Extracts from the

Arctic Biodiversity Assessment

with special relevance for management of harvest of mammals, birds and fish in Greenland

Statements with key relevance for Greenland are highlighted in yellow.
Foreword by the Chief Scientist, Hans Meltofte

Until recently, most Arctic biodiversity was relatively unaffected by negative impacts from human activities. Only over-exploitation of certain animal populations posed serious threats, such as the extermination of Steller’s sea cow, the great auk, the Eskimo curlew and a number of whale populations in recent centuries, in addition to the contribution that humans may have made to the extermination of terrestrial mega-fauna in prehistoric times.

Human impacts, however, have increased in modern times with increasing human populations in much of the Arctic, modern means of rapid transport, modern hunting and fishing technology, increasing exploration and exploitation of mineral resources, impacts from contaminants and, most importantly, with climate change, which is more pronounced in the Arctic than elsewhere on the globe.

There is no inherited capacity in human nature to safeguard the Earth’s biological assets – moral and intellectual strength are needed to achieve conservation and wise use of living resources through cultural and personal ethics and practices. Sustainability is a prerequisite for such balance, but it does not come without restraint and concerted efforts by all stakeholders, supported by mutual social pressure, legislation and law enforcement.

Introduction

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The Arctic Biodiversity Assessment (ABA) focuses on the species and ecosystems characteristic of the Arctic region and draws together information from a variety of sources to discuss the cumulative changes occurring as a result of multiple factors. It draws on the most recent and authoritative scientific publications, supplemented by information from Arctic residents, also known as traditional ecological knowledge (TEK1). The chapters of the ABA have been through comprehensive peer reviews by experts in each field to ensure the highest standards of analysis and unbiased interpretation. The results are therefore a benchmark against which future changes can be measured and monitored.

Chapter 1. Synthesis: Implications for Conservation

Arctic biodiversity – the multitude of species and ecosystems in the land north of the tree line together with the Arctic Ocean and adjacent seas – is an irreplaceable cultural, aesthetic, scientific, ecological, economic and spiritual asset. For Arctic peoples, biodiversity has been the very basis for their ways of life through millennia, and is still a vital part of their material and spiritual existence. Arctic fisheries and tourism are also of particularly high value for the rest of the world, and so are the millions of Arctic birds and mammals migrating to virtually all parts of the globe during winter.

Until the second half of the 20th century, overharvest was the primary threat to a number of Arctic mammals, birds and fishes. A wide variety of conservation and management actions have helped alleviate this pressure in many areas to such an extent that many populations are recovering, although pressures on others persist.

A key challenge for conservation in the Arctic is to shorten the gap between data collection and policy response.

Conservation action based on the findings of the ABA will not happen in a vacuum. All Arctic Council states have made commitments that, directly or indirectly, help protect biodiversity and ecosystems through a number of conventions as well as bi- and multi-lateral agreements, including the Convention on Biological Diversity, United Nations Framework Convention on Climate Change, Convention to Combat Desertification, Bonn Convention, Ramsar Convention on Wetlands of International Importance, UN Educational, Scientific and Cultural Organization, World Heritage Convention and the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Each Arctic Council country is a Party to at least one of these conventions and has, thereby, made commitments that have the effect of protecting and restoring biodiversity.

Climate change and human hunting probably worked together to force major changes in Arctic biodiversity in the late Quaternary (Lorenzen et al. 2011). Still, for several millennia human population density was so low in most parts of the Arctic, and the means of transport and hunting so limited in range, that significant human impacts on animal populations were probably limited to a number of long-lived and slow-reproducing species together with easily accessible colonies of breeding seabirds and marine mammals (see e.g. Krupnik 1993 and Freese 2000). It is also likely that hunting had marked impacts on the behavior of several species, which became wary of human presence, while most remained relatively little affected.

Indeed, people living in the Arctic often harvested more than they consumed, and for good reasons (Krupnik 1993). The living conditions in the Arctic – i.e. among people without access to alternative boreal resources – have always been unpredictable enough that it was a necessary strategy to use any opportunity to secure as much food and other materials as possible, as a reserve against future scarcity (see also Meltofte 2001). Animals were harvested in accordance with need, considering both immediate use as well as longer-term insurance against scarcity. In addition, if important local resources were depleted, there was room in most parts of the Arctic to move elsewhere.
The migration of people from the south, particularly from the 17th century onwards, increased the pressure on several wildlife populations considerably. Several populations of marine mammals suffered sharp population declines due to commercial whaling and other new forms of exploitation. … Later, commercially exploited fish stocks came under pressure until recently when more effective management measures were put in place in most places, although by-catch and the allocation of harvest remain problematic for some stocks, especially for some indigenous fishers (FAO 2005, Christiansen & Reist, Chapter 6, Michel, Chapter 14, Huntington, Chapter 18; also see Section 5.1.2 for a summary of impacts and trends of harvest on biodiversity).

While Arctic biodiversity for thousands of years has formed the basis for human cultures in almost all parts of the Arctic, today the harvest of Arctic living resources cannot provide sufficient incomes to support a modern lifestyle across entire communities or regions. Thus, access to additional income from mineral resource exploitation or subsidies from southern societies (transfer payments) are necessary to maintain living standards considered basic in the 21st century (Duhaime 2004), though these economic changes have repercussions for biodiversity and human use thereof. Accordingly, in large parts of the Arctic the importance of Arctic biodiversity to human societies will increasingly emphasize cultural and ethical values including activities such as increasing tourism (see e.g. Hvid 2007 and Huntington, Chapter 18). Yet, harvest of wildlife has importance in securing people against the fluctuation and instability of the monetary economy, such as happened after the end of the Soviet Union (Duhaime 2004).

Marine fisheries form an important exception to this trend, in that some of the richest fisheries on Earth are found in the North, particularly along the sub-Arctic fringes. These commercial fisheries harvest millions of tonnes annually, including more than 10% of global marine fish catches by weight and 5.3% of crustacean catches, for an economic value in billions of US dollars (Christiansen & Reist, Chapter 6, Michel, Chapter 14, Huntington, Chapter 18). By contrast, harvest of Arctic species other than fishes and shellfish – even though an important part of the seasonal activities and nutrition of many humans in the Arctic – is an important source of income for a dwindling number of people (Huntington et al., Chapter 18).

The rapid growth of human population in most other parts of the world was primarily due to the development of agriculture, followed more recently by the industrial revolution and modern health practices. Thanks to these innovations, southern societies have increased population densities by several orders of magnitude and at the same time – in most parts of the world – raised living standards to hitherto unknown levels. This was not possible in the Arctic as the ‘carrying capacity’ of Arctic biodiversity could not support dense human populations. Instead, recent Arctic population growth has resulted from increasing integration with southern economies and societies including the introduction of modern medicine and technology (such as rifles) together with the prevention of widespread starvation and death in periods of poor hunting. For example, the population of Greenland has grown by a factor of 10 since contact with Europe was established almost 300 years ago (Born & Böcher 2001, Danmarkshistorien.dk 2012). Within this general trend, there have been local and regional population decreases and other impacts resulting from impacts of commercial exploitation, environmental variability and economic downturns. However, the separation of human
population levels from local carrying capacity and the advent of commercial hunting practices that reward higher harvests led to severe overexploitation of several animal populations such as walrus and a number of seabird species in W Greenland (Merkel 2004a, Witting & Born 2005, Reid et al. Chapter 3, Ganter & Gaston Chapter 4).

During the last few hundred years, harvest of wildlife in the Arctic changed from a small-scale practice by scattered human populations to the use of modern hunting and catching technologies, more efficient means of transport such as snowmobiles, all-terrain vehicles, power boats and ocean going vessels, and increased accessibility through more extensive road systems. In combination with population growth and commercial markets in some regions for wildlife products, this increased the pressure on several wildlife populations (Huntington, Chapter 18).

Even though historically overharvest was one of the most common pressures on Arctic wildlife, it is also the most manageable (Klein 2005). In most areas, hunting and fishing are regulated, at least for species of conservation concern. Indeed, the pressure from overharvest has been largely removed as a major conservation concern for most species due to improved management and conservation actions.

Some populations (for example some whales, muskox and common eider; Fig. 1.4) have recovered or are recovering from overharvest following conservation and management measures that have been put in place over the past few decades (Reid et al., Chapter 3, Ganter & Gaston, Chapter 4). Similarly, sound regulation of bowhead whale hunting in the Bering-Chukchi-Beaufort region has helped populations increase from previously depleted levels (see Box 14.6 in Michel, Chapter 14). Others are not recovering or are only slowly recovering (several sub- and low Arctic carnivore populations, some polar bear populations and some reindeer/caribou populations together with W Greenland walrus, harbor seal and thick-billed murre; the three latter being red-listed in Greenland; Boertmann 2007, Rosing-Asvid 2010, Reid et al., Chapter 3, Ganter & Gaston, Chapter 4).

**Figure 1.4.** Common eider population depletion and recovery in W Greenland from the early 19th century to the present (estimates by F. Merkel in litt. based on data from Müller 1906 (down collection), Merkel 2002, 2004a, Christensen & Falk 2001 and annual growth rates from 2001 to 2007 in NW Greenland from Merkel 2010). The depletion was probably mainly caused by overharvest (hunting and egg collection), while the recovery was the result of tightened legislation and cooperation with local hunters since 2001 (Gilliland et al. 2009, Merkel 2010).
Species protection has focused on preventing overharvest, which has historically been the largest threat to Arctic biodiversity. Seabirds are an example of biodiversity that is susceptible to such overharvest, and this has caused population declines in some parts of their range. In these areas, careful regulation of harvest is necessary as part of a conservation and restoration strategy. Photo: Knud Falk, Kippaku, NW Greenland.

In several species of seabirds and small cetaceans, bycatch in fishing nets and on hooks is related to overharvest in that it results in additional mortality on top of other harvests. However, by-catch in gill-nets in the Arctic seems to have diminished in recent decades, at least in the Atlantic sector, due to reduced use of gill nets in the high seas of Greenland and Norway (Bakken & Falk 1998).
However, it still is of major concern in coastal fisheries, e.g. in W Greenland and the NW Pacific (Chardine et al. 2000, Merkel 2004b, 2011).

Fisheries conservation and management measures put in place over the last few decades have resulted in large Arctic commercial fisheries which from a global perspective are relatively well managed, although there have been management failures, and high harvest pressure continues on some fish stocks (Christiansen & Reist, Chapter 6, Huntington, Chapter 18). Arctic countries are at the forefront of development of sustainable fisheries. Examples of improvements include national and sub-national regulations, restrictions and large scale management planning processes and international cooperation (Huntington, Chapter 18, see especially Box 18.3). The need for using a precautionary approach for fisheries and resources management is reinforced by the paucity of baseline data and long-term monitoring in the Arctic compared with other marine ecosystems, combined with rapid climate-associated changes (Michel, Chapter 14). In US waters of the Arctic, for example, commercial fishing has recently been prohibited as per the Arctic Fisheries Management Plan until more information is available to support sustainable management of potentially harvestable species (NPFMC 2009).

Accurate statistics on by-catch are crucial in upcoming Arctic fisheries and call for adaptable management policies to meet conservation aims. No single harvesting practice is foolproof (Pitcher & Lam 2010). Catch Quota Management (CQM; Danish Ministry of Food, Agriculture and Fisheries 2012), a new policy that is currently being tested in North Sea fisheries, may provide urgently needed by-catch data, which is a first step to better controlling the impacts of by-catch.

Possible conservation actions

- To maximize the adaptive capacity of harvested populations of mammals and birds, with respect to harvest, climate change and genetic viability, populations should be allowed to achieve and maintain healthy population levels that meet sustainable harvest management goals. This step includes allowing depleted populations to recover (see text above for examples). Maintaining viable populations can be achieved by, for example, regulation of the take itself, harvest methods and the establishment of protected zones e.g. for reproduction, molting and feeding.
- Ongoing improvements in data gathering and analytical techniques for estimating sustained yield are needed. Ideally, such information would include an ability to differentiate populations and stocks, repeated estimations of stock or population abundance, and accurate and complete harvest or catch data including individuals not retrieved. The same applies to by-catch of mammals and birds – and non-targeted fish species – in fishing gear.
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and complete harvest or catch data including individuals not retrieved. The same applies to by-catch of mammals and birds – and non-targeted fish species – in fishing gear.¹

In general, the more a population of mammals or birds has been subject to hunting, the shyer it is, and potentially the more effect further disturbance (e.g. in the form of human presence) can have on the population. Photo: Jenny E. Ross/Lifeonthinice.org

The effects of disturbance on displacing mammals and birds from important habitats are closely related to shyness of the individual species (Madsen & Fox 1995, Laursen et al. 2005). This shyness has both an inherited (genetically fixed) and an acquired element. Both are related to the level of population pressure created by such disturbance through death and injury over the course of generations. Usually, the more a population of mammals or birds has been subject to hunting, the shyer it is, and potentially the more effect further disturbance (e.g. in the form of human presence) can have on the population. The exceptions to this are species that rely on cryptic behavior, such as ptarmigan.

Most mammal and bird species in the Antarctic are indifferent towards humans when on land, where there are no mammalian predators (see Box 4). Similarly, in the Arctic much wildlife is relatively indifferent to human presence, so that they can be approached by humans to within 10-20 m – similar to the escape distance from foxes and other mammalian predators. This is not the case

¹ The appropriateness of co-management systems is outside the scope of this report to make recommendations on. However, much experience exists in Arctic countries on how to handle this, if such methods are desired (see Huntington, Chapter 19).
for hunted populations, which often have flight distances of several hundred meters, at least during the time of the year when they are hunted. Conversely, birds and mammals can sometimes reduce their flight distances surprisingly quickly when protected from hunting (e.g. mallards and other waterfowl in ‘city parks’ such as in larger cities in Greenland – a situation that was unthinkable until few decades ago; H. Meltofte, pers. obs.).

Few studies have documented the effects of disturbance at the population level (see Madsen & Fox 1995), probably because they are hard to disentangle from other effects of human presence such as direct mortality or habitat disturbance. Large aggregations of breeding, molting and wintering waterbirds, marine mammals at haul outs and calving caribou may be most sensitive to disturbance, with heavy and continued disturbance having an effect similar to habitat loss, since the birds or mammals are prevented from utilizing important habitat. Such behavioral changes may lead to reduced foraging time, increased energy expenditure and poorer physiological condition leading to reduced fecundity and increased mortality. Disturbance may also have indirect effects such as increased predation, when birds leave their nests due to human disturbance and predators can move in easily to take eggs or chicks.

This effect is especially severe in dense bird colonies. In some cases it may be hard to separate the effect of disturbance from the direct effect of the take of individuals from the population. For example, when walruses no longer haul out on land in W Greenland (Born et al. 1994), it is hard to know whether this is an effect of continued shooting at haul out sites or the extermination of the local animals, but most likely it is a combination of these pressures.

The potential disturbance due to human presence is closely related to the level of hunting that the populations in question are subject to. For instance, tourists may approach incubating black-legged kittiwakes and thick-billed murres to within a few meters in Svalbard, while these and other harvested species may flush at distances of several hundred meters in areas where they are hunted such as in Greenland (Merkel et al. 2009, pers. com., Egevang 2011, H. Meltofte, pers. obs.). The balance between hunting-induced shyness and the interests of non-hunters, including tourists, in being able to enjoy wildlife will ultimately depend on the priorities of the individual jurisdictions responsible for hunting and recreational activities.

Possible conservation actions

- The effects of human disturbance on population size and fecundity is largely unknown. As human activities increase, the impact of this as a stressor needs to be better understood and monitored.
- Human disturbances should to be kept at a level that does not significantly alter animals’ patterns of utilizing existing food resources, natural behaviors and ability to breed, molt and rest. One of the tools for achieving this is the establishment of reserves and other low-disturbance areas as refugia especially for hunted populations (see e.g. Madsen & Fox 1995). Other tools include seasonal restrictions, speed limits, reducing or minimizing travel
in key areas during sensitive periods\(^2\), height restrictions for aircraft and minimizing noise in marine ecosystems including stand-off distances and a ramp-up period at the start of seismic activities.

- For species coming under severe pressure from climate change, alternative habitat should be safeguarded such as safe coastal haul out sites for walrus, in areas where ice haul out sites are no longer suitable due to loss of ice or distance from feeding areas.
- Cooperation with non-Arctic states is crucial to address threats on the staging and wintering grounds of migratory species. This includes international cooperation through multi-lateral and bi-lateral agreements. One example is the Convention on the Conservation of Migratory Species of Wild Animals together with its agreements and management plans (see Scott 1998).

### Chapter 3. Mammals

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Harvesting of Arctic mammals has a long history. Commercial interests have driven major declines in some populations of whales and reindeer, but intensive harvest management has demonstrated that many populations can recover, and that various species can sustain well-regulated harvests (e.g. whales, polar bears, seals, reindeer and caribou, Arctic fox). Indigenous peoples have strong cultural and economic ties to the harvesting of mammals. These can be sustained with a combination of cultural tradition and better science-based monitoring of population sizes and harvest levels.

In SW Greenland, the larger Akia-Maniitsoq and Kangerlussuaq-Sisimiut herds live year-round on tundra and undergo relatively short migrations. Five small populations also occur farther north on Greenland’s west coast. A population in the Thule district of NW Greenland was apparently extirpated in the late 20th century, but the region has been recolonised by caribou from Ellesmere Island (Roby et al. 1984).
In Greenland, failure to detect increasing numbers [of caribou] may have contributed to conservative harvest management at a time when the herds were likely increasing (Cuyler et al. 2007).

Human presence is increasing across most caribou and wild reindeer ranges. In Greenland, hunting of caribou and muskoxen has increased with more people, stronger boats and a market economy for wild meat (Landa 2002).

In NE Greenland, Dawes et al. (1985) report a decline in the wolf population during the 1930s, and by the early 1940s the species was most likely extirpated. However, the species came back after the cessation of fur trapping activities, and Marquard-Petersen (2009) found evidence that between 1978 and 1998 the wolf population of N and E Greenland consisted of up to 55 wolves in favorable times and maximum wolf density was estimated at 0.03 wolves/100 km2 in this very alpine area.

In W Greenland, numbers of wintering belugas have increased during the 21st century (Heide-Jørgensen et al. 2010a).

Although good population estimates are available for most narwhal stocks (Heide-Jørgensen et al. 2010b, Richard et al. 2010), they cannot be used for trends in abundance because of a lack of long-term monitoring or changes in survey methods making estimates incomparable. Surveys in central W Greenland in late winter are considered important for estimating trends in narwhals, but those surveys cover unknown proportions of whales from different summering subpopulations from W Greenland and Canada (Heide-Jørgensen et al. 2010b).

The bowhead whales in Disko Bay, W Greenland, have increased at a rate of approximately 5% per year since 2000 (Heide-Jørgensen et al. 2007, Wiig et al. 2011) and comprise a spring aggregation which is part of the eastern Canada-W Greenland population.

Among the 19 polar bear subpopulations, seven are assessed as declining (Baffin Bay, Chukchi Sea, Kane Basin, Lancaster Sound, Norwegian Bay, S Beaufort Sea, W Hudson Bay), four are considered stable (Davis Strait, Gulf of Boothia, N Beaufort Sea, S Hudson Bay) and one is considered to be increasing (M’Clintock Channel). There are not enough data to determine trend for the other seven subpopulations (Arctic Basin, Barents Sea, E Greenland, Foxe Basin, Kara Sea, Laptev Sea, Viscount Melville Sound) (Obbard et al. 2010).

Modeling and simulation studies indicate that populations in W Greenland and the North Water have been declining due to over-exploitation, while the population in E Greenland has perhaps been increasing (Witting & Born 2005, NAMMCO 2009).

Recent model runs by ICES (2008) have confirmed that the population of harp seals in E Greenland may have increased in size from its earlier depleted state since ca. 1970, and it has been predicted that the population could continue to increase under the current harvest regime, which involves very small annual removals (Øigård et al. 2010).
Humpback whales off the coast of W Greenland have been increasing 9.4% per year (SE = 0.01) since 1984 (Larsen & Hammond 2004, Heide-Jørgensen et al. 2012). The population of fin whales that occurs off the west coast of Greenland has also likely been increasing, but the rate is unknown due to differences in survey methodology and correction factors (Heide-Jørgensen et al. 2010d).

Overharvest has been demonstrated to cause declines for several local or small isolated populations of Arctic marine mammals (e.g. West Greenland walrus) (Taylor et al. 2002, Witting & Born 2005, Taylor et al. 2008, Hobbs et al. 2011, Peacock et al. 2011).

Besides hunting, known or potential anthropogenic threats include industrial activities such as oil and gas exploration and development (seismic exploration, drilling), commercial shipping and increased tourism, northward expansion of fisheries (with possible implications for bycatch, competition and resource depletion; e.g. narwhal and Greenland halibut), incidental mortality and serious injury caused by entanglement in fishing gear and ship strikes (e.g. bowhead whales), hydroelectric development (e.g. beluga whales in Hudson Bay), concomitant increases in underwater noise (Moore et al. 2012b), and industrial and urban pollution (Laidre et al. 2008a).

Possible conservation actions

- The variety of legislation, regulations and policies across the circumpolar Arctic needs to be harmonized, ideally with the assistance of the Arctic Council. Environmental legislation and regulations vary in strength and intensity across jurisdictions. These include: (1) environmental impact assessment for major industrial projects, (2) endangered species protection, (3) harvest management, (4) marine transportation safety, pollution and routing regulations, (5) offshore oil and gas drilling and extraction standards, and (6) identification of responsibility for providing resources for necessary studies before new anthropogenic activities occur.
- Previously depleted populations of harvested Arctic mammal species, and of species currently well below historical levels, need to be recovered wherever possible, especially where there is high likelihood that excessive human harvesting was (e.g. SW Greenland beluga), or still is (e.g. W Greenland walrus), a major factor in reducing abundance. The international moratorium on commercial whaling appears to have facilitated the recovery of some bowhead whale sub-populations (George et al. 2004, Heide-Jørgensen et al. 2007).

Chapter 4. Birds

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In the Nearctic, breeding snow geese have expanded southwards along the coast of Hudson Bay (Mowbray et al. 2000), and Canada geese have expanded into W Greenland where they continue to increase (Malecki et al. 2000).

In Greenland, there are two examples of recent northward range expansions of duck species: common eiders have expanded their range within Greenland (Boertmann & Nielsen 2010), and Eurasian teal together with northern pintail have recently been breeding or supposed to breed, respectively, in Greenland (Boertmann 1994, Glaisher & Walsh 2010, Meltofte & Dinesen 2010, Jensen & Rasch 2011).

The factors behind several eider population declines reported in the 1980s and 1990s (including populations in Alaska, Canada, Greenland and Russia) were often unknown, but in some cases involved human disturbances, excessive harvest of eggs and birds together with severe climatic events (Robertson & Gilchrist 1998, Suydam et al. 2000, Merkel 2004a). The current trend of common eider populations varies but at least some populations in Alaska, Canada and Greenland (see Fig. 1.4 in Meltofte et al., Chapter 1) are now recovering with improved harvest management as a likely contributing factor (Goudie et al. 2000, Chaulk et al. 2005, Gilliland et al. 2009, Merkel 2010, Burnham et al. 2012).

Black-legged kittiwake, an abundant species throughout circumpolar Arctic and Boreal waters, has shown significant population declines almost throughout the Atlantic sector of the Arctic, especially around the Barents Sea (Barrett et al. 2006), in Iceland (Garðarsson 2006) and in W Greenland (Labansen et al. 2010), as well as farther south, in Britain (Frederiksen et al. 2004b).

The population of thick-billed murres in central W Greenland is much depressed compared with numbers in the early 20th century, as a result of heavy harvesting of adults at colonies (Evans & Kampp 1991, Kampp et al. 1994) and perhaps, drownings in gill-net fisheries (Tull et al. 1972; but see also Falk & Durinck 1991, Kampp 1991 and Kampp et al. 1994). Furthermore, it shows no sign of recovery, with the population south of Thule District remaining at < 20% of historical levels, and at least 18 out of 31 small and large colonies having been exterminated (Kampp et al. 1994 and unpubl., F. Merkel unpubl.; see also Box 18.5 in Huntington, Chapter 18). Numbers in E Greenland, although small, have also declined.

With the exception of overharvest dealt with in Section 4.5.2.1, the causes of population and range changes can rarely be confidently attributed to a single source. The decline of ivory gulls in the Canadian Arctic illustrates a case where several potential contributory causes can be identified: mortality from hunting of adults in Upernavik District, Greenland (Stenhouse et al. 2004), high levels of mercury in eggs (Braune et al. 2006) and changes in ice conditions associated with global warming (Gilchrist et al. 2008, Environment Canada 2010). All may have contributed to the recent population decline, although shooting of ivory gulls in Greenland is thought to have declined since the 1980s when most band recoveries occurred (Gaston et al. 2008, Gilchrist et al. 2008).

Parasites and predators may be more mobile in response to climate change and may initiate or expand their activities at new sites. Some examples of such expansions have already been observed,
with an increase in the incidence of tapeworms in alcids in Labrador and Greenland since the 1960s (Muzaffar 2009), and the appearance of the parasitic tick Ixodes uriae on murres in Svalbard after 2000 (Coulson et al. 2009). The implications of these parasite range expansions are not yet clear, but adverse consequences for the seabird populations involved are possible (see also Hoberg & Kutz, Chapter 15).

The Arctic is an important area for marine bird diversity and endemism. Most Arctic seabird populations for which information is available over several decades have shown negative trends in recent years. These trends are superimposed on a situation where several important populations were substantially depressed by anthropogenic mortality, compared with numbers in the first half of the 20th century (especially thick-billed murres in Greenland and Novaya Zemlya).

Possible conservation actions

- … The overharvesting of Arctic birds is a problem mainly of inhabited regions, principally in the sub-Arctic or the fringes of the Arctic. In some cases these problems are either solved or on the way to solution: eider populations affected by over-harvesting in the late 20th century are recovering, and the greatly diminished population of thick-billed murres in Novaya Zemlya has stabilized.

Chapter 6. Fishes

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The large fisheries for Atlantic cod along the west coast of Greenland collapsed in the early 1970s, but a positive trend in recruitment has been observed in inshore waters since 2005 (Fig. 6.15; GINR online).

In Greenland, the fishery for northern shrimp forms the local socioeconomic base, and in 2011 the scientific TAC was set to 120,000 tonnes (Fig. 6.15; GINR online). Bycatches are estimated to be about 1% of the shrimp catches and consist almost solely of the vulnerable redfishes.

Possible conservation actions

- Fishing gear technology designed for sustainable fisheries in Arctic waters is poorly developed. Multidecadal datasets from the North Sea unequivocally demonstrate that
conventional bottom trawl fisheries for groundfishes are extremely efficient but also highly damaging to the environment, as they impoverish, perturb and change the functional composition of benthic communities (Tillin et al. 2006, Thurstan et al. 2010). Arctic fish species are largely bottomliving and territorial (Karamushko 2012), and since Arctic groundfish fisheries are expected to increase in coming years, less harmful fishing technologies should be developed and used to minimize bycatch and seabed destruction.

- Abrupt shifts in abundance trends are warning signals for conservation. Therefore, accurate bycatch statistics in upcoming Arctic fisheries are crucial and call for adaptive monitoring plans and policies to meet conservation aims (Lindenmayer et al. 2012). A range of management policies for marine fisheries are in operation worldwide (Pitcher & Lam 2010), and fisheries founded on balanced rather than selective harvesting are currently debated (Garcia et al. 2012, Borrell 2013). No single harvesting practice is foolproof. But any management policy would be desirable if it relies on the principle of full accountability – that is a procedural change from the present-day selective fishing and fixed landing quotas of targeted species to catch quotas that embrace the entire biomass extracted from the sea, i.e. targeted and non-targeted species alike. For example, catch quota management (CQM) seems a promising policy that has been tentatively implemented in the North Sea fisheries (Kindt-Larsen et al. 2011, Schou 2011). Combined with taxonomic expertise on non-targeted Arctic species, CQM may well be the immediate and first step toward obtaining credible and urgently needed bycatch data as a precautionary measure for upcoming Arctic fisheries.

Chapter 8. Marine Invertebrates

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A limited number of crustaceans are commercially and/or subsistence-harvested in the Arctic. Examples include fisheries of the northern shrimp, which brings substantial income to Greenland and Norway.

Bivalves in the shallow coastal areas and banks off the Greenland coast provide important feeding items for walrus and the two eiders, common and king eider (Born et al. 2003, Boertmann et al. 2004, Blicher et al. 2011).

Based on present knowledge we recommend protection of the following areas:

- Polynyas which are areas known to be important for maintaining seabird and mammal populations. These areas should be closed for fishing as well as petroleum extraction. The latter is necessary because it is virtually impossible to clean up oil in waters with broken ice.
• Large estuaries, which harbor several of the unique Arctic species.

Chapter 18. Provisioning and Cultural Services

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Ice cover, cold water temperatures and low primary production prevent the development of fish stocks of commercial interest in the central Arctic Ocean, whereas in the seas surrounding the Arctic Ocean there are commercial fisheries of global importance (Hoel & Vilhjámsson 2005). These areas comprise the Bering Sea and the Aleutian Islands, the Northwest Atlantic between Canada and Greenland, the waters around Greenland and Iceland, the Norwegian Sea and the Barents Sea. Although fish stocks in these oceans wax and wane as fish stocks do everywhere, in a global perspective most of the major commercial fisheries in these areas are currently comparatively well managed. Fishing is important to the local and national economies in most of these regions (Hoel & Vilhjámsson 2005; see however Christiansen & Reist, Chapter 6 for further discussion).

A warm climate during the 1930s and 1940s led to a substantial cod fishery off Greenland. With the onset of a cooling climate in the 1960s this fishery disappeared (see Fig. 6.15 in Christiansen & Reist, Chapter 6).

In Greenland […] consumption of local foods ranged from 10% of the diet of women in Nuuk to one quarter of the diet in the hunting districts of Uummannaq and Qaanaaq. The same studies found that consumption of local foods also varied by the age of the person, from an average of 13% local food for those under 30 years of age to one quarter for those older than 50 (Hansen et al. 2008). Nonetheless, traditional foods can provide the majority of many vital nutrients (protein, vitamins, minerals) in some communities (e.g. Kuhnlein & Receveur 2007).

Local wild food production operates differently in Greenland than in Canada or Alaska. The government licenses professional hunters and fishermen, who sell their products in local markets known as brædet, which have existed since the 18th century (Marquardt & Caulfield 1996). Professional hunters provide 80-90% of the locally produced meat that is consumed, with the rest coming from personal activity including sport hunting (Rasmussen 2005). The number of active professional hunters is decreasing, however, and the average age of hunters has increased sharply in recent decades. In 1987, half of the professional hunters were under 35 years of age, whereas today
Resources from marine mammals have been pivotal to Inuit and other Arctic cultures for millennia. Meat and blubber were and are used for food for humans and dogs, blubber for light and heating as well, and skin and bones for clothing and tools. Seal meat remains a most appreciated food item. Photo: Carsten Egevang.

only a quarter of the hunters are that young. Another quarter of hunters are over 55 years old. Informal exchange of hunting and fishing products in small settlements remains important, but professional hunting in Greenland is experiencing an overall downward trend (Nordregio 2010).

Improved snowmobile technology has allowed hunters to travel more quickly to traditional hunting areas (Aporta & Higgs 2005). This has allowed an increasingly urban Arctic population to continue pursuits on the land, while maintaining a lifestyle that is increasingly sedentary and removed from
daily interaction with the environment. Although improved technologies may sustain a level of interaction with the environment, this may also have negative impacts on biodiversity. **Biodiversity that was previously inaccessible and *de facto* protected from harvest may now be susceptible to overharvest** (Fig. 18.6; Due & Ingerslev 2000).

Figure 18.6. The regions of Greenland’s coastal areas that can be reached on day trips by motorboat, shown by circles with a radius of 100 km from communities of more than 1,000 inhabitants and generally bigger boats and 50 km from settlements of less than 1,000 inhabitants with generally smaller boats. The figure illustrates that no locations in the populated west coast of Greenland are out of reach for hunters (Due & Ingerslev 2000).

There is a tendency toward increasing seabird harvests for cultural or recreational reasons, rather than for basic subsistence or commercial purposes. In most countries, commercial hunting of seabirds is forbidden, but in the Faeroes, Iceland and Greenland it is legal to supplement other sources of income by domestic or local sale of seabirds (Merkel & Barry 2008).
The game species and the number of birds currently harvested, or believed to be harvested, vary enormously between the nations (see Box 18.5 Tab. 1). Over the past three decades, depending on the country, harvest levels have declined in most countries due to more restrictive hunting regulations, declining seabird populations, fewer or less active hunters, or a combination of these factors. In some countries, particularly the Faeroes, Iceland and Greenland, the decline in harvest has been drastic.

Although the impact of harvest on seabird populations is often poorly documented in the Arctic as a result of limited information on both seabird numbers and harvest levels, there is no question that it has played a key role in the population dynamics of many species. There are examples of both overharvesting causing substantial decreases in breeding populations and rapid population recovery following major changes in harvest regulation (Merkel & Barry 2008; see Fig. 1.4 in Meltofte et al., Chapter 1). There are also examples from the Faeroes and elsewhere about traditional practices that created sustainable harvests (e.g. Nørrevang 1978, 1986, Olsen & Nørrevang 2005), in addition to examples from Greenland and elsewhere over the years about rapid overhunting of eiders and other seabirds (e.g. Koch 1945).

Seabirds are often sensitive to reductions in adult survival rates since they produce small clutch sizes and have delayed maturity (Furness & Monaghan 1987). Anthropogenic stressors including overharvest have in some parts of their range caused population declines (Gaston & Irons 2010). On a local scale, such declines can also negatively affect the harvest and thus reduce ecosystem services for future generations (Falk & Kampp 2001). One example is the thick-billed murre colony in Sagdleq, close to the Greenlandic town Uummannaq, where large numbers of these birds formerly bred. Here, the population declined from at least 70,000 pairs in 1949 to zero in 1987. Many other murre colonies in Greenland have seen similar declines or extirpations, so that except for large intact colonies in the thinly populated Thule District in N Greenland, less than 20% of breeding population is currently left in the remaining Greenland colonies, compared with the beginning of the 20th century (Kampp 1994 and F. Merkel unpubl.). Perhaps in combination with large bycatches in salmon drift nets during the 1960s and 1970s (Tull et al. 1972, Falk 1998), local summer hunting close to the breeding colony has been identified as the main reason for this decline (Evans & Kampp 1991, Kampp 1994, Mosbech et al. 2009), an interpretation that is supported by a close correlation between proximity to settlements and rate of decline (Box 18.5 Fig. 1; see also Ganter & Gaston, Chapter 4).

By using this example, Falk and Kampp (2001) illustrated the way in which an unsustainable harvest of thick-billed murres can greatly reduce the goods and services to a local community for generations. They predicted that if the hunting was carried out sustainably and on the right segment of the population (young birds), the total harvest could have been up to 14 times higher over a 120 year period than the actual harvest. This corresponds to 1.3 million birds that could have been harvested instead of the approximately 70,000 pairs and their offspring that actually disappeared from the colony.
The thick-billed murre is still a very important seabird species harvested in Greenland. Today all seabird species are protected in the spring and during the breeding season. For some species such as common eider, reduced harvests have had a documented positive effect on population level (Merkel 2010b, Ganter & Gaston, Chapter 4), though for others, such as the thick-billed murre, it is unclear if existing regulations are sufficient to lead to population increases.

In Greenland and much of northern Canada, about 80% of the population lives in an urban setting, and hunting and fishing are still continuously accentuated and developed because they are considered an integral part of living in the Arctic. In W Greenland, the number of motorboats has increased tremendously (Rask 1993, Nielsen 1998, Due & Ingerslev 2000), sustaining recreational activities both near the towns and also farther away as mobility has greatly increased. In general, access to biodiversity has improved considerably with improved transportation technology (Klein 1972, Bernes 1996, Due & Ingerslev 2000). This latter trend can be attributed to cash generating activities and more secure jobs in urban areas.

Parallel to the process involving improved mobility, the number of private cabins is increasing in many regions (Bernes 1996). In 1998 in Nuuk, Greenland 150 cabins were registered. Three years later, in 2001 the number had increased by two thirds to 250 (Nuup Kommunea 2003). In order to control this interest in outdoor life, the municipality set aside special areas for recreational purposes.
In Greenland, the number of commercial hunters has been stable (around 2,700) or slowly decreasing (Department for Hunting and Fishing, Greenland, unpubl.). As the population of Greenland is rising, the relative number of commercial hunters is indeed decreasing. However, the number of recreational hunters decreased by one third from 5,455 in 1993 to 3,609 in 2010 with an extreme peak of 9,686 in 2002. This peak can be explained by management decisions and the availability of attractive target species (in this case caribou) (Grønlands Statistik 2008). The fluctuations in numbers of recreational license-holders and in their harvests indicate that this category of hunters is more open for recruitment than the category of commercial hunters, and that their harvest levels may change rapidly.

Chapter 19. Disturbance, Feedbacks and Conservation

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Most species protection falls under national legislation, or a mix of national legislation, and bilateral and international agreements. In Greenland for example, the International Whaling Commission (IWC) sets national subsistence quotas for minke whales. Narwhals and beluga whales, however, are regulated by the Canada-Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga (DFO 2008).

Full participation in biodiversity monitoring programs [CBMs] continues to be a challenge for many Arctic peoples. Greenland’s effort to increase involvement of CBM with management provides one of the promising stories becoming more common in the Arctic. The Greenland government is piloting a natural resource monitoring system whereby local people and local authority staff are directly involved in data collection, interpretation and resource management. The scheme is called Piniakkanik sumiiffinni nalunaarsuineq (Opening Doors to Native Knowledge). Four communities in Disko Bay and Umanak/Uummannaq Fjord are involved: Akunnaaq, Kitsissuarsuit, Qaarsut and Jakobshavn/Iluissat.

As in other parts of the Arctic, the communities in Greenland are widely distributed over a vast territory, and the opportunities for environmental monitoring and for implementing hunting and fishing regulations on the ground are limited. It has long been a priority of the Greenland government to increase the involvement of local citizens in the decision-making process related to
natural resources (Greenland Government 1999, Haaland et al. 2005). However, there is limited funding available for monitoring Greenland’s resources, and many species and populations are thus monitored infrequently or not at all (Nielsen 2009). There is therefore insufficient knowledge available about some wildlife populations to guide government decision making and consequently a need to supplement the existing scientist led monitoring programs with low-cost monitoring, for example through CBM.

The following are examples of how the influence and impact of the data are increasing when it comes to Arctic resource management. In each of the examples, local community observations were central to effecting changes to management regimes.

... In all three examples, it is noteworthy that the proposals if implemented will benefit the people having put them forward. International experiences however suggest that CBM also often leads to people suggesting restrictions in their own take of resources (Danielsen et al. 2007).

CBM encourages people to take a long term perspective on the use of resources through facilitating agreements at community and municipal level to increase or reduce the use of resources.

Discussion and conclusions

- **Community involvement offers a number of clear benefits, but should not replace national and other monitoring and conservation efforts, since community practices may not always be consistent with the protection of biodiversity** (see Huntington, Chapter 18).
- Tracking all potential indicators is not possible, but a robust set of measures against which progress or decline can be monitored would greatly help in providing the public and policy makers with a means of assessing whether Arctic communities, Arctic countries and the world as a whole are contributing to the conservation of Arctic biodiversity or the opposite. Without timely and unambiguous measures of performance, uncertainty will provide an excuse for inaction or for accepting greater levels of risk than are consistent with a commitment to protecting the future of Arctic ecosystems and those who use them.

See the entire report on [http://www.arcticbiodiversity.is](http://www.arcticbiodiversity.is)

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analyzing Western Palearctic/African shorebird migration strategies. He was a driving force behind the establishment of the Zackenberg Research Station in NE Greenland in 1995, where he worked for 11 seasons, initially as station manager, and during the entire period as head of the biological monitoring program. Currently, he is Senior Scientist at the Department of Bioscience at Aarhus University, Denmark, primarily engaged with research in Arctic ecology and waterbird biology. He has authored or co-authored about 600 scientific and popular articles/reports and produced 14 books. Privately and professionally, he has visited more than 100 states on all continents.

In total, this extract makes up 1.7% of the full text in the ABA, which can be downloaded here:


The press release *(in Danish and Greenlandic)* from Department of Bioscience, Aarhus University, on severely depleted populations of certain species of wildlife in Greenland is seen here http://scitech.au.dk/aktuelt/nyheder/vis/artikel/overudnyttelse-er-stadig-et-problem-i-groenland