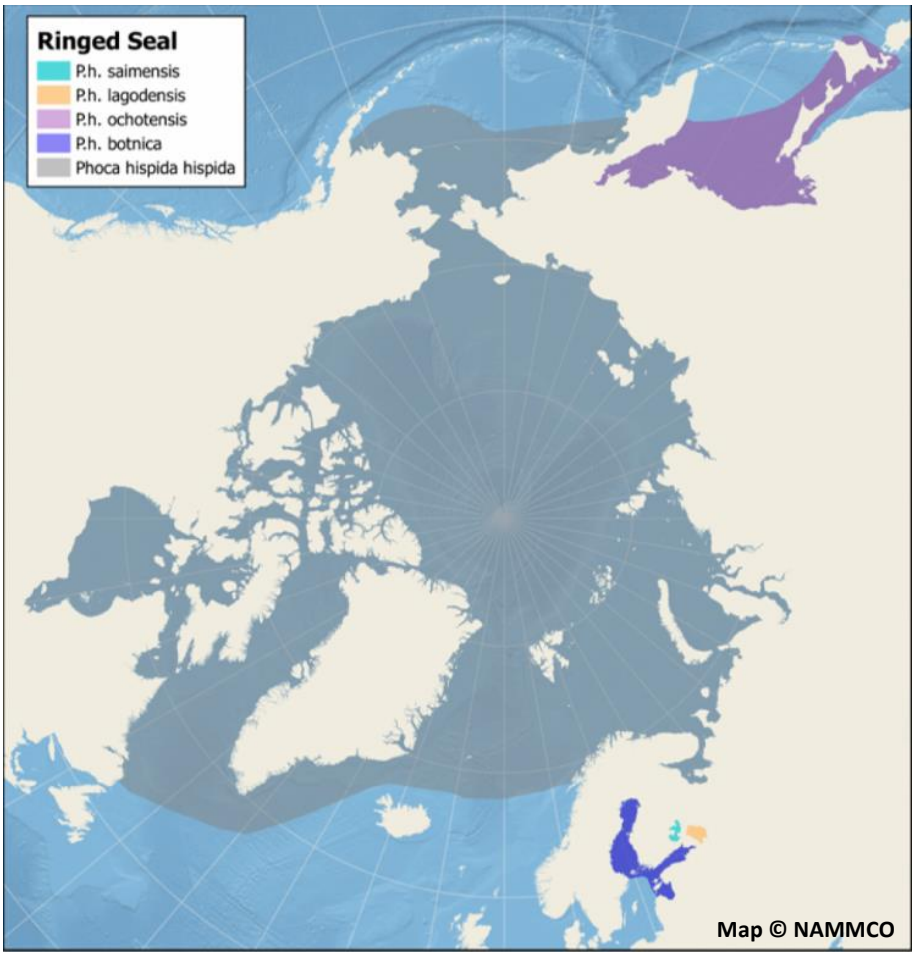

Figure 4 - Distribution of Ringed seals

Ringed seals can live to be over 40 years old, whilst their average life span is about 15–28 years [28]. Adults usually measure up to 1,4-1,5m and weigh up to 80-95kg, with males slightly larger than females. Ringed seals eat about 5% of their body weight per day, and their diet consists of a wide variety of fish and invertebrates, but strong preferences for polar cod, redfish, capelin, smelt and herring. Ringed seals have been, and continue to be, hunted by indigenous peoples for food and skin in Alaska, Canada, Greenland, and Russia. Time spent in and out of the water by ringed seals varies regionally, although some general patterns are apparent. Except during the spring molt, Arctic ringed seals spend most of their time under the ice or concealed in subnivean lairs on top of the ice [29].

Hooded seal – *Cystophora cristata*

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Hooded seals are found at high latitudes in the North Atlantic, and seasonally they extend their range north into the Arctic Ocean. Hooded seals were heavily hunted by Norwegians and Canadians in the past but are no longer subjected to commercial hunting [30]. The Hooded seal has an estimated population of about 600.000 animals in the Northwest Atlantic and 76.000 in the Greenland Sea. Estimates of mature individuals are approximately 340.000 and the IUCN considers them a vulnerable species. Figure 5 shows the distribution of the hooded seal populations, which are in the western and central parts of the northern North Atlantic Ocean.

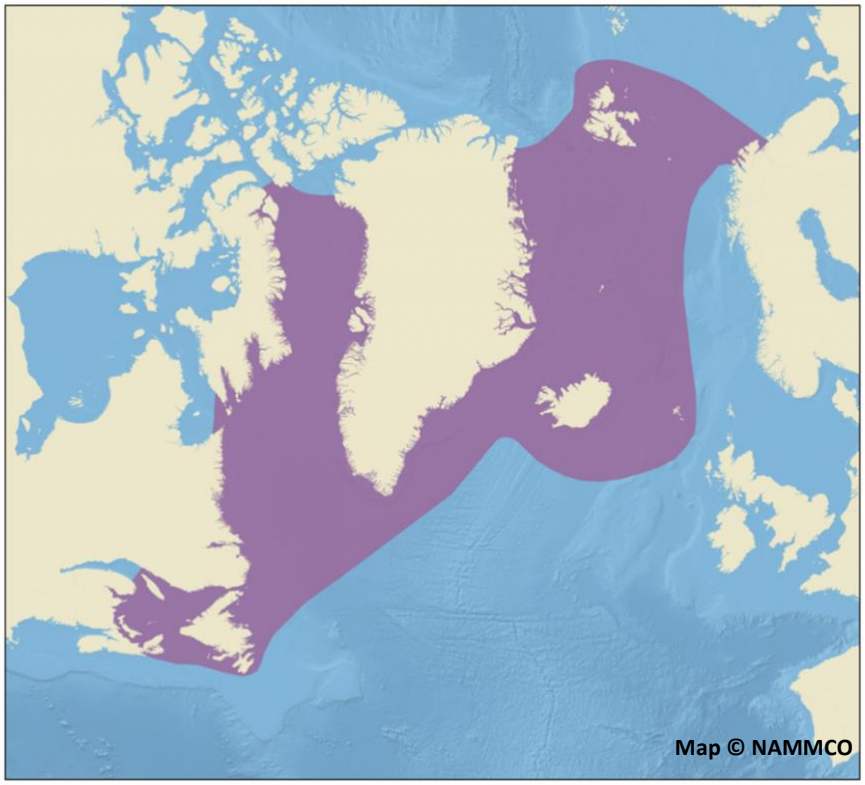

Figure 5 - Distribution of the hooded seal in the North Atlantic

Hooded seals are highly "sexually dimorphic", meaning that males are quite different in size and to some extent body form and colouration than females. Adult males average about 2,5 m in length and

weigh 300 kg at maturity, with large animals reaching over 400 kg. Adult females are smaller, averaging 2,2 m and 160 kg. Hooded seals have a lifespan of about 25-35 years [31]. Hooded seals eat bout 5% of their body weight per day, and their diet consists mainly of pelagic fish and squid, but also often includes large fish such as halibut, redfish, and cod [32].

Previously, hooded seals were hunted in both the Greenland Sea and Northwest Atlantic. Commercial catches were banned in 2007 although a low level of catches for scientific purposes continues.

Bearded seal – *Erignathus barbatus*

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The bearded seal gets its name from the long white whiskers on its muzzle. Bearded seals are found throughout the Arctic. Bearded seals are divided into two subspecies, *E.b. nauticus* and *E.b. barbatus* or the Atlantic subspecies. The data availability for bearded seal abundance is rather poor, there do not exist any large-scale surveys, only local abundances and the global abundance has been evaluated from different indices and varies but is considered large. Estimates suggest that there are approximately 500.000 to 1 million bearded seals The Greenland institute of Natural Resources estimates that there are approximately 250.000 of the *E.b. barbatus* subspecies [33]. Due to this large population size, its broad distribution, variable feeding habits, and no evidence of a current decline, the Bearded seal was classified as “least concern” by IUCN in 2016, but susceptible to be negatively impacted by climate change, in particular because of losses of sea ice. For this latter reason, the species has recently been reassessed in Norway from “least concern” to “near threatened” due to declining habitat quality [34]. Figure 6 shows the distribution of the bearded seal in the North Atlantic and Arctic Ocean.

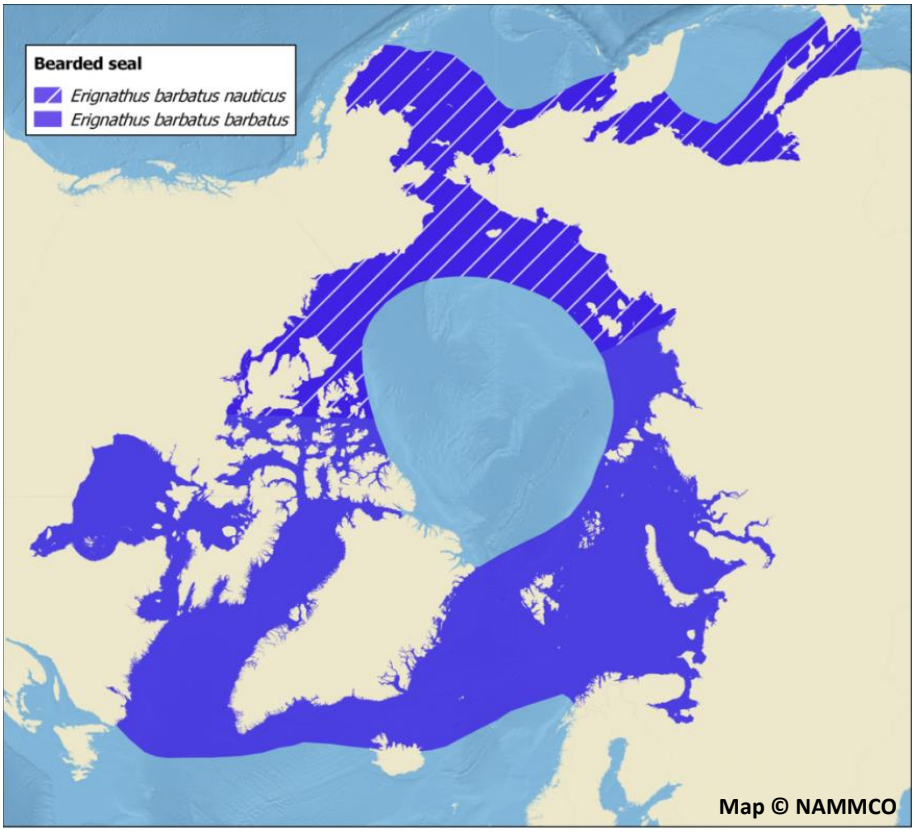

Figure 6 - Distribution of bearded seals

The Bearded seal is the largest seal species in the North and can reach 2.1–2.7 m in length and weigh between 200–430 kg. Males and females are difficult to distinguish, although in the spring the females tend to be slightly larger than the males. The largest bearded seal recorded was a female that weighed 432 kg [35]. Bearded seals can live for up to 30 years. An adult bearded seal eats about 5% of its body weight per day, and the diet consists mostly of benthic invertebrates (e.g., shrimps, crabs, clams, and whelks) and some fish (e.g., cod and sculpin) [36]. There is a subsistence hunt of bearded seals throughout their range, with some previous commercial hunt in Svalbard and Russia. There is also currently a small sport-hunt in Svalbard [37].

Atlantic walrus - *Odobenus rosmarus rosmarus*

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The walrus is the largest pinniped living in the North Atlantic and Arctic Ocean. Walruses belong to three subspecies (figure 7), all of which live primarily in the arctic and are rarely seen close to populated areas. The Atlantic walrus is then divided into ten separate populations, eight of which are located in Arctic Canada and west of Greenland, and two are in the NE-Arctic (Svalbard & Franz Josef Land, and Barents & Kara Seas) [38].

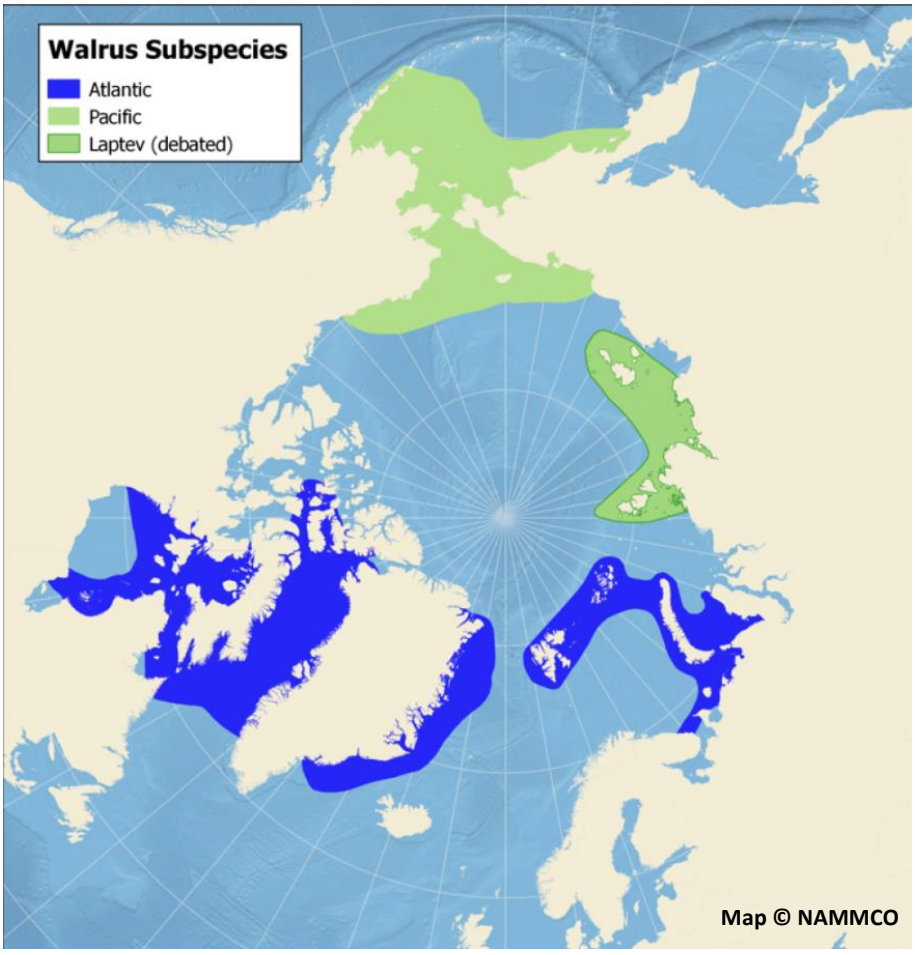

Figure 7: Distribution of the walrus subspecies

The total number of Atlantic walruses is estimated at 30.000 animals, most of which live in Arctic Canada and west of Greenland. It is listed as “near threatened” on the global IUCN Red List, and as “vulnerable” on the Norwegian and Greenlandic red lists. Walruses are long-lived animals with a low reproductive rate. A walrus can live to be 40 years old. Females reach sexual maturity between 4-10 years of age, males at 6-10 years, although males likely cannot compete successfully for females until they are around 15 years of age. Mature males weigh around 1200 to 1500 kg and reach lengths of close to 3 m. Females are smaller, weighing around 600–700 kg and reaching lengths of 2.5 m.

An adult walrus eats about 5% of its total body weight per day, and its diet consists primarily of bivalve molluscs (clams) and other invertebrates [39]. Research have shown that clams make up 95% of the weight of walrus food intake.

Walrus were commercially hunted in the past, and some populations were severely reduced, and even depleted e.g., in Iceland. It is solely indigenous communities in Canada and Greenland that hunt walrus today, for food, leather, and tusks. Reported catches in NAMMCO countries in 2023 was 305 animals [28].

Seals role in ecosystems

Seals are important in the marine ecosystem in many complex ways and help balance the food web. Seals are not only predators and consumers of fish and invertebrates, but also important prey for other species such as polar bears, sharks, and orcas. Even as top predators, seals play an important proximate role (dynamic and structural) within the ecosystem. It is important that management stakeholders realize that large removals and/or extinction of seal species in an area can have negative effects on the whole ecosystem, including the species that seals are preying on [40]. Seals contribute to the overall biodiversity of marine ecosystems and removing seals from the ecosystem can, among other things, affect the growth and reproduction of its prey species negatively. Seals and other marine mammals have also been shown to be important contributors to necessary nutrient circulation in the oceans [41].

Seals reflect changes in their environment and can act as an indicator for climate change, especially for the five seals species that live primarily on ice (harp seals, ringed seals, hooded seals, bearded seals, and walruses). The northern Atlantic is undergoing a period of tremendous change with alterations in temperature, ocean circulation, pH balance, ice cover and sea level. The potential impact of climate change on Arctic marine mammals, both directly through loss of ice habitat, and indirectly through changes in foraging ecology, has been under review for quite some time. Warmer oceans could result in higher concentrations of zooplankton, in favour for some marine mammals, but the loss of prey species that depend on ice could have negative impacts on other marine mammals that feed extensively upon them, such as harp and ringed seals [42].

Seals are sensitive to environmental change, and research has shown evidence of such effects on seal abundance and viability [43]. In a recent summary of effects due to climate change on harbour seals on a global scale the following categories are listed as primary climate-related drivers; (i) changes in weather patterns, which can affect thermoregulation; (ii) decrease in availability of haul-out substrates; (iii) large-scale changes in prey availability and inter-specific competition; (iv) shifts in the range of pathogens; (v) increase in temperature favouring the biotransformation of contaminants; and (vi) increased exposure to pollutants from increased freshwater run-off [44]. As Arctic Sea ice declines, new shipping routes are being established, increasing vessel traffic, noise- and chemical pollution, and other disturbances which will impact seal populations.

Conservation efforts

Conservation efforts are species- and area specific. Different types of conservation measures have for example been taken in areas where the population trends have been negative. One measure often used is protection of areas, which are protected either part of the year during sensitive biological periods (often including pupping and moulting periods). Further, reducing vessel and vehicle interactions, and hunting ban and/or only allowing "protection hunt", where the hunt is limited to individual seals that are doing harm, such as damaging fishing gear. As an example, the harbour seal is considered critically endangered, and the grey seal vulnerable in Iceland, whilst having a status of "Least concern" on the IUCN global list. A ban for all seal hunting was therefore introduced in Iceland in 2019 [45].

The seal hunting industry became heavily criticised in the 1980's as animal welfare issues started to be raised. Around the turn of the century seal hunting had become politically and socially unacceptable, which had effects on the markets for seal products, making it difficult for commercial seal hunters to continue. In 2009 the European Union issued a ban on trade in seal products [46], which marked the end-of-the line for most commercial hunters. As a result, large scale commercial seal hunting in the North Atlantic and Arctic has been almost non-existent for the last two decades.

Interaction between fisheries and seals

The interaction between fisheries and seals have become more noticed in recent years, at least in some areas. Growing populations of grey seals, harbour seals and ringed seals in the Baltic Sea, Skagerrak, Kattegat, and North Sea have for example created severe difficulties for fishers in the area, due to competition with the seals and damage to fishing gear [47, 48]. The impact of nematodes (seal worms) on fish quality has also been an issue for fishers [49], and for example with increasing populations of grey seals in the Baltic from the year 2000 an increase in *C.osculatum* infections has been shown in cod, however stating that the *C.osculatum* in cod originated from grey seals or from other sources such as zooplankton is difficult [50]. Coastal seals, such as grey seals, and harbour seals, are likely to have more interactions with fishermen, as they are the species that overlap the most in distribution and fishing grounds [51]. Seal bycatches, predation, depredation, damage to fishing gear and nematodes are the issues of most concern with regard to the interaction between fisheries and seals.

Seals bycatch from fisheries

Bycatch is the largest mortality risk for seals in Iceland [52]. In Norway abundance estimates of grey seal populations in 2018 have declined substantially from estimates in 2011. Bycatch may be a key factor contributing to the apparent population decreases in middle Norway (Trøndelag - Nordland region). Reports from the coastal reference fleet indicate a high level of grey seal bycatch with average annual bycatch estimates of 363 animals [53]. The accidental bycatch of seals in fishing gear has created bad publicity and problems with attaining sustainability certification. The Icelandic lumpfish fishery's MSC certification was for example withdrawn in 2017 due to high bycatch rates of harbour seals and grey seals and seabirds [54]. This was especially problematic since both of the seal species are on the national red list for threatened mammal populations (harbour seals are currently defined as endangered and grey seals as vulnerable). The fishery has now regained its MSC certification after having initiated an improvement plan to reduce bycatch. The International Marine Mammal Bycatch Criteria for U.S. Imports within the US Marine Mammal Protection Act is also likely to have serious impact on market access for seafood products imported to the US [55]. The criteria calls for a marine mammal bycatch ban, where trade partners will need to secure a "comparability finding" showing that their wild-caught commercial fishing operations align with U.S. conservation standards for marine mammals. Nations that do not have a comparability finding would be banned from exporting those seafood products to the U.S. The rule has technically been in effect since 1 January 2017, but NOAA Fisheries included an initial five-year exemption to give trade partners time to secure compatibility findings and come into compliance with the new requirements. The exemption has now been extended to January 1st 2026.

Predation – Direct competition between seals and fishermen

A debate on the intrinsic effect of seal predation on commercial fisheries has been ongoing for a long time. Although many seal species are opportunistic, feeding on commercial fish species when these species are easily available, it has been proven hard to estimate the actual effect of seal predation on commercially important fish stocks. Despite that lack of empirical evidence for how much the seal predation is affecting human harvesting of fish, they are often assumed to have such effects [56]

The energy requirements for seal species have been studied to an extent. As an endothermic mammal living in cold and harsh environments it can be expected that seals have high energy requirements, e.g., it has been estimated that an adult grey seal consumes roughly 5500 kcal per day [57]. It is therefore not hard to assume that a large stock of seals with such heavy energy requirements could adversely affect commercial fish stocks in their area [58]. However, it is necessary to consider the complex prey predator relationship and its many variables. Detailed knowledge of this relationship is necessary to reliably assess the impact of seals on commercial fish species.

Research has shown that seals in the Norwegian Skagerrak fed mostly on non-commercial species and cod predation only consisted of 5% of the total annual cod landings and was therefore not considered a threat to local fisheries [59]. It has also been shown that although seals feed among others on commercial species, the size of the fish they choose is often smaller than the size targeted by commercial fisheries [60]. In contrast, research in the Baltic area indicates that seals prey mainly on commercial species in some areas [61], for example one research study in 2018 indicated that grey seals in the Baltic prey mostly on cod, or 83% of their total consumption [62], while another study in the Baltic in 2019 identified herring as the primary prey [63].

As some seals are opportunistic predators it can be assumed that volumes of predation on commercial fish species is dependent on spatial co-habitation. A report published by the Canadian Science Advisory Secretariat in 2011 [64] determined unusually high mortalities in adult cod (5+ yrs.). Male grey seals in Eastern Canada were shown to prefer medium and large size cod as they inhabited deeper waters during the winter season. The authors also note a change in distribution patterns for adult cod from areas with elevated risk of seal predation. The report concluded that even when considering other cumulative factors, the increases in grey seal populations in the area is likely a major cause in the unusually high mortality rates in adult cod.

Overall, it is primarily grey seal, harbour seal and ringed seal that are competing with fishermen for the same or similar fish species, while other seal species feed mostly on species that are of little or no commercial value lower in the food web. As previously mentioned in the discussions on each seal population in the Arctic, North Atlantic and adjacent waters, the estimated total number of seals in the area is around 14.5 million animals, and if that number is multiplied with the average size of adult animals for each species mentioned in a previous chapter, it is possible to estimate the total biomass at 2 million tonnes. Assuming then that each seal must consume 5% of its bodyweight per day to sustain itself, the total theoretical estimated biomass consumption will be 36.4 million tonnes per year, as shown in Table 1.

Table 1: Estimated population size and biomass consumption of seals in the Arctic, North Atlantic and adjacent waters

Species	Population (no of animals)	Biomass (ton)	Consumption (ton/year)	Feeding
Grey Seals	650.000	195.000	3.558.750	Demersal and benthic fish
Harbour Seals	200.000	20.000	365.000	Demersal and pelagic fish
Harp Seals	7.400.000	962.000	17.556.500	Krill, amphipods, invertebrates, demersal and pelagic fish
Ringed Seals	5.000.000	450.000	8.212.500	Demersal- and pelagic fish, crustaceans, cephalopods
Hooded Seal	600.000	120.000	2.190.000	Pelagic fish and squid
Bearded Seal	700.000	210.000	3.832.500	Demersal fish and invertebrates
Walrus	30.000	36.000	657.000	Bivalve molluscs, clams, and benthic invertebrates
Total	**14.580.000**	**1.993.000**	**36.372.250**	

This estimate represents an initial, though basic, method for evaluating the impact of seal populations on biomass removal in the North Atlantic and Arctic ecosystems. It requires further development to enhance its accuracy and comprehensiveness. However, it offers valuable preliminary insights into the ecological role of seals in these regions. The type of prey does then need to be considered with respect to competition with fishermen. For comparison, fisheries captures in the North Atlantic (FAO areas 21 and 27) amount to less than 10 million tonnes a year, and global marine fish captures are around 80 million tonnes a year [65].

To reduce suspected effect of seal predation on human harvesting, seals have in some areas been culled, despite scientific evidence for the effects. As an example, seals have for decades been hunted around important river mouths in Iceland, to reduce the effect that people believed seal predation was having on the success of harvesting river angling of salmonids. Over 80% of the seal catches in Iceland in the last five years, before a hunting ban was introduced in 2019, was due to culling around river mouths. A study published in 2018 [66] however, showed no evidence that seals hauling out in the vicinity of an important river mouth did prey on salmon, trout or charr. Although it was not possible to rule out the possibility that individual seals occasionally prey on salmonids, the results indicated that the reason for seals hauling out in the river mouth was more likely due to other reasons. Seals have also frequently been accused of injuring salmonids (claw and tooth marks), which several studies have shown is less common than expected [67]. This type of finding underlines the importance of evidence-based seal management and the need for increasing research to understand and mitigate, if/when necessary, conflicts between seals and humans.

Depredation from fishing gear

Seals are well known to feed on fish from fixed fishing gears. This causes both loss of catches and damage to gear, which negatively affect the economic viability of the fisheries [68]. It has been demonstrated that seals can alter their feeding behaviour to feed from specific fishing gear [69]. They have also been shown to target specific prey from fishing gear. This behaviour is called depredation, which has been defined as “an act of predation where the prey is already held captive, either by being

caught in wild capture fisheries equipment or as part of an aquaculture system" [70]. An example of this behaviour has been shown in the Kattegat - Skagerrak region in Sweden, where harbour seals have been shown to select eels over other catch, such as cod and flounder, in fyke nets [71]. Another study showed that grey seals can specialize in salmon pontoon traps, as 426 out of 600 seal visits to the two traps used in the study were found to be the responsibility of only 11 individuals [72]. Grey seals have also been shown to have a negative impact on herring gill net catches, as a study in the Baltic showed up to 60% incident rates of seal depredation [73]. That result is however most likely an underestimation, as the study also showed that grey seals can empty a gill net of herring without leaving any trace on the fishing gear. Similarly, a study on cod gill net fishery has shown that the majority of seal predation is not noticeable by the fishermen, as the seals in the study did not leave half eaten or damaged fish in the nets, or cause damage to the gear [74]. A Danish study also documented visible losses in a cod fishery ranging from 6,4% to 24,4% [75].

Figure 8 - Grey seal caught in a fishing net.

There are unfortunately only a few explicit economic analyses available on the monetary cost of seal depredation, most of which focus on the Baltic, Skagerrak, Kattegat and North Sea. Further, the available research on seal depredation from fishing gear and subsequent cost for fishermen and society is limited and possibly biased, as it mostly focuses on areas and species that are most effected by such impacts. Extrapolating the results of such research to other areas or species, would therefore be highly questionable. One of these analyses, done on the Baltic salmon fishery applying economic modelling, showed that long-term net present value of the fishery would approximately double in scenarios without seals [76]. A study published in 2015 showed that the impact of reducing culling of sea lions in the Hokkaido prefecture in Japan by 80% lead to an increase in the direct cost of fisheries damage by almost 200% [77]. Whether the results of a study on sea lions in Japan can be transferred to seals in the North Atlantic can be debated, but in the lack of similar research must be considered at least relevant.

Damage to fishing gear caused by seals can be significant. The Swedish Agency for Marine and Water Management (SwAM) has for example estimated total seal damages to fishing gear per year to be approximately 3.5 million EUR [78]. A study published in 2020 estimated the cost for gear maintenance due to damages caused be seals at 17% of the operational costs (total purchase of goods) of the

Swedish small-scale fleet, and 13% of the total working time of the crew. Another study among 100 eel fishermen in the Kattegat - Skagerrak region in Sweden has also estimated such damage at around 200 thousand EUR a year [79]. The fisherman's cost for modifying and repairing the fishing gear is not included in these estimations. The sum probably represents a considerable underestimate because including seal damage reports in their logbooks is voluntary.

Nematodes – seal worms

Nematodes are parasitic roundworms that are found manly in the stomachs of cetaceans (e.g., whales, dolphins, and porpoises) or pinnipeds (e.g., seals, sea lions, and walruses). The eggs produced by adult Nematode worms are then excreted with the hosts' faeces and hatch in the water and enter into other hosts, such as commercially important fish species. The worms often have severe impact on the quality and profitability in seafood production, by increasing the production cost, reducing product yield, and causing food safety issues. Research have shown that nematodes are more common close to shore and in the vicinity of areas populated with seals, than offshore [80]. The waters around Iceland have for example been mapped for decision support to avoid nematodes "hot-spots", and the hot-spots are generally linked with high concentrations of seals and other marine mammals [81]. The same research estimated that 5% of the labour cost in cod processing was due to removal of nematodes.

The prevalence and intensity of nematodes in the flesh of commercially important fish species can be extremely high in highly concentrated areas. Research published in 2022 on nematodes in cod in the Norwegian sea showed for example that up to 88% of the fish were infected and that the average intensity was up to 30 worms per fish [82]. Similar study published in 2020 conducted in the waters around Greenland showed a 96% prevalence and mean intensity of 10.3 worms per fish [83].

Seal management / control

The significant reduction in commercial sealing over the past few decades has led to a steady increase in seal numbers in most populations in the Northern hemisphere. This is however not the development for all seal populations, as some have at the same time decreased [84]. There are even some populations that are severely threatened, despite not being hunted. Hence other factors than seal hunting must also be considered when attempting to manage seal populations. Understanding of the ecosystem, the ecosystem services of seals, and predator-prey interactions, as well as how factors like climate and anthropogenic impacts are affecting seal populations is key for effective seal management.

The theory that removing a top predator will increase the numbers of available prey is popular and, on the surface, seems logical. However, it fails to account for the complex prey-predator interactions and other factors such as habitat and food sources as limiting factors that would render any culling efforts pointless [85]. The available literature on culling procedures of pinnipeds suggests that culling programs rarely have measurable objectives with respect to prey populations and their success is rarely evaluated. Some studies have supported the effectiveness of culling “trouble seals”, which are individual seals that have specialized on depredation from nets or fish farms, rather than reducing the total number of seals in the area. This type of hunt is often referred to as a “protective hunt” and requires investigation before the hunting event to ensure that the right individuals are removed [86]. The advantage of this method is that it minimizes the need for culling to only a few individuals, while resulting in an effective protection of fishing equipment from depredation. Spatial segregation can also be an effective approach, where vulnerable areas for seal-fishery interactions are either protected from fishing activities or seal disturbance. This can be a tool both for fishermen to protect their catch as well as a tool for conservation [87]. Examples are for legal actions to be taken to secure spatial segregation by imposing moratoriums in specific areas where the risk of by catch and other seal-fishery interactions is high, such as the ones imposed on the Icelandic lumpsucker fishery [88].

There are however areas that seem to be overpopulated with seals, creating imbalances in the ecosystem, and causing problems for fishermen. For example, in Canada the fishing industry demands immediate action to reduce seal numbers, however the Department of Fisheries and Oceans prefers a cautious approach due to lack of scientific data supporting such actions [89]. How to exactly assess this is a challenge, which the ICES Working Groups on Multispecies Assessment Methods (WGSAM) and the Working Group on Marine Mammal Ecology (WGMME) have for example been trying to address by developing methods to quantify the impact of seals and other marine mammals in the ecosystem, thereby enabling for advice on seal management. Similarly, the MSE project has been attempting to incorporate seal and marine mammal impact into modelling of Maximum Sustainable Yield (MSY) and Management Strategy Evaluations (MSE) [90].

Commercial utilization of seal products

The Canadian arctic explorer Vilhjálmur Stefánsson was once quoted to say that "*to live a comfortable life, all you need is a seal. Not only meat for sustenance but also fur for clothing and blubber for kindling*"[91]. This was, in many areas, the case for centuries, as commercial sealing was a very profitable business, and people living along the coast around the North Atlantic and the Arctic Ocean depended on seals for subsistence, lighting, and clothing. Commercial utilisation of seal products has however been extremely limited over the past two or three decades. The EU seal regime put in place in 2009 and amended in 2015 with a general ban on placing of seal products on the EU market has played a major role in removing economic incentives for sealing [92]. The question therefore arises if humanity is not wasting an opportunity by not utilizing a top-predator that potentially could be sustainably harvested, especially when food resources are becoming scarce and food security is threatened.

Seals as a food or feed source

Seal meat has a rich flavour and is very rich in protein, calcium, magnesium, vitamin C, B, and iron, making it a good source of nutrition for both people and animals, as shown in table 2 [93].

The proportion of meat derived from each animal is typically between 22-30% and protein content of the meat is 21-30%. The meat contains only 3% fat and is therefore very lean. Seal meat is therefore very nutritious and has in addition a favourable amino acid profile [94]. Figure 9 shows the different parts of an "average" seal living in the North Atlantic and Arctic, and the protein and fat composition (adapted from Ghaly A. 2012) [95].

Table 2: Nutritional value per 100g seal meat

Fat	**3.2g**	
Saturated	0.820g	
Monounsaturated	1.720g	
Polyunsaturated	0.060g	
Protein	**28.4 g**	
Vitamins	**Quantity**	**%DV***
Vitamin A equiv.	116 µg	13%
Thiamine (B1)	1 mg	83%
Riboflavin (B2)	0.530 mg	41%
Pantothenic acid (B5)	0.650 mg	13%
Minerals		
Calcium	5 mg	0%
Iron	19.60 mg	109%
Phosphorus	238 mg	19%
Sodium	110 mg	5%

Source: Wikipedia

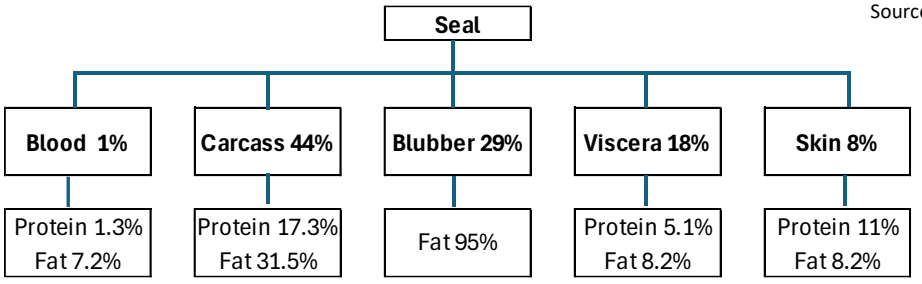

Figure 9: Protein and fat composition in the different parts of seals in the North Atlantic and Arctic

During WWI seal meat was considered as an alternative for meat from farmed animals as prices and availability of the latter rose to great heights during the war [96]. The Inuit diet, often referred to as “country food” or “Inuit food” historically consisted mostly of seal and other wild pinnipeds, whale species, fish, and birds. This diet was an integral part of the Inuit identity and a key component in maintaining a population in the harsh arctic environment. However, the proportion of country food in the Inuit diet is decreasing and makes up only a small part of the Inuit diet today [97]. There are several explanations for this decline in consumption, one of which is the increased knowledge on food safety risks of consuming the meat, particularly because of persistent toxic compounds like PCB‘s, PFAS and heavy metals that accumulate in long-lived top predators such as seals, and nematodes roundworms [98]. Since 2009 the EU has prohibited the import and marketing of seal products, with the exception of seal products derived from hunts conducted by Inuit or indigenous communities, and hunts conducted for marine resource management. Today seal meat is mostly associated with Inuit's and to a lesser extent rural communities in the Nordics as a supplemental catch with traditional fisheries. Seal products are however more readily available in Canada, where regulations that hinder marketing of seal products is less stringent than in Europe. For example, Health Canada has certified 614 natural health products that contain seal oil [99]. Seal products are even marketed in Canada with the slogan “Good for you – Good for the environment [100]. Figure 10 shows some of the products marketed by the Canadian producer SeaDNA [101].

Figure 10: Seal meat products, such as prime cuts, sausages, salami and jerky marketed by the Canadian producer SeaDNA

The use of seal products for animal feed has mostly been restricted to dog food for the indigenous communities in the Arctic. The animal feed legislations in the US and EU are very strict, which would (regardless of the ban on imports of seal products) make it difficult to use seal products in animal feed due to undesirable chemicals and other health risks. The reason for strict animal feed regulations is the fact that the animals eat the same feed more or less every day, and do not have the same sort of variability in diet as humans do. The regulations for pet treats or snacks are however much more flexible, as those are generally only given to pets on occasion and in low volumes. Figure 11 shows a seal meat snack for dogs, that the Canadian based company SeaDNA produces.

Picture: SeaDNA

Figure 11: Seal meat snacks for dogs

Although regulations hinder the use of seal raw materials in production of animal feed there is a general lack of knowledge regarding the effects of many hazardous toxins that can be transferred to humans through diet, the health risks posed to humans consuming marine mammals, or animals fed with marine mammal ingredients, therefore this should be investigated further [102]. Research on using seal raw materials as input to a biorefinery is also lacking, but such processes that include biotech processes could likely find ways to produce valuable products that are safe and healthy to consume [103, 104].

Seal oil, rendered from the blubber, was originally the most desired product obtained from hunting seals. At the time, it was used globally in the preparation (tanning) of leather, for domestic and public lighting, to make soap, in textile manufacturing and as a food source. Other oil-based and synthetic chemicals have now replaced seal oil. It is however still very popular for nutritional and medicinal purposes, due to its unique fatty acid composition. Seal oil contains three long-chain pure unsaturated essential fatty acids (EPA, DHA, DPA) in a natural balance similar to the human body. This is a combination that no other vegetable or fish oil can offer [105]. Figure 12 shows an example of seal oil capsules available for human consumption and seal oil supplements for dogs and cats.

Picture: SeaDNA

Figure 12: seal oil capsules available for human consumption and seal oil supplement for dogs and cats

The uniqueness of seal oil in comparison with fish oils is that it contains relatively high levels of DPA fatty acids, which fish oils do not. DPA offers some specific benefits, including optimizing the human body's omega-3 intake, absorption and use of DHA and EPA [106].

Other seal products

Seal products have as well been used for other purposes, most well-known are the use of seal pelts (sealskin/fur) in clothing and textiles. The sealskin industry largely disappeared in 2009 when the EU implemented a ban on trade in seal products [107]. The sealskin exports from Greenland were for example in excess of 100 thousand skins per year before the ban but was reduced to next-to-nothing when the ban was introduced. Figure 13 shows a skin of a hooded seal being dried and stretched in West Greenland, and an Icelandic congress man wearing a seal fur coat.

Picture: Peter Prokosch, https://www.grida.no/resources/4182 Picture: www.dv.is

Figure 13: Hooded seal skip prepared and an Icelandic congress man wearing a seal fur coat

The demand for sealskin clothing and textiles is currently limited, as public opinion and import bans have heavily affected this once mighty industry.

Seals as tourist attraction

In recent years, the interest in seal watching tourism has grown and seals have started to become valuable as tourist attractions [108]. Wildlife tourism can be economically valuable, not the least in rural communities where local authorities and entrepreneurs have widely grabbed the opportunity to establish profitable businesses. It is likely that this sector will grow in the coming years in many areas around the North Atlantic and Arctic Ocean, potentially creating a new industry.

Figure 14: Seal watching is a new tourist industry around the North Atlantic

However, the downside of wildlife tourism has frequently been reported in the scientific literature [109]. Disturbance due to tourism can have negative impact on wild seals on an individual and a population level. Potential impacts due to tourism include both physiological effects on the animals, such as increases in heart rate and stress hormones, but can also cause behavioural responses. Specifically, disturbance during sensitive biological periods, including the pupping and moulting seasons, is critical. Further, seals might in some cases be forced to leave heavily trafficked areas due to disturbance and move to areas that are less optimal.

EU consultation regarding the ban on trade in seal products

The EU regulation banning the trade of seal products [110] has been in place since 2009 and the seal pups directive [111] is from 1983, but they have never been evaluated. While there is no legal requirement for an evaluation, the commission has concluded that it is time to assess whether they remain fit for purpose, and whether there is any room for simplification. As the two pieces of legislation are closely related, the Commission is carrying out a fitness check covering them both [112]. This is also an opportunity to assess their socio-economic impact and their impact on seal populations. The initiative follows up on a Commission report [113] published in 2023 on the implementation of the seals regulation in 2019-22, which concluded that it seems to work well in preventing the sale of seal products. However, the report highlights that some EU countries around the Baltic Sea reported increasing seal populations causing damage to fish stocks and fishing gear. These countries consider that the regulation has a negative socio-economic impact on their territory, in particular since the

exception was removed that allowed the sale of seal products resulting from culls conducted for the sole purpose of sustainably managing marine resources. The report also noted that the recognised bodies in Canada consider that the regulation is perceived in the EU as a total ban on trade in seal products, that the Inuit and other indigenous communities' exception is not sufficiently well known in the EU, and that this has an impact on the economic development of their Inuit/Inuvialuit communities. The consultation and the associated fitness check will cover the period since both acts entered into application and will also address Commission implementing Regulation [114], which lays down rules for recognising government bodies mandated to certify seal products that comply with the "Inuit and other indigenous communities" exception, and to issue documents attesting this fact. Based on the fitness check findings, the Commission will consider whether further measures are needed.

The fact that the commission is initiating this consultation and fitness check may suggest that there might be a need to revise the ban on trade of seal products. The consultation will be ongoing 15 May – 7 August 2024, and the outcome will be published on the portal eight weeks after its closure.

Summary and discussion

This report has shown that as several seal populations have grown in the Arctic, North Atlantic and adjacent waters, they have become a controversial topic with fishermen and other stakeholders within seafood value chains who claim that they negatively affect commercial fish stocks, catch, product quality and economic viability of the fisheries. Many marine mammal scientists and conservationists have on the other hand pointed out the lack of understanding of the functioning of seals in the ecosystem. Although seals are known to feed on commercial fish species, research on their effect on fish size and age distribution of prey populations, as well as stock size, is complicated and incomplete. More knowledge on the role and effects of seals in the ecosystem, and on the specific predator-prey relationship in each area is necessary to draw concrete conclusions to base mitigation measures on.

Depredations and damage to fishing gear and fish farms caused by seals is well documented, as well as bycatch in fishing gear that severely affects seal populations in some areas. Much effort has been put towards "seal-proofing" fishing gear and some results are promising. Specific targeting of "problem animals" has also been shown to be an efficient, cost effective, humane way to replace mass hunting/culling, in order to protect specific fishing equipment or important fishing grounds. Spatial segregation is another method that has been shown to be very effective. Spatial segregation has the benefit of requiring no culling or modification to equipment. On the downside, spatial segregation can restrict access to attractive fishing grounds. Spatial segregation can be used both as a tool for fishermen to protect their catch as well as a tool for conservation. Examples are for legal actions to be taken to secure spatial segregation by imposing moratoriums in specific areas where the risk of bycatch is high, such as the ones imposed on the Icelandic lumpsucker fishery. Technical solutions have also been introduced, such as acoustic deterrent devices (ADD's) with variable effectiveness.

Seals have a long history as an important food source for Inuit's of Canada and Greenland, as well as a supplemental food source for Nordic rural communities. Seal meat is nutritious and full of important amino acids, vitamins, and minerals. But they also contain food safety threats, such as nematode ringworm parasites, and bioaccumulation of trace elements like PCBs, PFAS, heavy metals and other toxins. The import bans on seal products imposed by the US and EU have made any kind of trade in seal products difficult, or even impossible. The EU commission is however starting a public consultation and a review of the ban, as it has been criticised by some member states in recent years. As seal populations grow, the question on potential utilization becomes more pressing. But to answer that question there is a need for more research to better understand the role of seals in the ecosystem, and their socio-economic impacts, as well as on how to produce sustainable, safe and stable food or feed ingredients from seals.

The issues discussed in this report, although not nearly exhaustive, should give a glimpse into the multifaceted nature of finding a consensus in seal-fishery interactions. While individual studies can be used to vilify seals in the eyes of fishers, or the fishers in the eyes of conservationists, they often do not tell the whole story and a broader context is therefore needed. Knowledge of environmental and ecological interactions for the seals must be known and understood to ensure a successful, humane,

and sustainable course of action for both seals, and fishermen. The fact however remains that although some of the aforementioned seal populations have a sensitive conservation status in some areas, their populations are increasing at a rapid rate in other areas. The possibility of sustainable utilization where a seal hunting ban has previously been in effect might arise in such areas and should be investigated and reviewed regularly.

The authors of this report agree that more research is needed on every aspect of the role and impact of seals in the ecosystem, and potential utilisation. The conclusion of the report is therefore that more research is needed and that cooperation of the scientific community, fishing industry, local communities and national/international authorities is essential to reach a meaningful outcome.

References

[1] Granquist, S.M. and Hauksson, E. (2019). Population estimate, trends, and current status of the Icelandic harbour seal (*Phoca vitulina*) population in 2018. Marine and Freshwater Research Institution, HV 2019-36. Reykjavík 2019. 22pp. https://www.hafogvatn.is/static/research/files/1575899073-hv2019-36.pdf

[2] Granquist, S.M. and Hauksson, E. (2019). Aerial census of the Icelandic grey seal (*Halichoerus grypus*) population in 2017: Pup production, population estimate, trends and current status. Marine and Freshwater Research Institution, HV 2019-02. Reykjavík 2019. 19 pp. https://www.hafogvatn.is/static/research/files/1549015805-hv2019-02.pdf

[3] HELCOM (2018). Population trends and abundance of seals. https://helcom.fi/wp-content/uploads/2019/08/Population-trends-and-abundance-of-seals-HELCOM-core-indicator-2018.pdf

[4] OSPAR (2023). Seal Abundance and Distribution. https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/seal-abundance-and-distribution/#:~:text=Grey%20seal%20abundance%20is%20largely,but%20trends%20are%20generally%20increasing.

[5] Cronin M.A., Gerritsen H., Reid D.G. & Jessopp M. (2016) Spatial Overlap of Grey Seals and Fisheries in Irish Waters, Some New Insights Using Telemetry Technology and VMS. PLOS ONE 11(9). https://doi.org/10.1371/journal.pone.0160564

[6] NAMMCO (2024). Grey Seal. https://nammco.no/grey-seal/ .

[7] NAMMCO (2024). Grey Seal. https://nammco.no/grey-seal/

[8] IUCN. (n.d.). *IUCN Red List*. Grey Seal. https://www.iucnredlist.org/species/9660/45226042

[9] *NOAA Fisheries*. (n.d.). Gray Seal. https://www.fisheries.noaa.gov/species/gray-seal/overview.

[10] Granquist, S.M. and Hauksson, E. (2019). Aerial census of the Icelandic grey seal (*Halichoerus grypus*) population in 2017: Pup production, population estimate, trends and current status. Marine and Freshwater Research Institution, HV 2019-02. Reykjavík 2019. 19 pp. https://www.hafogvatn.is/static/research/files/1549015805-hv2019-02.pdf

[11] NAMMCO (2024). Grey Seal. https://nammco.no/wp-content/uploads/2017/04/07-bycatch-of-grey-and-harbour-seals-in-norway.pdf.

[12] Nilssen, K.T., Lindstrøm, U., Westgaard, J.I., Lindblom, L., Blencke, T.-R. & Haug, T. (2019). Diet and prey consumption of grey seals (*Halichoerus grypus*) in Norway. Marine Biology Research 15: 137-149. https://www.tandfonline.com/doi/full/10.1080/17451000.2019.1605182

[13] Hammill, M.O., Stenson, G.B., Swain, D.P. and Benoit, H.P. (2014). Feeding by grey seals on endangered stocks of Atlantic cod and white hake. ICES Journal of Marine Science, 71(6), 1332–1341. https://doi.org/10.1093/icesjms/fsu123

[14] NAMMCO (2024). Grey Seal. https://nammco.no/grey-seal/

[15] NAMMCO (2024). Harbour seal. https://nammco.no/harbour-seal/

[16] NAMMCO (2024). Harbour seal. https://nammco.no/harbour-seal/

[17] Lowry, L. (2016). *Phoca vitulina*. *The IUCN Red List of Threatened Species* 2016: e.T17013A45229114. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T17013A45229114.en

[18] NAMMCO (2024). Harbour seal, status of stocks within the remit of NAMMCO management. https://nammco.no/harbour-seal/#1475844513273-d6d59198-d3a0

[19] NOAA (2024). Harbor seal. https://www.fisheries.noaa.gov/species/harbor-seal

[20] NAMMCO (2024). Harbour seal. https://nammco.no/harbour-seal/

[21] NAMMCO (2024). Harp seal. https://nammco.no/harp-seal/

[22] International Council for the Exploration of the Sea (ICES). (2019). ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP). ICES Scientific Reports, 1, 72. 193 pp. http://doi.org/10.17895/ices.pub.5617

[23] IUCN. (n.d.). *IUCN Red List*. Harp Seal. https://www.iucnredlist.org/species/9660/45226042

[24] NAMMCO (2024). Harp seal. https://nammco.no/harp-seal/

[25] NAMMCO (2024). Ringed seal. https://nammco.no/ringed-seal/

[26] NOAA (2024). Ringed Seal. https://www.fisheries.noaa.gov/species/ringed-seal

[27] NOAA (2024). Ringed Seal. https://www.fisheries.noaa.gov/species/ringed-seal

[28] NOAA (2024). Ringed Seal. https://www.fisheries.noaa.gov/species/ringed-seal

[29] Kelly, B.P., Bengtson, J.L., Boveng, P.L., Cameron, M.F., Dahle, S.P., Jansen, J.K., Logerwell, E.A., Overland, J.E., Sabine, C.l., Waring, G.T. and Wilder, J. M. (2010). Status Review of the ringed seal (*Phoca hispida*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-212. 250pp. Available at http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-212.pdf

[30] NAMMCO (2024). Hooded seal. https://nammco.no/hooded-seal/

[31] NOAA (2024). Hooded seal. https://www.fisheries.noaa.gov/species/hooded-seal

[32] Greenland institute of natural resources (n.d.). Hooded seal. https://natur.gl/arter/hooded-seal/?lang=en

[33] NAMMCO (2024). Bearded seal. https://nammco.no/bearded-seal/

[34] Rødlista for arter (2021). https://artsdatabanken.no/lister/rodlisteforarter/2021/835

[35] Cameron, M. F., Bengtson, J.L., Boveng, P.L., Jansen, J.K., Kelly, B.P., Dahle, S.P. Logerwell, E.A. Overland, J.E., Sabine, C.L., Waring, G.T. and Wilder, J.M. (2010). Status review of the bearded seal (Erignathus barbatus). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-211, 246 p. Available at https://www.fisheries.noaa.gov/resource/document/status-review-bearded-seal-erignathus-barbatus

[36] NOAA (2024). Bearded seal. https://www.fisheries.noaa.gov/species/bearded-seal

[37] NOAA (2024). Bearded seal. https://www.fisheries.noaa.gov/species/bearded-seal

[38] NAMMCO (2024). Atlantic Walrus. https://nammco.no/atlantic-walrus/

[39] Outridge P.M., Davis, W.J., Stewart, R.E.A. and Born, E.W. (2003). Investigation of the stock structure of Atlantic walrus (*Odobenus rosmarus rosmarus*) in Canada and Greenland using dental Pb isotopes derived from local geochemical environments. Arctic, 56, 82-90. https://doi.org/10.14430/arctic605

[40] Trites, A.W. 1997. The role of pinnipeds in the ecosystem. In Pinniped populations, eastern north Pacific: status, trends and issues. Eds. G. Stone, J. Goebel and S. Webster. Pages 31-39. A symposium of the 127th Annual Meeting of the American Fisheries Society. New England Aquarium, Conservation Department, Central Wharf, Boston, MA 02110. https://mmru.ubc.ca/wp-content/pdfs/Trites_1997.pdf

[41] Roman J. and Mccarthy J. (2010. The Whale Pump: Marine Mammals Enhance Primary Productivity in a Coastal Basin. *PLOS ONE*, 5(10):e13255. https://doi.org/10.1371/journal.pone.0013255

[42] Stenson, G. B., Haug, T., & Hammill, M. O. (2020). Harp Seals: Monitors of Change in Differing Ecosystems. Frontiers in Marine Science, 7. https://doi.org/10.3389/fmars.2020.569258

[43] Granquist, S. 2021. Selir. In Óskarsson, G. J. (Ed.) Staða umhverfis og vitkerfa í hafinu við Ísland og horfur næstu áratuga. Haf- og vatnarannsóknir, HV 2021-14. https://www.hafogvatn.is/static/research/files/hv2021-14.pdf

[44] Blanchet, M. A., Vincent, C., Womble, J. N., Steingass, S. M., & Desportes, G. (2021, March). Harbour Seals: Population Structure, Status, and Threats in a Rapidly Changing Environment. In Oceans (Vol. 2, No. 1, pp. 41-63). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/oceans2010003

[45] Granquist, S.M. and Hauksson, E. (2019a). Population estimate, trends, and current status of the Icelandic harbour seal (*Phoca vitulina*) population in 2018. Marine and Freshwater Research Institution, HV 2019-36. Reykjavík 2019. 22pp. https://www.hafogvatn.is/static/research/files/1575899073-hv2019-36.pdf

[46] EC (2009). Regulation (EC) No 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products (Text with EEA relevance). http://data.europa.eu/eli/reg/2009/1007/oj

[47] Jónas R. Viðarsson, Marvin Ingi Einarsson, Sigurður Örn Ragnarsson, Unn Laksá, Rannvá Danielsen, Audun Iversen, Edgar Henriksen, Tønnes Berthelsen, Heather Manuel, Tom Brown, David Decker, Henrik S. Lund, Bengt Larson and Carl-Axel Ottosson (2018). Nordic coastal fisheries and communities: Status and future prospects. TemaNord 2018:507. Copenhagen, Denmark. https://doi.org/10.6027/TN2018-507

[48] Kristina Svels, Pekka Salmi, Petri Suuronen, Nelson F. Coelho, Åsa Waldo, Sara Königson, Sven-Gunnar Lunneryd, Viktor Eriksson, Markus Vetemaa, Esa Lehtonen, Naja Dyrendom Graugaard, Maria Johansson. (2022). Mitigating a social conflict between seal, conservation and fisheries in the Baltic Sea: multilevel and synergistic approaches. TemaNord 2022:569. Copenhagen, Denmark. http://dx.doi.org/10.6027/temanord2022-569

[49] Sveinn Margeirsson, Guðmundur R. Jónsson, Sigurjón Arason and Guðjón Þorkelsson (2007). Influencing factors on yield, gaping, bruises and nematodes in cod (*Gadus morhua*) fillets. Journal of food engineering, Volume 80, issue 2 pg. 503-508. https://doi.org/10.1016/j.jfoodeng.2006.05.032

[50] Buchmann K., (2023). Seals, fish, humans and parasites in the Baltic: ecology, evolution and history. Folia Parasitologica 2023, 70:011. https://doi.org/10.14411/fp.2023.011.

[51] Blomquist J. & Waldo S. (2021). Seal interactions and exits from fisheries: Insights from the Baltic Sea cod fishery. *ICES Journal of Marine Science* 78(8). https://doi.org/10.1093/icesjms/fsab173

[52] Granquist, S. M. (2022). The Icelandic harbour seal (*Phoca vitulina*) population: trends over 40 years (1980–2020) and current threats to the population. *NAMMCO Scientific Publications*. https://doi.org/10.7557/3.6328

[53] NAMMCO-North Atlantic Marine Mammal Commission (2023). Report of the Scientific Committee Working Group on Coastal Seals. May 2023, Copenhagen, Denmark. https://nammco.no/wp-content/uploads/2023/06/final-report-cswg-2023-_14-june-2023.pdf

[54] MSC (2024). Icelandic Gillnet Lumpfish. https://fisheries.msc.org/en/fisheries/icelandic-gillnet-lumpfish/@@view

[55] NOAA (2024). Marine Mammal Protection Act Policies, Guidance, and Regulations. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations

[56] Granquist, S.M., Esparza-Salas, R., Hauksson, E., Karlsson, O., & Angerbjörn, A. (2018). Fish consumption of harbour seals (*Phoca vitulina*) in north western Iceland assessed by DNA metabarcoding and morphological analysis. Polar Biology, 1-12. https://doi.org/10.1007/s00300-018-2354-x

[57] Sparling CE, Smout SC (2003) Population energy budget for UK North Sea grey seals. In: Briefing paper 03/9 to NERC Special Committee on Seals. https://www.smru.st-andrews.ac.uk/files/2016/08/SCOS-2003.pdf

[58] Hammond P.S. & Wilson L.J. (2016). Grey Seal Diet Composition and Prey Consumption. Scottish Marine and Freshwater Science Vol 7 No 20 https://www.smru.st-andrews.ac.uk/documents/scotgov/CSD3-3_Grey_Seal_Diet_Composition_and_Prey_Consumption.pdf

[59] Sørlie, M., Nilssen, K. T., Bjørge, A., & Freitas, C. (2020). Diet composition and biomass consumption of harbour seals in Telemark and Aust-Agder, Norwegian Skagerrak. Marine Biology Research. https://doi.org/10.1080/17451000.2020.1751205

[60] Granquist, S. and Hauksson, E. (2016). Diet of harbour seals in a salmon estuary in North-West Iceland. Icelandic Agricultural Sciences 29, 7-19, http://dx.doi.org/10.16886/IAS.2016.02

[61] Tverin M, Esparza-Salas R, Strömberg A, Tang P, Kokkonen I, Herrero A, et al. (2019) Complementary methods assessing short and long-term prey of a marine top predator – Application to the grey seal-fishery conflict in the Baltic Sea. PLoS ONE 14(1): e0208694. https://doi.org/10.1371/journal.pone.0208694

[62] Behrens, J., Andersen, N. G., Buchmann, K., Galatius, A., Hansen, J. H., Huwer, B., Kania, P., Kroner, A.-M., Krumme, U., & Lundström, K. (2018). The potential direct and indirect effects of grey seal on Baltic cod. EUfishmeal 2018. https://effop.org/wp-content/uploads/2019/01/fishmel-conference-oct-11-2018_jane-behrens.pdf

[63] Tverin M, Esparza-Salas R, Strömberg A, Tang P, Kokkonen I, Herrero A, et al. (2019) Complementary methods assessing short and long-term prey of a marine top predator – Application to the grey seal-fishery conflict in the Baltic Sea. PLoS ONE 14(1): e0208694. https://doi.org/10.1371/journal.pone.0208694

[64] DFO. (2011). Impacts of Grey Seals on Fish Populations in Eastern Canada. DFO Canadian Science Advisory Secretariat Advisory Report. https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/343116.pdf

[65] FAO (2023). The state of world fisheries and aquacultures 2022". https://www.fao.org/3/cc0461en/cc0461en.pdf

[66] Granquist, S.M., Esparza-Salas, R., Hauksson, E., Karlsson, O., & Angerbjörn, A. (2018). Fish consumption of harbour seals (*Phoca vitulina*) in north western Iceland assessed by DNA metabarcoding and morphological analysis. Polar Biology, 1-12. https://doi.org/10.1007/s00300-018-2354-x

[67] Granquist, S.M. (2014). Ummerki eftir sel á veiddum laxfiskum í völdum laxveiðiám í Húnaþingi vestra og Austur-Húnavatnssýslu. Veiðimálastofnun. VMST/14019. https://www.hafogvatn.is/static/research/files/skra_0066154.pdf

[68] Gonzalvo, J. & Carpentieri, P. (2023). Depredation by marine mammals in fishing gear – A review of the Mediterranean Sea, Black Sea and contiguous Atlantic area. Studies and reviews (General Fisheries Commission for the Mediterranean), No. 102. Rome, FAO. https://doi.org/10.4060/cc6210en

[69] Wilson S.C. (2020). Seal-Fisheries Interactions: problems, science and solutions. https://bdmlr.org.uk/wp-content/uploads/2020/04/Resources-seal-fisheries-interactions.pdf

[70] Coram, A. J., Mazilu, M., & Northridge, S. P. (2016). Plugging the Gaps - Improving Our Knowledge of How Predators Impact Salmon Farms. Scottish Aquaculture Research Forum. http://www.sarf.org.uk/cms-assets/documents/245877-466609.sarf097.pdf

[71] Königson, S., Lundström, K. E., Hemmingsson, M. M. B., Lunneryd, S.-G., & Westerberg, H. (2006). Feeding Preferences of Harbour Seals (*Phoca vitulina*) Specialised in Raiding Fishing Gear. Aquatic Mammals, 32(2), 152–156. https://doi.org/10.1578/am.32.2.2006.152

[72] Königson, S., Fjälling, A., Berglind, M., & Lunneryd, S. G. (2013). Male gray seals specialize in raiding salmon traps. Fisheries Research, 148, 117–123. https://doi.org/10.1016/j.fishres.2013.07.014

[73] Königson, S., Fjälling, A., & Lunneryd, S.-G. (2007). Grey seal induced catch losses in the herring gillnet fisheries in the northern Baltic. NAMMCO Scientific Publications, 6, 203. https://doi.org/10.7557/3.2735

[74] Königson, S., Lunneryd, S.-G., Stridh, H., & Sundqvist, F. (2010). Grey Seal Predation in Cod Gillnet Fisheries in the Central Baltic Sea. Journal of Northwest Atlantic Fishery Science, 42, 41–47. https://doi.org/10.2960/J.v42.m654

[75] F. Larsen, C. Krog, M. Klaustrup & K. Buchmann: Kortlægning af sælskader i dansk fiskeri. DTU Aqua-rapport nr. 299-2015. Institut for Akvatiske Ressourcer, Danmarks Tekniske Universitet. 74 pp. https://www.aqua.dtu.dk/-/media/institutter/aqua/publikationer/forskningsrapporter_251_300/299-2015_kortlaegning-af-saelskader-i-dansk-fiskeri.pdf

[76] Holma M., Lindroos M. and Oinonen S. (2014). The economics of conflicting interests: Northern Baltic salmon fishery adaption to gray seal abundance. *Natural Resource Modeling*, 27(3), 275-299. https://doi.org/10.1111/nrm.12034

[77] Matsuda H., Yamamura O., Kitakado T., Kobayashi Y., Kobayashi M., Hattori K. and Kato H. (2015). Beyond dichotomy in the protection and management of marine mammals in Japan. THERYA, 2015, Vol. 6 (2): 283-296. http://dx.doi.org/10.12933/therya-15-235

[78] Königson, S., Hemmingsson, M., Lunneryd, S. G., & Lundström, K. (2007). Seals and fyke nets: An investigation of the problem and its possible solution. Marine Biology Research, 3(1), 29–36. https://doi.org/10.1080/17451000601072596

[79] Königson, S., Lundström, K. E., Hemmingsson, M. M. B., Lunneryd, S.-G., & Westerberg, H. (2006). Feeding Preferences of Harbour Seals (*Phoca vitulina*) Specialised in Raiding Fishing Gear. *Aquatic Mammals*, 32(2), 152–156. https://doi.org/10.1578/am.32.2.2006.152

[80] Hauksson E. (2011). The Prevalence, Abundance, and Density of Pseudoterranova sp. (p) Larvae in the Flesh of Cod (*Gadus morhua*) Relative to Proximity of Grey Seal (*Halichoerus grypus*) Colonies on the Coast off Drangar, Northwest Iceland. *Journal of Marine Sciences*, Volume 2011, Article ID 235832, 8 pages. https://doi.org/10.1155/2011/235832

[81] Guðmundsson R., Margeirsson S., Arason S. and Jensen P. (2006). Ákvarðanataka og bestun í sjávarútvegi. Rannsóknastofnun fiskiðnaðarins 27-06. https://matis.is/media/matis/utgafa/Skyrsla_27-06.pdf

[82] Nadolna-Ałtyn K., Podolska M., Pawlak J. and Szostakowska B. (2022). Distribution of anisakid nematodes in the muscle tissue of cod (*Gadus morhua*) from the Norwegian Sea. *Oceanologia*, Volume 64, Issue 3, Pages 489-502. https://doi.org/10.1016/j.oceano.2022.03.003

[83] Severin, N.L., Yurchenko, M., Sørensen, J.S. et al. Anisakid nematode larvae in the liver of Atlantic cod Gadus morhua L. from West Greenland. Parasitol Res 119, 3233–3241 (2020). https://doi.org/10.1007/s00436-020-06807-z

[84] NAMMCO-North Atlantic Marine Mammal Commission (2023). Report of the Scientific Committee Working Group on Coastal Seals. May 2023, Copenhagen, Denmark. https://nammco.no/wp-content/uploads/2023/06/final-report-cswg-2023-_14-june-2023.pdf

[85] Bowen, W. D., & Lidgard, D. (2013). Marine mammal culling programs: Review of effects on predator and prey populations. In *Mammal Review* (Vol. 43, Issue 3, pp. 207–220). Blackwell Publishing Ltd. https://doi.org/10.1111/j.1365-2907.2012.00217.x

[86] Kristina Svels, Pekka Salmi, Petri Suuronen, Nelson F. Coelho, Åsa Waldo, Sara Königson, Sven-Gunnar Lunneryd, Viktor Eriksson, Markus Vetemaa, Esa Lehtonen, Naja Dyrendom Graugaard, Maria Johansson. (2022). Mitigating a social conflict between seal, conservation and fisheries in the Baltic Sea: multilevel and synergistic approaches. TemaNord 2022:569. Copenhagen, Denmark. http://dx.doi.org/10.6027/temanord2022-569

[87] Cronin M, Gerritsen H, Reid D, Jessopp M (2016) Spatial Overlap of Grey Seals and Fisheries in Irish Waters, Some New Insights Using Telemetry Technology and VMS. PLoS ONE 11(9): e0160564. https://doi.org/10.1371/journal.pone.0160564

[88] MAR (2020). The Ministry of Food, Fisheries and agriculture – Ráðherra undirritar reglugerð um grásleppuveiðar. https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/2020/02/28/Radherra-undirritar-reglugerd-um-grasleppuveidar/

[89] Canadian Seal Products (2021). Why is seal overpopulation harmful for the ecosystem? https://canadiansealproducts.com/blog/why-is-seal-overpopulation-harmful-for-the-ecosystem

[90] MSE Project (2024). https://www.mseproject.org/

[91] Vísir - 116. tölublað (30.04.1933) - Tímarit.is. (n.d.). Retrieved April 26, 2021, from https://timarit.is/page/1139764#page/n6/mode/2up

[92] EC (2016). European Commission, Directorate-General for the Environment, The EU seal regime, European Commission, 2016, https://data.europa.eu/doi/10.2779/70265 / Trade in seal products https://environment.ec.europa.eu/topics/nature-and-biodiversity/trade-seal-products_en

[93] Wikipedia (2024). Seal meat. https://en.wikipedia.org/wiki/Seal_meat

[94] Jónsson Á., Ragnarsdóttir J., Arnarson G.Ö., Hilmarsson Ó.Þ. and Finnbogadóttir G.A. (2002). Nýting selkjöts til manneldis. Matra report 0211. Reykjavík, Iceland. https://rafhladan.is/bitstream/handle/10802/2035/Matra_Nyting_selkjots_til_manneldis_lokaskyrsla.pdf?sequence=1

[95] Ghaly A. (2012). Biorefinery: an approach to sustainable fish & seal processing industry. Canadian Center for Fishery Innovation. https://www.yumpu.com/en/document/view/24157381/an-approach-to-sustainable-fish-seal-processing-industries-ccfi

[96] Kvennablaðið - 12. tölublað (21.12.1916) - Tímarit.is. (n.d.). Retrieved April 26, 2021, from https://timarit.is/page/2224136#page/n0/mode/2up.

[97] Robinson, A. (2018). Country Food (Inuit Food) in Canada | The Canadian Encyclopaedia. The Canadian Encyclopaedia. https://www.thecanadianencyclopedia.ca/en/article/country-food-inuit-food-in-canada

[98] Remili, A., Letcher, R. J., Samarra, F. I. P., Dietz, R., Sonne, C., Desforges, J.-P., Víkingsson, G., Blair, D., & McKinney, M. A. (2021). Individual Prey Specialization Drives PCBs in Icelandic Killer Whales. Environmental Science & Technology. https://doi.org/10.1021/acs.est.0c08563

[99] POFO (2024). Evidence (Lisa Lange, Director, Bureau of Product Review and Assessment, Natural and Non-prescription Health Products Directorate, Health Products and Food Branch, Health Canada), 19 October 2023 https://sencanada.ca/en/Content/Sen/Committee/441/POFO/56387-E . In: Senate Canada (2024). Sealing the future: A call to action. The Standing Senate Committee on Fisheries and Oceans Senate. https://sencanada.ca/content/sen/committee/441/POFO/Reports/2024-05-23_POFO_SS-3_Report_Final_e.pdf

[100] Canadian Seal Products (2024). https://canadiansealproducts.com/

[101] SeaDNA (2024). https://www.seadna.ca/seal-cuts-phoconailles/

[102] Spaan, K. M., van Noordenburg, C., Plassmann, M. M., Schultes, L., Shaw, S., Berger, M., Heide-Jørgensen, M.P., Rosing-Asvid, A., Granquist, S.M., Dietz, R., Sonne, C., Roos, A., Benskin, J.P. (2020). Fluorine mass balance and suspect screening in marine mammals from the Northern Hemisphere. Environmental Science & Technology, 54(7), 4046-4058. https://doi.org/10.1021/acs.est.9b06773

[103] Zang Y., Rui X., Vaugeois R., & Simpson B. (2022). Seal meat enzymatic hydrolysates and its digests: A comparison on protein and minerals profiles. *LWT-Food science and technology*, Volume 157, 1 March 2022, 113072. https://doi.org/10.1016/j.lwt.2022.113072

[104] Ghaly A. (2012). Biorefinery: an approach to sustainable fish & seal processing industry. Canadian Center for Fishery Innovation. https://www.yumpu.com/en/document/view/24157381/an-approach-to-sustainable-fish-seal-processing-industries-ccfi

[105] SeaDNA (2024). Why seal oil? https://www.seadna.ca/why-seal-oil/

[106] Xiao W, Wang L, Davis PJ, Liu H. Microemulsion of seal oil markedly enhances the transfer of a hydrophobic radiopharmaceutical into acetylated low density lipoprotein. Lipids. 1999;34:503–9. https://doi.org/10.1007/s11745-999-0391-7

[107] EC (2016). European Commission, Directorate-General for the Environment, The EU seal regime, European Commission, 2016, https://data.europa.eu/doi/10.2779/70265 / Trade in seal products https://environment.ec.europa.eu/topics/nature-and-biodiversity/trade-seal-products_en

[108] Granquist S.M. & Sigurjónsdóttir H. (2014). The effect of land based seal watching tourism on the haul-out behaviour of harbour seals (*Phoca vitulina*) in Iceland. Applied Animal Behaviour Science. Vol. 156, July 2014, 85-93. https://doi.org/10.1016/j.applanim.2014.04.004

[109] Granquist S.M. & Nilsson P-Å. (2016). Who's watching whom? – an interdisciplinary approach to the study of seal-watching tourism in Iceland. *Journal of cleaner production*, volume 111, Part B, 16 January 2016, Pages 471-478. https://doi.org/10.1016/j.jclepro.2014.11.060

[110] EC (2009). Regulation (EC) NO 107/2009 on trade in seal products. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R1007

[111] EEC (1983). Council Directive 83/129/EEC of 28 March 1983 concerning the importation into Member States of skins of certain seal pups and products derived therefrom. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31983L0129&qid=1717868284839

[112] EC (2024). Trade in seal products – fitness check of EU rule. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14031-Trade-in-seal-products-fitness-check-of-EU-rules_en

[113] EC (2023). Report from the Commission to the European parliament and the council on the implementation of Regulation (EC) No 1007/2009, as amended by Regulation (EU) 2015/1775, on Trade in Seal Products. COM(2023) 633 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023DC0633&qid=1698048882484

[114] EC (2015). Commission implementing regulation (EU) 2015/1850 laying down detailed rules for the implementation of Regulation (EC) No 1007/2009 of the European Parliament and of the Council on trade in seal products. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2015_271_R_0001