

Marine Mammals of the Greenland Seas

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Abstract

This article describes the relationship between sea ice and marine mammals around Greenland, the possible effects of climate change and the importance of subsistence hunting in modern Greenland. We also summarize the biology, conservation status and utilization of the polar bear, walrus, seal and whale species of Greenland.

Sea Ice, Climate Change and Marine Mammals in Greenland

Sea ice has a major influence on the movements of marine mammals in Greenland. Nine of the marine mammals in Greenland waters are endemic to the Arctic and associated with sea ice (Table 1): bowhead whale (*Balaena mysticetus*), narwhal (*Monodon monoceros*), beluga (*Delphinapterus leucas*), walrus (*Odobenus rosmarus*), polar bear (*Ursus maritimus*), bearded seal (*Erignathus barbatus*), ringed seal (*Pusa hispida*), hooded seal (*Cystophora cristata*) and harp seal (*Pagophilus groenlandicus*). The last four are also known as ice seals, as they use sea ice for whelping. In addition, cetaceans with more boreal distributions, such as rorquals (minke whale, *Balaenoptera acutorostrata*; fin whale, *B. physalus*; blue whale, *B. musculus*; humpback whale, *Megaptera novaeangliae*, and to a lesser extent, sei whale, *B. borealis*), harbor porpoise (*Phocoena phocoena*), white beaked dolphins (*Lagenorhynchus albirostris*), white sided dolphins (*L. acutus*), long finned pilot whales (*Globicephala melas*), killer whales (*Orcinus orca*), sperm whales (*Physeter microcephalus*) and bottlenose whales (*Hyperoodon ampullatus*) spend the summer feeding in ice-free Greenland waters. Also present is the harbor seal (*Phoca vitulina*), which does not necessarily associate with ice but lives in some parts of Greenland year round. The gray seal was documented in Greenland for the first time in 2009 (and observed again in 2010), but has not been reported since then. Table 1 shows the different populations of marine mammal that are common in Greenland, together with their most recent abundance estimates, status in relation to historical levels and population trends (i.e. increasing, decreasing or stable), when known.

The Arctic is warming twice as fast as the rest of the planet (see refs in Laidre et al., 2015a,b). In Greenland, the open water season has increased by about 10 days per decade since the 1970s (Stern and Laidre, 2016). One expected consequence is that the range of the nine Arctic species will shift northwards following their preferred temperature ranges and available sea ice habitat, while the boreal species will extend the period of time they are in Greenland, and move into habitat not previously available. For ice-dependent species like the ice seals and polar bear, we expect that the reduction of sea ice will cause declines in body condition, reproduction, survival and abundance.

Regions Around Greenland and Seasonal Marine Mammal Occurrence

Based on the seasonal changes in sea ice and movement patterns of marine mammals, the seas around Greenland can broadly be divided in four general regions (Fig. 1).

Northwest Greenland: In Baffin Bay, sea ice forms during fall and winter in the west and north, advancing from Canada to Northwest Greenland. Polar bears range over the sea ice, while walrus, bowhead whales, narwhals and belugas follow the ice formation from Canada to Greenland. During spring and summer, the sea ice melts from the southeast to the northwest, and many of the animals return to their summer grounds in the Canadian Arctic and the boreal cetaceans and harp seals move in.

North and Northeast Greenland: In North and Northeast Greenland, there is year round multi-year sea ice, with nearly total to partial coverage during winter, except for the polynyas. Polynyas are areas of open water surrounded by ice during winter, kept open

Table 1 Populations or management stocks of marine mammals in Greenland, with known abundances, status and trends.

Species	Population/stock	Area of Greenland	Abundance (with 95% confidence interval (CI) or coefficient of variation (CV) if available)	Year of census	Status: unknown, reduced or not reduced	Trend: unknown, increasing, decreasing or stable	References
Polar bear	Arctic Basin	North	Unknown	–	Unknown	Unknown	IUCN/PBSG (2019)
	Baffin Bay	Northwest	2826 (95% CI 2059–3593)	2013	Not Reduced	Unknown	IUCN/PBSG (2019)
	Davis Strait	Southwest	2158 (95% CI 1833–2542)	2007	Not Reduced	Stable	IUCN/PBSG (2019)
	E Greenland	Northeast, Southeast, Southwest	Unknown	–	Unknown	Unknown	IUCN/PBSG (2019)
	Kane Basin	North	357 (95% CI 221–493)	2014	Not reduced	Increasing	IUCN/PBSG (2019)
Walrus	N Hudson Bay-Hudson Strait-SE Baffin Island-N Labrador						
	“West Greenland winter aggregation”	Northwest	1408 (95% CI 922–2150)	2012	Reduced	Increasing	Heide-Jørgensen et al. (2013a)
	Baffin Bay “Winter component in Greenland”	North	2544 (95% CI 1513–4279)	2014	Reduced	Increasing	Heide-Jørgensen et al. (2016b)
	East Greenland	Northeast	559 (95% CI: 357–875)	2009	Unknown	Stable	NAMMCO (2018)
Ringed seal	Baffin Bay	North, Northwest	1,200,000	1990s	Unknown	Unknown	Kingsley (1998)
	Greenland Sea & Southeast Greenland	Northeast, Southeast	Unknown		Unknown	Unknown	
	Labrador Arctic Basin	Southwest North	Unknown		Unknown	Unknown	
Bearded seal	<i>E. barbatus</i> subspecies						
	Eastern Canada and West Greenland	North, Northwest, Southwest	Unknown		Unknown	Unknown	
Harp seal	East Greenland	Northeast, Southeast	Unknown	–	Unknown	Unknown	
	Northwest Atlantic	North, Northwest, Southwest, Southeast	7,420,000 (95% CI 6,360,000–8,360,000)	2012	Not Reduced	Stable	Hammill et al. (2015)
Hooded seal	Greenland Sea	Northeast, Southeast	627,410 (95% CI 470,540–784,280)	2012	Not Reduced	Increasing	ICES (2013)
	Northwest Atlantic	North, Northwest, Southwest, Southeast	593,500 (95% CI 404,400–728,300)	2005	Reduced	Increasing	Hammill and Stenson (2006)
Harbor seal	Greenland Sea	Northeast, Southeast	84,020 (95% CI 68,060–99,980)	2013	Reduced	Stable	Øigård et al. (2014)
	South Greenland	Southeast, Southwest	Unknown		Reduced	Increasing	NAMMCO (2019)
	West Greenland	Southwest, Northwest?	Unknown		Reduced	Stable	NAMMCO (2019)
Gray Seal	East Greenland	Southeast	Unknown		Reduced	Unknown	NAMMCO (2019)
	South Greenland	Southeast?	Unknown		Unknown	Unknown	NAMMCO (2019)

Table 1 (Continued)

<i>Species</i>	<i>Population/stock</i>	<i>Area of Greenland</i>	<i>Abundance (with 95% confidence interval (CI) or coefficient of variation (CV) if available)</i>	<i>Year of census</i>	<i>Status: unknown, reduced or not reduced</i>	<i>Trend: unknown, increasing, decreasing or stable</i>	<i>References</i>
Bowhead	E Canada-W Greenland (BBDS and FBHB)						
	“West Greenland winter component”	Northwest	1538 (95% CI 827–2249)	2012	Reduced	Stable	Rekdal et al. (2014)
	Svalbard-Barents Sea						
	“NE Greenland summer component”	Northeast	318 (95% CI 110–956)	2017	Reduced	Unknown	Hansen et al. (2018)
	“NEW polynia winter component”	Northeast	301 (95% CI 127–769)	2017	Reduced	Unknown	Hansen et al. (2018)
Narwhal	“W Greenland winter aggregation”	Northwest	18,583 (95% CI 7308–47,254)	2012	Reduced	Stable	NAMMCO/JCNCB (2015)
	Smith Sound	North	16,360 (CV 0.65)	2013	Not Reduced	Unknown	NAMMCO/JCNCB (2015)
	Inglefield Bredning, W Greenland	North	8368 (95% CI 5209–13,442)	2007	Reduced	Stable	NAMMCO/JCNCB (2015)
	Melville Bay, W Greenland	Northwest	3091 (95% CI 1228–7783)	2014	Reduced	Decreasing	NAMMCO/JCNCB (2015), GINR unpublished data
	E Greenland						
	“Scoresby Sund management stock”	Southeast	433 (95% CI 186–1099)	2016	Reduced	Decreasing	Hansen and Heide-Jørgensen (2019)
	“Kangerlussuaq management stock”	Southeast	269 (95% CI 137–550)	2016	Reduced	Decreasing	Hansen and Heide-Jørgensen (2019)
	“Tasiilaq management stock”	Southeast	206 (95% CI 76–562)	2008	Reduced	Decreasing	Hansen and Heide-Jørgensen (2019)
	NE Greenland						
	“Dove bugt summer component”	Northeast	1395 (95% CI 744–2641)	2018	Not reduced	unknown	Hansen et al. (2019)
Beluga	E high Arctic-Baffin Bay						
	“West Greenland winter”	Northwest	9072 (95% CI 4895–16,450)	2012	Reduced	Stable	NAMMCO/JCNCB (2015)
	“NOW Polynya winter”	Northwest	2324 (95% CI 1786–2820)	2014	Reduced	Unknown	NAMMCO/JCNCB (2015)
	Southwest Greenland winter	Southwest	0	ca. 1930	Extirpated	Extirpated	Heide-Jørgensen and Laidre (2006)
Blue whale	Western North Atlantic	Southwest, Northwest	Unknown		Reduced	Unknown	
	Central and Eastern North Atlantic	Southeast, Northeast (offshore)	3000 (95% CI 1377–6534)	2015	Reduced	Increasing	Pike et al. (2019)

(Continued)

Table 1 (Continued)

<i>Species</i>	<i>Population/stock</i>	<i>Area of Greenland</i>	<i>Abundance (with 95% confidence interval (CI) or coefficient of variation (CV) if available)</i>	<i>Year of census</i>	<i>Status: unknown, reduced or not reduced</i>	<i>Trend: unknown, increasing, decreasing or stable</i>	<i>References</i>
Fin whale	West North Atlantic “West Greenland coastal”	Southwest	2215 (95% CI 1107–4823)	2015		Fluctuating	Hansen et al. (2019)
	Central North Atlantic “Iceland/Faroe Islands”	Southeast (offshore), Northeast (offshore)	36,773 (95% CI 25,811–52,392)	2015			Pike et al. (2019)
	“East Greenland coastal”	Southeast (nearshore)	6440 (95% CI 3901–10,632)	2015		Increasing	Hansen et al. (2019)
Minke whale	West Greenland “West Greenland coastal”	Southwest, Northwest	5095 (95% CI 2171–11,961)	2015		Fluctuating	Hansen et al. (2019)
	Central Atlantic “East Greenland coastal”		2762 (95% CI 1160–5574)	2015	Not reduced	Fluctuating	Hansen et al. (2019)
Sei whale	North Atlantic “West Greenland coastal”	Southwest	1599 (95% CI 690–3705)	2005	Unknown	Fluctuating	Heide-Jørgensen et al. (2007)
Humpback whale	North Atlantic “West Greenland Coastal”	Northwest, Southwest	933 (95% CI 434–2272)	2015	Not reduced	Fluctuating	Hansen et al. (2019)
	“East Greenland Coastal”	Southeast	4223 (95% CI 1845–9666)	2015	Unknown	Increasing	Hansen et al. (2019)
Harbor porpoise	“West Greenland”	Southwest Greenland	83,321 (95% CI 4377–160,047)	2015	Unknown	Unknown	Hansen et al. (2019)
	“West Greenland”	Southeast Greenland	1642 (95% CI 318–8464)	2015	Unknown	Unknown	Hansen et al. (2019)
Killer whale	Unknown populations	Northwest, Southwest, Southeast	Unknown		Unknown	Unknown	
Pilot whale	“West Greenland”	Southwest, Northwest	9190 (95% CI 3635–23,234)	2015	Unknown	Unknown	Hansen et al. (2019)
	“East Greenland”	Southeast	258 (95% CI 50–1354)	2015	Unknown	Unknown	Hansen et al. (2019)
White beaked dolphin	“West Greenland”	Southwest, Northwest	15,261 (95% CI 7084–33,046)	2015	Unknown	Unknown	Hansen et al. (2019)
	“East Greenland”	Southeast	11,889 (95% CI 4710–30,008)	2015	Unknown	Unknown	Hansen et al. (2019)
Atlantic white sided dolphin	Unknown populations	Southwest	Unknown		Unknown	Unknown	
Sperm whale	North Atlantic	Northwest, Southwest, Southeast	Unknown		Unknown	Unknown	
Bottlenose whale	Unknown populations	Northwest, Southwest, Southeast	Unknown		Unknown	Unknown	

by strong currents and winds. The North Water Polynya (NOW) is located between Northwest Greenland, and Ellesmere Island, while the North East Water Polynya (NEW) is at the northernmost part of East Greenland. Polynyas are important for marine mammals, especially walrus and beluga in the NOW and walrus and bowhead whale in the NEW. Narwhals, bearded seals, ringed seals and polar bears use the polynyas, as well as other areas with higher concentrations of sea ice. Kane Basin lies to the north of the NOW and is important habitat for polar bears.



Fig. 1 Marine mammals areas of Greenland.

Southeast Greenland: During winter or early spring, the fjords of Southeast Greenland freeze, while the offshore areas are dominated by drift ice transported from the north by the southern flow of the East Greenland current. Polar bears, ringed seals and bearded seals thrive in the frozen fjords. In summer, the sea ice in the fjords melts and the amount of drift ice offshore gradually decreases. Several fjords are dominated in summer by freshwater ice coming from calving glaciers. Polar bears, narwhals, ringed seals and bearded seals retreat mainly into glacier dominated fjord systems, while harp seals, rorquals, pilot whales and killer whales move into the open coastal waters. Sperm whales and bottlenose whales stay in the deeper waters.

Southwest Greenland: The East Greenland Current (ECG) mixes with a branch of the north Atlantic current, along the southeast Greenland coast. The current transports sea ice, bearded seals, ringed seals and polar bears from the east to the west around the southern tip of Greenland. The current transports sea ice north along the west coast for about 200 km, with a peak around July. Polar bears are regularly seen in the southernmost part of Southwest Greenland, while walrus, narwhal, and beluga are occasional stragglers. The beluga population that migrated to the fjords of Southwest Greenland from autumn to June was extirpated by hunting last century. The southern tip of West Greenland is the only place in Greenland where all 6 species of seals from the North Atlantic have been seen (ringed seal, bearded seal, harp seal, hooded seal, harbor seal and gray seal). The boreal cetaceans, especially rorquals and harbor porpoise are abundant in Southwest Greenland.

Marine Mammals and People in Greenland

Hunting: The ancestors of Greenlanders were Inuit that came from Arctic Canada, traveling over the sea ice with dog sledges and by sea with kayaks and umiaqs (“women boats”). Marine mammals were a fundamental part of their diet. Even though human’s diet in Greenland is nowadays supplemented with imported products and agriculture is developing in Southern Greenland, marine mammals are still hunted for subsistence and their products are an important part of the local economy. Hunting provides food for subsistence hunters and their families, as well as food for sledge dogs. Hunting also provides a source of revenue, through the sale of animal products, including meat, mattak (whale skin and blubber, spelled “muktuk” in the Western Arctic), fur from seals and polar bear and narwhal or walrus tusks. The challenges imposed by climate change on subsistence hunters in Greenland include a shortening of the season when it is safe to travel over sea ice with dog sledges and snow scooters. Some winter routes have become unsafe. As a consequence of the reduction of sea ice, the population of sledge dogs is dwindling. Skiffs are used more than before for

fishing and hunting and in some areas, especially in Southeast Greenland, hunting during summer has shifted from narwhals to dolphins, pilot whales and killer whales.

Management: Greenland is a country under the kingdom of Denmark, with a high degree of autonomy in several areas, including, since 1979, the management of wildlife. The Greenland Institute of Natural Resources (GINR), established in 1993, conducts research and monitoring to provide the Government with management advice to secure that fishing and hunting are sustainable. Much of the marine mammal research and monitoring work is done in coordination with organizations regulated by international government agreements. Thus, GINR presents research and monitoring results to the scientific working groups of the relevant organizations and, after a review of results and an assessment process, the organizations provide advice to the management authorities of the government of Greenland. The government then takes this advice, together with input from hunters, to decide upon regulations such as hunting seasons or quotas.

The international organizations that advise Greenland include the International Whaling Commission (IWC) for large whales; the North Atlantic Marine Mammal Commission (NAMMCO) for pinnipeds and cetaceans; the Canada/Greenland Joint Commission for the Conservation of Narwhal and Beluga (JCNB) for narwhals and belugas in West Greenland; a working group under the International Council for the Exploration of the Seas (ICES), the North Atlantic Fisheries Organization (NAFO) and NAMMCO for harp and hooded seals and the Canada-Greenland Joint Commission on Polar Bear for polar bears in Baffin Bay and Kane Basin. Management of Polar bears in all of Greenland is done following the 1972 Agreement on the Conservation of Polar Bears under the Polar Bear Range States Agreement, whose scientific advisor is the Polar Bear Specialist Group of the International Union for the Conservation of Nature (IUCN/PBSG). Effects of trade in endangered species are overseen under the Council for International Trade of Endangered Species (CITES).

Biology, Status and Utilization of Marine Mammals in Greenland

Polar Bear

Polar bears are dependent on sea ice for all aspects of their life, including travel, breeding and foraging for ice seals. In the areas where the sea ice melts annually during summer, polar bears either fast on land, spend the summer on multi-year sea-ice, or spend the summer near glaciers where limited opportunities for feeding on seals resting on glacial ice may arise.

There are 19 subpopulations of polar bears around the Arctic, five of which live in Greenland: Baffin Bay, Kane Basin, Arctic Basin, East Greenland and Davis Strait (Table 1).

As of the 2010s, polar bears from the Baffin Bay subpopulation are showing effects of reduced sea ice and a longer open water season. These include smaller home range, northwards shift of the subpopulation range, more time fasting on land during the open water season, reduced body condition, maternity dens built on higher ground and shorter maternity denning periods (SWG, 2016).

In contrast, the Kane Basin population, that occupies the small area with multi-year ice in the far north, between North Greenland and Ellesmere Island, appears to be stable or increasing. This is likely because the multi-year ice is transitioning to annual ice which is more productive, and the hunting pressure by humans is lower than before (SWG, 2016).

There are fewer polar bears in the Arctic Basin than in other parts of the Arctic (IUCN/PBSG, 2019). The area, especially the parts close to North Greenland and the Canadian Archipelago, will likely be important for polar bears in the future, as the thick multiyear ice will melt and transition to seasonal ice, which is good habitat for seals and polar bears. This is expected to be the last refuge for polar bears across the Arctic when the southern parts of their current habitat disappear because of climate change.

In East Greenland polar bears occupy areas with reduced sea ice habitat and their habitat use has changed (Laidre et al., 2018). The abundance of polar bears in East Greenland is unknown, as is the connectivity of bears along the coast. An assessment of East Greenland polar bears is ongoing and our knowledge will increase considerably during the 2020s.

The Davis Strait population of polar bears was assessed as stable, with basis on an inventory terminated in 2007. Fieldwork for a new census based on genetic mark recapture was carried out in 2017 and 2018. Davis Strait polar bears spend the summers in Canada and only a small part of their range is in Greenland, when the sea ice forms during winter. As the extent of sea ice recedes due to climate change, the proportion of polar bears from this subpopulation wintering in Greenland is becoming smaller.

Polar bears are classified as Vulnerable under both the global Red List (<https://www.iucnredlist.org/>) and Greenland's national Red List (<https://natur.gl/leksikon/roedliste/>) because it is probable that the world population will be reduced by 30% between 2015 and 2050 due to reductions in sea ice.

Polar bears are important for human subsistence in Greenland, however loss of sea ice and the introduction of hunting quotas in 2005 have also increased human-bear conflicts where polar bears that approach towns and settlements are being killed to protect human lives and property. During 2017–19, an average of 143 polar bears were taken annually in Greenland, including an average of 7 taken in defense of life and property (Anon, 2019; Wilken, 2019).

Atlantic Walrus

Walrus are social animals. They haul-out for resting over land or over sea ice and feed on shellfish at the seabed in waters shallower than 50 m. Feeding bouts can last 3–4 days, followed by 1–2 days resting. There is some degree of sexual segregation, where females and calves tend to spend summer months further north than the adult males. Mating occurs during winter, in waters with high concentrations of sea ice. Seasonal movements follow the formation of sea ice, with walrus spending summers close to land and

winters close to the ice edge (Born, 2011, 2017). There are three populations of walrus in Greenland: Baffin Bay, West Greenland Winter Aggregation and East Greenland.

Walruses in northern Baffin Bay spend summers along the northeastern coast of Arctic Canada, mainly off Ellesmere Island, and winter on the Greenland side of the North Water Polynya (Heide-Jørgensen et al., 2017).

Similarly, some of the walruses that summer in Southern Baffin Island spend winters feeding on the shallow banks off West Greenland.

In East Greenland, walruses are abundant only in the National Park. An interesting feature of the walruses in East Greenland is that many males migrate hundreds of kilometers north to spend winter with the females in the North East Water Polynya (Born, 2011).

Atlantic walrus are listed as Near Threatened in the global red list. The populations in Baffin Bay and West Greenland are increasing, recovering from previous hunts, and listed as Vulnerable in the Greenland Red List. Walruses in East Greenland are listed as Near Threatened in the Greenland Red List, which is a more favorable status.

Greenlandic hunters reported taking an average of 157 walruses per year in 2016–18 (<https://nammco.no>). Nowadays, the Greenlandic subsistence hunt is sustainable. However, in the period 2013–15, catches in Baffin Bay were higher than the scientific advice from NAMMCO, which led to a self-imposed ban on export of walrus products in July 2016. This ban had not been lifted at the time of writing this text.

Past hunting has resulted in walrus being rare in some of their original range in Greenland. This includes East Greenland, south of the national park, where they no longer use terrestrial haul-outs, and current catches consist of stragglers from the north (Born, 2011). Today, walruses in West Greenland haul out almost exclusively on sea ice and their former haul-out sites on land have been abandoned for at least 50 years (Born, 2017).

Seals

There are five or maybe six species of seals inhabiting the seas around Greenland. Four of them are strongly associated with sea ice, and depend on ice for whelping, molting and resting. The remaining two species, the harbor seal and the gray seal, are coastal seals that haul-out on land. The majority of the seals of these two species live in temperate waters. Some small harbor seal populations however, live permanently in the Arctic (including Greenland) and a few gray seals may sometimes stray into Greenland waters.

Ringed seal: Some ringed seals (especially adult seals) maintain breathing holes in the ice throughout the winter and others (especially juvenile seals) winter in areas with light ice conditions, where they do not need to maintain breathing holes. They are generally solitary, although a few seals may share one breathing hole and rest beside it during molt in spring and early summer. Ringed seals make birth lairs in compact snowdrifts that are associated with a breathing hole. They feed on fish, such as polar cod and Arctic cod and are, themselves the favored prey of polar bears in most areas. Ringed seals are widely spread throughout the Arctic and are listed as Least Concern in both the global and the Greenland red list.

Ringed seals are important for the subsistence economy of Greenlanders in some regions. The average annual reported catches during 2012–17 were 56,000 seals (<https://nammco.no>). The meat is food for humans and sledge dogs. The national tannery purchases many of the skins.

Bearded seal: Bearded seals eat fish and invertebrates found on the seabed. They live alone or in small groups, in close association with sea ice, which they use for whelping and resting, especially during molting. They have a circumpolar distribution in the Arctic. East and West Greenland probably have separated stocks, but their population status and trends are unknown. Both the IUCN and Greenland Redlists have bearded seals as Least Concern.

The average annual reported catches during 2012–17 were 1200 seals (<https://nammco.no>). This hunt is likely sustainable, as bearded seals only are hunted in a small part of their wide distribution area. The skin from bearded seals is tough compared to that from other seals and often used to make soles for kamiks (Inuit footwear) and the whips used to guide the sledge dogs.

Hooded seal: Hooded seals have an impressively wide home range. They feed along the continental shelves in the North Atlantic and dives to depths of 1652 m have been recorded (Andersen et al., 2013). They mainly feed on large fish and squid. Females give birth on sea ice in March to April and they only nurse their pups for 4 days, after which they mate again and leave the whelping area. Pups remain alone on the ice for a few days, before taking to sea, spreading and learning to feed by themselves. There are two stocks in the North Atlantic, one in the Northwest Atlantic (whelping in the Gulf of St Lawrence, off Newfoundland and in the Davis Strait) and one that whelps in the Greenland Sea. Hooded seals from both stocks swim in and out of Greenland's waters. Based on surveys conducted in 2005, the West Atlantic population was estimated to be around 600,000 seals (Hammill and Stenson, 2006). No full surveys have been conducted since then and the present population trends and status remain unknown. The Greenland Sea stock decreased during a period with very high catches following the Second World War. The stock has now stabilized at a low level and Hooded seals are therefore listed as "Vulnerable" in both the global and the Greenland Red List.

There is no longer commercial sealing on hooded seals. The average annual reported subsistence catches in Greenland during 2012–17 were 1700 seals almost exclusively from the West Atlantic population (<http://nammco.no>). This catch level should not have any noticeable effect on the populations.

Harp seal: Adult harp seals often swim in large groups when foraging during summer and fall. They forage in most of the Greenland waters that are not ice covered, from offshore open water to deep inside fjords and close to glaciers. They feed on a variety of fish and invertebrates, but small schooling fish, especially capelin, but also polar cod and sand lance seem to be the most important. The West Atlantic harp seals give birth off Newfoundland around the start of March, whereas the population in the

Greenland Sea whelp about a month later. At the beginning of this century a small group of harp seals (around 1000) started to give birth on the drift sea ice off Southwest Greenland (Rosing-Asvid, 2008).

Overharvest greatly reduced the North Atlantic harp seal stocks as long ago as the 19th century, but regulations of the catches since the 1970s have allowed a strong recovery (Hammill et al., 2015). Harp Seals are listed as “Least Concern” in the global and the Greenland Red Lists.

The subsistence catch of harp seals is important in most parts of Greenland. The average annual reported catches in Greenland during 2012–17 were around 59,000 seals (<http://nammco.no>). The main purpose of the catch is to obtain meat for human consumption and for dog food, but hunters also sell skins to the national tannery.

Harbor seal: During molting and breeding, harbor seals concentrate in colonies that in Greenland typically are on small off shore rocks or sandy beaches inside fjords. Their diet includes arctic char, and some groups summer near estuaries and river mouths where this fish is abundant. Harbor seals are the only seal in Greenland that frequently swim up rivers. Although probably never numerous, harbor seals were once spread over much of the West Greenland coast. Due to excessive hunting and perhaps interactions with fisheries, harbor seals disappeared or became extremely rare throughout most of their former range. Harbor seals are now only regularly observed at three breeding/molting localities, but observations of individual seals and small groups of seals far from these localities, indicate that other small remnant populations still exist. Harbor seals are listed as of Least Concern in the global Red List, but are Critically Endangered in the Greenland Red List.

The skin from harbor seals are traditionally used in the women’s national costume and therefore specially coveted but hunting of this species has been banned in Greenland since 2010.

Gray seal: Gray seals were not conclusively documented in Greenland before 2009, when two seals were photographed during an inventory in a colony of harbor seals, near the southernmost tip of Greenland (Rosing-Asvid et al., 2010). The following summer, a gray seal pup was live-captured by scientists in a net in the same area, and it had a satellite-linked transmitter glued to its back. Unfortunately, the tag only lasted for 29 days during which the seal swam 224 km up along the Greenland east coast. This capture is the last documented contact with a gray seal in Greenland.

Arctic Cetaceans

There are three arctic whales that live year-round in Greenland: Bowhead whale, narwhal and Beluga. These are cold water species endemic of the Arctic, often associated with sea ice.

Bowhead whale: The bowhead whale is, together with blue and fin whales, one of the largest animals of Greenland. They feed on copepods, small zooplankton found in productive areas. In West Greenland, bowhead whales are especially abundant in Disko Bay, where they arrive during winter. Bowhead whales prefer water colder than 2 °C, so they leave Disko Bay in June, when water temperatures begin to increase, even though this means they miss the peak on abundance of *Calanus* prey at the surface (Chambault et al., 2018). The bowhead whales coming to Disko Bay are primarily mature females in resting year without calves (Heide-Jørgensen et al., 2010). They belong to the larger East Canada–West Greenland (ECWG) population.

Bowhead whales may reach ages of more than 200 years, were hunted to near extinction in East Greenland during the 18th and 19th century, and severely depleted in West Greenland during the 19th and 20th century (Cooke and Reeves, 2018 and references therein). They were protected worldwide by the League of Nations in 1932. By then, they were thought extinct in East Greenland and rare in West Greenland. After the 1990s, bowhead whales in West Greenland showed a steep recovery, to the point that, in 2009 the IWC agreed to give Greenland a quota of 2 whales per year for subsistence whaling. However, no bowhead whales were caught in Greenland between 2016 and 2019.

Bowhead whales in East Greenland belong to the East Greenland–Svalbard–Barents Sea population, also called the “Spitsbergen stock,” which shows small signs of recovery. The population nowadays is in the hundreds. This is a difficult population to study because the whales keep themselves inside areas with high density of sea ice.

The EGSBS population is listed as endangered in the IUCN Red List, while globally, bowhead whales are listed as Least Concern. The Greenland red List lists bowhead whales in West Greenland as Nearly Threatened and in East Greenland as Vulnerable.

Narwhal: Narwhals swim in groups, often spread over a large area in clusters made by a few animals of the same gender, such as only males or only females with calves, swimming very close to each other. Narwhals can live to be 100 years old and, together with humans, are one of the few species in which females live a considerable part of their life after menopause. The male’s left tusk is a very long tooth which pierces the skin of the upper lip and grows in a spiral form in front of the head. In medieval times these tusks were believed to be unicorn horns. It is a sexual trait that males use to establish dominance and hierarchy. Narwhals can dive to more than 1700 m to feed on Greenland halibut, although can also find their prey, including squid, shrimp and fish at depths of 200–600 m (Watt et al., 2015). Narwhals spend summers in fjords with glacier fronts. They have a high degree of site fidelity and return to the same areas every summer (Heide-Jørgensen et al., 2015). During winter, when the fjords freeze, narwhals migrate to offshore areas with high concentrations of sea ice. Narwhals from several summer stocks in Arctic Canada and Northwest Greenland mix during winter in areas with high concentration of sea ice of Baffin Bay, Davis Strait and West Greenland (Heide-Jørgensen et al., 2013b).

The global Red List lists narwhals as Least Concern, while the Greenland red list considers them Nearly Threatened in West Greenland and Endangered in East Greenland. Greenlanders are highly motivated to hunt narwhals because their mattak (skin and blubber) is a delicacy and sells for high prices. A yearly average of 445 narwhals were reported hunted in Greenland in 2016–18 (<http://nammco.no>). The smallest populations are at the edge of their summer range in Melville Bay in Northwest Greenland and

south of the National Park in East Greenland (i.e. south of 72°N), where they are decreasing in numbers due to unsustainable hunting, warming temperatures caused by climate change and disturbance from increased boat traffic (NAMMCO, 2019).

Beluga: Belugas and narwhals belong to the same family, Monodontidae, and can produce hybrids (Skovrind et al., 2019). Belugas swim in groups and feed on pelagic fish, such as arctic cod (*Boreogadus saida*). A large population of belugas spends summers in Arctic Canada, then migrates every winter, when the sea freezes, to West Greenland. Some of them overwinter at the North Water Polynya, while others continue following the ice edge to Midwest Greenland. Until the early 1920s, there was another aggregation of belugas that lived most of the fall, winter and early summer in the fjords of Southwest Greenland. The belugas of Southwest Greenland were driven to extinction by unsustainable hunting (Heide-Jørgensen, 1994).

Belugas are listed as least concern both in the global and the Greenland Red List.

The Arctic Canada—West Greenland population is hunted and was in decline during the second half of the 20th century. Because of the reduction of sea ice due to climate change, the preferred habitat for the belugas, which is by the ice edge, is getting further away from the coast of West Greenland, and they have become less accessible to Greenlandic hunters. This, together with the introduction of quotas in 2005, resulted in a reduction of catches and the population is therefore increasing (Heide-Jørgensen et al., 2016a). During 2016–18, a yearly average of 204 belugas were landed in West Greenland (<http://nammco.no>). In East Greenland, belugas are only occasional vagrant visitors and protected by law.

Boreal Cetaceans

Boreal cetaceans visit the ice-free waters of the Arctic and other northern seas during summer and migrate to warmer waters during winter. In Greenland, these include four rorquals and six toothed whales.

Rorquals: Rorquals are baleen whales with grooves on their throat. The grooves allow the mouth cavity to expand, gulping large quantities of water to trap prey such as schooling fish or krill. The five species of rorquals in the North Atlantic are the minke whale, fin whale, humpback whale, blue whale and sei whale. They all migrate from southern breeding grounds in the winter to northern feeding grounds in the summer, including the ice free waters of Greenland. Rorquals produce low frequency sounds, and the increasing levels of sound pollution in the ocean probably have an effect on the ability of rorquals to communicate with each other over long distances. Unsustainable whaling by industrialized countries depleted most stocks of baleen whales during the 20th century. However, numbers are recovering because of whaling regulations. In the global Red List, minke whales and humpback whales are listed as Least Concern, while fin whales are listed as Vulnerable and blue whales and sei whales are still listed as endangered. In the Greenland red list, minke whale, fin whale and humpback whale are listed as Least Concern, Blue whale as Vulnerable and sei whale as Endangered.

During 2016–18, Greenlanders caught a yearly average of 141 minke whales, 4 humpback whales and 8 fin whales for subsistence (<http://nammco.no>). Blue whales and sei whales are protected in Greenland.

Harbor porpoise: Harbor porpoise is the smallest cetacean in the seas around Greenland. They usually swim alone or in small groups and feed on several species of fish and squid. Harbor porpoise tagged in the summer in Southwest Greenland traveled long distances during winter, into deep oceanic waters close to the Azores and offshore waters of East Greenland, and returned to the coastal waters of Southwest Greenland the following summer (Nielsen et al., 2018). Thus, Greenland harbor porpoises travel over longer distances than porpoises tagged in the North Sea. They also dive deeper, with average depths of 248 m and a maximum depth of 410 m.

Harbor porpoise are listed as “Least Concern” in the IUCN Red List and in the Greenland Red List.

The average yearly subsistence catch in the years 2015–17 was 2275, according to hunter’s reports (<http://nammco.no>). This number is higher than the 1869 recommended by NAMMCO (NAMMCO, 2019).

Delphinids: Four species of the dolphin family use the seas of East and West Greenland during the open water season: killer whale, long finned pilot whale, white beaked dolphins and white sided dolphins. White sided dolphins are rare so far north, and their distribution may be limited to the southern parts of Greenland. They are all social animals that swim in groups.

Before 2009, killer whales were seen (and hunted) without clearly regular patterns; every year they would show up at different places of Greenland and during different months. That is still the case in most of Greenland, except from Southeast Greenland, where they are hunted every year since 2009 (Jourdain et al., 2019). A similar situation applies for pilot whales and white sided dolphins, except that these two species are more abundant in Greenland. The increased occurrence of boreal cetaceans in Southeast Greenland is probably a result of climate change, with the sea being warmer, less sea ice coming from the north with the East Greenland Current and boreal fish species moving in.

Killer whales from East Greenland are genetically related to killer whales from Iceland and Norway (Foote et al., 2013). The majority of killer whales in Iceland and Norway feed on herring, while the killer whales in East Greenland feed on seals, whales and fish. This is interesting because killer whales in other parts of the world have cultural traditions regarding food and hunting techniques, specializing in either fish or marine mammals (review in Jourdain et al., 2019).

Dolphins and pilot whales feed on fish and squid. However, dolphins feed relatively close to the surface, while pilot whales are deep divers. Pilot whales occasionally feed on other marine mammals.

Killer whales are listed as Data Deficient in the global and Greenlandic Red Lists. Pilot whales and white beaked dolphins are Least Concern in both lists, while white sided dolphins are Least Concern in the global Red List and Data Deficient in the Greenland Red List.

Average reported yearly catches in Greenland in 2015–17 were 12 killer whales, 289 pilot whales and 108 dolphins (<http://nammmco.no>). The North Atlantic Marine Mammal Commission has not assessed whether these catches are sustainable, but advises Greenland to regulate the catches of killer whales, as it is not known if the killer whales caught in Greenland belong to a small population or not (NAMMCO, 2019).

As top predators, killer whales accumulate chemical pollutants consumed by their prey and by the prey's prey. This pollution is magnified through the food chain from phytoplankton to zooplankton to fish to marine mammals to killer whales. This process of magnification occurs in all marine mammals, but because killer whales are the absolute top predator, and have long live spans, they are also much contaminated by chemical pollutants, to the point that the pollution may affect their survival and fertility (Desforges et al., 2018). Killer whales, pilot whales and dolphins are used as food for humans and sledge dogs in Greenland. In 2018, the health authorities in Greenland issued a press release recommending people to abstain from eating killer whale products, as it may be unhealthy due to its contaminant load. An ongoing study indicates that contaminant levels on pilot whales and dolphins in Greenland may also be high (Roos et al., 2019).

Sperm whale and bottlenose whale: The two largest toothed whales are the sperm whale and the bottlenose whale. They are both inhabitants of deep, offshore waters, although sperm whales venture into the deep fjords of Greenland. Bottlenose whales swim in groups that include males, females and calves. Sperm whales have a strong sexual segregation, with females and calves living in groups in tropical and subtropical waters, while males move to feed at high latitudes. Thus, there are only male sperm whales in Greenland. Sperm whales and bottlenose whales are both deep divers that hunt squid and deep-water fish such as halibut.

Both species were hunted by European and North American whalers for their oil in the 20th century, while sperm whales were caught in the 18th and 19th century as well. Sperm whales were depleted in the North Atlantic but have been protected globally since the 1980s and their numbers have increased. The conservation status of bottlenose whales is not known, but they seem to be abundant. Sperm whales are listed as Vulnerable in the global and Greenland Red Lists, while in both lists bottlenose whales are listed as Data Deficient.

Sperm whales are protected in Greenland. It is legal to hunt bottlenose whales, but their meat is believed to have a strong laxative effect and therefore Greenlanders do not consider them edible. Both species are known for “stealing” halibut from fishing lines and have been unpopular among fishermen. Nowadays, however, offshore fisheries in Greenland waters are carried out by trawlers and there are no conflicts with these species.

Conservation Status of Marine Mammals in Greenland

Of the 55 stocks of marine mammals from Greenland listed in Tables 1, 26 have an unknown status, 23 are stable or increasing, four are in decline and one was extirpated in the 1920s. Most of those with unknown status appear to be numerous and are either protected or harvested in a sustainable way. Thus, we can conclude that the majority of marine mammals in Greenland are managed on a sustainable way, and many of the populations that have declined because of overhunting in the past have recovered or are now recovering. There are a few exemptions, though.

NAMMCO has voiced concern for the unregulated catches of killer whales in East Greenland, as the size of the population has not been assessed and they may already be compromised by high levels of contaminants (NAMMCO, 2019). It remains to be seen if the recommendations by the health authorities to limit the consumption of killer whale meat will have an effect on the number of killer whales taken by subsistence hunters.

Reported catches of harbor porpoises are higher than recommended by NAMMCO (2019), and there is a risk for population decline. However, there are still tens of thousands of porpoises in Greenland, so their population is not facing imminent risk of extinction.

Harbor seals were almost wiped out from most of their range in West Greenland. Since their protection in 2010, the colony of Cape Farewell, at the southern tip of Greenland has become larger. In other locations however, harbor seals are still rare. It seems like their recovery is hampered by poaching, entanglement in fishing gear or accidental hunting as they are mistaken for other seals and shot in open water.

As a species, narwhals are not in the risk of extinction yet, since they are protected in the national park of Northeast Greenland, and relatively abundant in north Greenland north of the North Water Polynya and in arctic Canada. However, the small populations at the southern edge of the narwhal's summer distribution, in Melville Bay (Northwest Greenland) and East Greenland south of the national park, are the ones most affected by warming climate. Those small populations are also under increasing stress from boat traffic and, most importantly, they are under pressure from unsustainable subsistence hunt and their future is uncertain (NAMMCO, 2019).

Narwhal, beluga, bowhead whale, walrus, polar bear and ice seals are endemic of the arctic and their survival depends on sea ice and cold temperatures. They are or will be negatively affected by climate change, their ranges are expected to shrink northwards and their long term future depends on the global actions taken by people and governments during the next few decades to reduce the emission of greenhouse gases.

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