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International Black-legged Kittiwake Conservation Strategy and Action Plan

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- Icelandic Institute of Natural History, Reykjavik, Iceland
- Ministry of Foreign Affairs, Greenland
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Executive Summary

The black-legged kittiwake (*Rissa tridactyla*, hereafter kittiwake) is a small pelagic seabird and is the most numerous gull species in the world. It has a circumpolar distribution, and breeds in the arctic and boreal zones of the Northern Hemisphere. It's breeding distribution is widespread and ranges across the North Atlantic from the west coast to the Barents Sea, including Arctic Canada, Newfoundland and the Gulf of St. Lawrence, Greenland, Iceland, Faroe Islands, United Kingdom, Republic of Ireland, mainland Norway, Svalbard, Murman Coast, Novaya Zemlya and Franz Josef Land. In the Pacific, the kittiwake breeds in the Russian Far East and Alaska, USA. The kittiwake spends most of the non-breeding period offshore. Most of those breeding in the North Atlantic spend the winter in the North-West Atlantic, over the shelf, slope and deep waters off Newfoundland and Labrador and south of Greenland, whereas the Pacific birds stay in cool, productive waters north of the North Pacific Subtropical Convergence Zone.

The kittiwake is listed as vulnerable on the global IUCN Red List of Threatened Species due to massive population declines (https://www.iucnredlist.org/species/22694497/155617539). It also occurs on the OSPAR Convention's List of Threatened and/or Declining Species and Habitats (https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats). The global kittiwake population has decreased by 40% since 1975, and there is growing concern that this decline will continue. Although currently doing relatively well in some places (e.g. in Svalbard), the European (including Iceland and Greenland) breeding population has decreased significantly since the 1980s. The small Canadian Arctic breeding population has increased slowly at an annual rate of about 1%, while the Atlantic Canada breeding population has yet to recover from severe declines in the 1990s. The Alaskan population varies, with some colonies decreasing and stable or even increasing, but overall, kittiwakes have decreased since the 1980s in Alaska. Scarce data for Russia reveals different trends with a recent (since 1980s) decline in the southern Barents Sea, and mostly stable or slightly increasing populations in areas further north and east.

The kittiwake is subjected to several actual and potential threats. These include climate change, fisheries, pollutants, oil pollution, predation, hunting, tourism and other anthropogenic disturbance. Marine ecosystem change is probably the main driver of kittiwake populations, and as kittiwakes adjust to new environmental conditions, anthropogenic pressures need to be minimized.

The goal of this strategy and action plan is to facilitate circumpolar implementation of initiatives to conserve and protect the circumpolar kittiwake population. The plan is developed by the Circumpolar Seabird Expert Group (CBird) (*https://www.caff.is/seabirds-cbird*), part of the Conservation of Arctic Flora and Fauna (CAFF) Working Group of the Arctic Council. It is one of a series developed by CBird with the others focused on Eiders, Ivory Gull and Murres. In this plan, four broad objectives (increased adult morality, reduced breeding success, habitat loss/degradation, and inadequate knowledge of limiting factors) are presented, with a fifty-five action items outlined.

Photo: Morten Ekker

Chapter 1: Introduction

The black-legged kittiwake (*Rissa tridactyla*, hereafter kittiwake) is a medium-sized pelagic seabird and the most numerous gull species in the world. It has a circumpolar distribution, and breeds in the arctic and boreal zones of the Northern Hemisphere. The kittiwake is a highly studied species, in both the Atlantic and Pacific regions. Because it is widespread and extensively studied, it was among eight species selected as a "Focal Ecosystem Component" for marine ecosystem monitoring in the Arctic (CAFF 2017). It's breeding range is widespread, in the Atlantic stretching from Arctic Canada to the Barents Sea, including Newfoundland and the Gulf of St. Lawrence, Greenland, Iceland, Faroe Islands, United Kingdom, Republic of Ireland, mainland Norway, Svalbard, across the Russian Arctic seas, except of the White Sea. In the Pacific, it stretches from the Chukotka Peninsula, and further to the south in the Bering Sea and Sea of Okhotsk to Kuril Islands and Sakhalin, the kittiwake breeds also in Alaska, USA. The global breeding population is estimated to be in the order of 4 000 000 pairs (Table 1).

The global kittiwake population has been decreasing rapidly since the 1990s, with an overall decline of 40% since 1975 (Descamps et al. 2017; BirdLife International 2018). In 2017, the species was for the first time rated as vulnerable on the global IUCN Red List of Threatened Species due to the massive population declines registered and an expected continued decrease (BirdLife International 2018). The kittiwake also occurs on the OSPAR List of Threatened and/or Declining Species and Habitats (https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats). This list is based upon nominations by contracting parties and observers to the Commission of species and habitats that they consider to be priorities for protection. The assessment of the status of species or habitats is intended to inform OSPAR's consideration of the effectiveness of the measures and actions that have been adopted and implemented by contracting parties. Therefore, the focus of the assessment should be to explore if existing measures are effective and sufficient. Thus, this circumpolar action plan will also have relevance to the measures that the contracting parties within OSPAR must report on. Europe supports more than 50% of the global breeding population, and this population has declined significantly since the 1980s (BirdLife International 2015). Both massive and more moderate declines have been observed in West Greenland, Iceland, Faroes, and mainland Norway (Labansen et al. 2010; Garðarsson et al. 2013; Fauchald et al. 2015). The small Canadian Arctic population has increased but only at an annual rate of about 1% (Mallory et al. 2009; Gaston et al. 2012). In Atlantic Canada, populations are currently generally stable, but have not recovered from declines in the early 1990s (Cotter et al. 2012). In Alaska, each region has colonies that are decreasing, stable or increasing, resulting in a patchwork of trends that in sum lean towards an overall decline (Dragoo et al. 2019). In Russia, different trends have been observed over the vast area of kittiwake breeding range with an overall tendency of recent (after a peak in the 1980s) decline in the westernmost part of the area where there has been long-term monitoring (Kola Peninsula, southern Barents Sea) (Krasnov et al. 1995; Krasnov et al. 2007a; Ezhov 2019). Scarce data from areas further to the north and east towards Sea of Okhotsk and Commander Islands indicate mostly stable and increasing populations (Stishov et al. 1991; Gavrilo and Volkov 2008; Babiy 2017; Golubova 2018; Artukhin unpublished data; Gavrilo unpublished data). The global changes in kittiwake population trends have been shown to be connected to trends in spring sea-surface temperature (SST) around colonies with declines accelerating during periods of rapid ocean warming (Descamps et al. 2017).

Despite its large range and numbers, there are several actual and potential threats to the kittiwake. These include climate change and regime shifts that alter the productivity of the food webs in the Atlantic Ocean and Pacific Ocean that change the abundance and timing of prey available for breeding kittiwakes. Fisheries, especially of pelagic forage fish such as capelin (*Mallotus villosus*), herring (*Clupea harengus*) and sandeels (*Ammodytes sp.*), may also affect these trophic relationships, but effects of fisheries are complex and more difficult to document (Frederiksen et al. 2004; Sydeman et al. 2017; Ezhov 2019). Pollutants, oil pollution, predation, tourism, increased arctic shipping, and hunting are also factors of concern.

Chapter 2: Ecology of the kittiwake

Species information

The kittiwake is a small gull (Laridae), 38-40 cm long, weighing between 305-512 g and with a wingspan of 91-97 cm (del Hoyo et al. 1996). It is a typical white-headed gull, but is unique in having completely black wing tips and short legs (Coulson 2011). The plumage is distinctive at all ages, and the adults are characterized by a yellow beak, black legs and feet and a blue-grey mantle and upper-wing coverts, whereas the outer wing is slightly paler, with defined black wingtips. The eyes are dark brown with a narrow red orbital ring (del Hoyo et al. 1996). Non-breeding adult birds have a dusky grey crown band and nape, a darker band across the back of the head and dark marks around the eye. Immature and juvenile kittiwakes have a black zig-zag pattern across the upper wings and a black band at the end of the tail (del Hoyo et al. 1996). The kittiwake is divided in two subspecies, *tridactyla* in the North Atlantic and *pollicaris* in the North Pacific. They are fairly similar, although the *pollicaris* has a larger body size, slightly darker mantle and the tips of the primaries are more black (Coulson 2011).

Kittiwakes are long-lived birds and population trends are therefore expected to be particularly sensitive to changes in adult survival rates. Studies The average survival rate in Alaska are relatively high (0.92; Hatch et al. 1993; Golet et al. 2004) while studies in the North Atlantic it is lower (0.78-0.88) resulting in a shorter expected life span (Cam et al. 1998; Coulson and Strowger 1999; Oro and Furness 2002; Sandvik et al. 2005). This may reflect an ocean-basin contrast in life-history pattern within the species (Frederiksen et al. 2005).

Habitat requirements

Breeding habitat requirements

The kittiwake breeds on steep cliffs in single- or mixed-species colonies that can house up to hundreds of thousands of pairs. As other birds, the kittiwake has certain habitat requirements. By breeding on steep cliffs, most birds avoid ground-living predators. There are, however, observations of kittiwakes nesting on the ground in Denmark, Alaska, Britain and Russia (Rausch 1958; Coulson and MacDonald 1962; De Korte et al. 1995; Vuilleumier 1995). They also nest on man-made structures such as buildings and bridges in more urban environments and on petroleum installations offshore (Coulson 2011), and have also been found nesting in caves with guillemots (e.g. Maunder and Threlfall 1972). The colonies are in coastal areas, where the birds have easy access to the near-shore and pelagic habitats on which they depend for foraging. Along the Norwegian coast, the distribution of the largest colonies is strongly associated to the distance to, predictability and availability of fish larvae (Sandvik et al. 2016). The distribution of colonies in Alaska suggest competition among colonies and that birds from larger colonies travel farther to forage (Suryan et al. 2000; Ainley et al. 2003).

Feeding habitat requirements

Kittiwake feeding habitat requirements change throughout the year. During the breeding season, they may forage in both pelagic and coastal environments and, at high latitudes, kittiwakes may forage intensely in inter-tidal glacier fronts (Urbanski et al. 2017). During the non-breeding season, they range further offshore, and do not normally approach land. Their winter migration is highly influenced by wind systems and the distribution of suitable ocean areas where food availability is relatively high (Coulson 2011; Frederiksen et al. 2012; Orben et al. 2015). A multi-colony study of winter distribution showed that 80% of all Atlantic kittiwakes wintered in the Central and North-West Atlantic (Frederiksen et al. 2012). Kittiwakes in the Pacific wintered north of the North Pacific Subtropical Convergence Zone and aggregated in areas between large oceanic gyres where food was concentrated (McKnight et al. 2011; Orben et al. 2015).

Kittiwakes in the North Atlantic are likely to be highly dependent on calanoid copepods, but most copepods overwinter at depth and are unavailable. In the West Atlantic however, an important secondary producer *Calanus finmarchicus* is fairly abundant near the surface even in winter (Planque et al. 1997; Frederiksen et al. 2012), supporting the importance of this area to overwintering seabirds (Brown 1986). Pteropods are also known to be a favored prey of kittiwakes in that area, and Reiertsen et al. (2014) showed that the abundance of *Thecosomata* sea snails at the Grand Banks and Labrador Sea is more important for the annual variation in survival rates of adults from the southern Barents Sea than the corresponding abundance of copepods. These results support the hypothesis that kittiwake winter habitat choice is mainly determined by food availability.

Black-legged kittiwake. Photo: Alan Schmierer

Life cycle and reproduction

The kittiwake is a long-lived seabird and does not start to breed before 3-5 years of age (Suryan et al. 2000; Hatch et al. 2009). The birds are mostly pelagic during their immature stage, and in many areas they are rarely seen in close proximity to breeding sites (Hatch et al. 2009). Like many other gulls, the kittiwake lays between 1 and 3 eggs, most commonly two. Clutch size and hatching- and fledging success are all affected by a range of environmental factors (e.g. Regehr and Montevecchi 1997; Barrett et al. 2017). In general, kittiwakes breeding in more northern areas tend to lay later, coinciding with peak maximum food availability (Coulson 2011; Burr et al. 2016).

Predation

By nesting on cliffs and on isolated islands, kittiwakes are seldom subjected to predation by mammalian predators. Nevertheless, nest predation by arctic foxes (*Vulpes lagopus*), red foxes (*V. vulpes*), American mink (*Neovison vison*), and even polar bears (*Ursus maritimus*) does sometimes occur (e.g. Sklepkovych 1986). Predation by avian predators is, on the other hand, much more common and is a significant factor explaining egg and chick losses (Hatch et al. 2009; Robbins 2009; Coulson 2011; Hipfner et al. 2012). Large species of gulls, skuas, eagles, falcons, and corvids are the most common predators of kittiwakes, and may take adults, chicks and eggs (e.g. Suryan et al. 2006).

Feeding and diet

Kittiwakes are pelagic surface-feeders, feeding only in the uppermost few meters of the sea (Coulson 2011), and are therefore reliant on prey being available near the surface (Monaghan 1996). They show spatial and dietary variability in foraging habitats within and between colonies. Several feeding techniques have been recorded for kittiwakes including plunge-diving (the most common method), surface dipping, feeding on the shore, and taking fish offal. In contrast to many other gull species, kittiwakes do not feed at garbage sites on land (Coulson and MacDonald 1962). During the breeding season, they are central-place foragers, where their feeding range is limited by the need to return to the colony to relieve their partner and/or provision their chicks, with birds at large colonies flying farther than birds from small colonies (Suryan et al. 2000; Ainley et al. 2003).

Kittiwakes forage in both coastal and pelagic habitats within a range of tens to hundreds of kilometers from the colony (Goutte et al. 2014; Paredes et al. 2014; Christensen-Dalsgaard et al. 2018). In Alaska, birds in colonies near the continental shelf tend to fly to the deep water off the shelf and feed on myctophids, deep-water fish that migrate to the surface at night. Furthermore, kittiwakes in this region flew farther and changed foraging behavior to more nocturnal or crepuscular when food was lacking near colonies (Paredes et al. 2014). Kittiwakes also show foraging site fidelity to particular areas where prey are predictable (Irons 1998).

Kittiwake feeding ranges and diet vary geographically. In warmer waters, sandeels are often a common prey during the breeding season. In colder waters, such as the southern Barents Sea and off Newfoundland, capelin are a primary food item, whereas the main food items in high-arctic waters are polar cod (*Boreogadus saida*) and small crustaceans (*Thysanoessa spp.* and *Mysis spp.*); the latter sometimes occuring in large densities in upwelling areas and fjords (Coulson 2011; Dragoo et al. 2012; Vihtakari et al. 2018). In the eastern Bering Sea, offshore kittiwake distribution corresponded with age-1 walleye Pollock (*Theragra chalcogramma*) at a course scale of ~100 km, but not at finer scales (Sigler et al. 2012). In the Pacific Arctic, kittiwakes are widespread in summer and autumn, but occur in significant 'hot spots' near the Bering Strait (the gateway between the northern Bering and Chukchi seas) and over the steep slopes of underwater canyons where strong currents, fronts, and upwelling concentrate forage fish and euphausiids (Kuletz et al. 2015).

The kittiwake diet also changes during the year, and studies of stable isotopes suggest that kittiwakes switch from a fish-based diet in the breeding season to a diet primarily consisting of invertebrates in winter (Mehlum and Gabrielsen 1993; Karnovsky et al. 2008; Reiertsen et al. 2014). However, detailed knowledge about the winter diet of kittiwakes is limited.

Interspecific interactions

Kittiwakes may breed in mixed-species colonies with common guillemots (*Uria aalge*), Brünnich's guillemots (*U. lomvia*), larger gull species (glaucous gulls (*Larus hyperboreus*), glaucous-winged gulls (*L. glaucescens*), herring gulls (*L. argentatus*), great black-backed gulls (*L. marinus*)), common gulls (*L. canus*), northern fulmars (*Fulmarus glacialis*), other alcids (e.g. little auks (*Alle alle*), black guillemots (*Cepphus grylle*), pigeon guillemots (*C. carbo*), razorbills (*Alca torda*), and puffins (*Fraterula artica, F.corniculata*)), shags (*Phalacrocorax aristotelis*) and/or cormorants (*P. carbo, P. pelagicus*), as well as its conspecific red-legged kittiwake (*Rissa brevirostris*) (e.g. Maunder and Threlfall 1972). In dense colonies, there is a possibility for interspecific competition for food (Ashmole 1963; Furness and Birkhead 1984; Wakefield et al. 2014). Maniscalco et al. (2001) demonstrated interference competition between kittiwakes and glaucous-winged gulls in mixed species foraging flocks.

As a surface-feeder, kittiwakes may also profit from diving predators pushing large concentrations of prey fish to the surface (Camphuysen and Webb 1999). In the northern Bering Sea, kittiwakes follow feeding gray whales (*Eschrichtius robustus*) and actively forage at the plumes of mud and prey brought to the surface by the whales (Obst and Hunt 1990). In the Barents Sea, kittiwakes and fulmars have been observed in aggregations around feeding humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) (e.g. Decker et al. 1998). In the Chukchi Sea, kittiwakes, along with other gull species, are also found on ice floes in association with walrus (*Odobenus rosmarus*), where they have been observed taking advantage of prey that the walrus displace from under the ice (Kuletz et al. 2015).

Distribution

The kittiwake is distributed over a wide area – ranging from the High Arctic to mid-temperate latitudes across most of the Northern Hemisphere (Coulson 2011). Kittiwakes spend most of their non-breeding period offshore (Coulson 2011) and recently considerable knowledge of their wintering distribution has been acquired through the use of geolocators (Frederiksen et al. 2012; SEATRACK unpublished data).

After the breeding season, kittiwakes migrate into the large sub-arctic oceans, but in the Pacific they sometimes first move north to feed in hotspots with high concentrations of euphausiids (Kuletz et al. 2015). In the Pacific Arctic, kittiwake abundance offshore tends to decline with latitude from the northern Bering to the Chukchi Sea and declines longitudinally from the central Chukchi Sea eastwards through the Beaufort Sea (Kuletz et al. 2019). Most kittiwakes breeding in the North Atlantic spend the winter in the North-West Atlantic, over the shelf, slope and deep waters off Newfoundland and Labrador and south of Greenland (Frederiksen et al. 2012). Kittiwakes in the Pacific winter north of the North Pacific Subtropical Convergence Zone (McKnight et al. 2011; Orben et al. 2015).

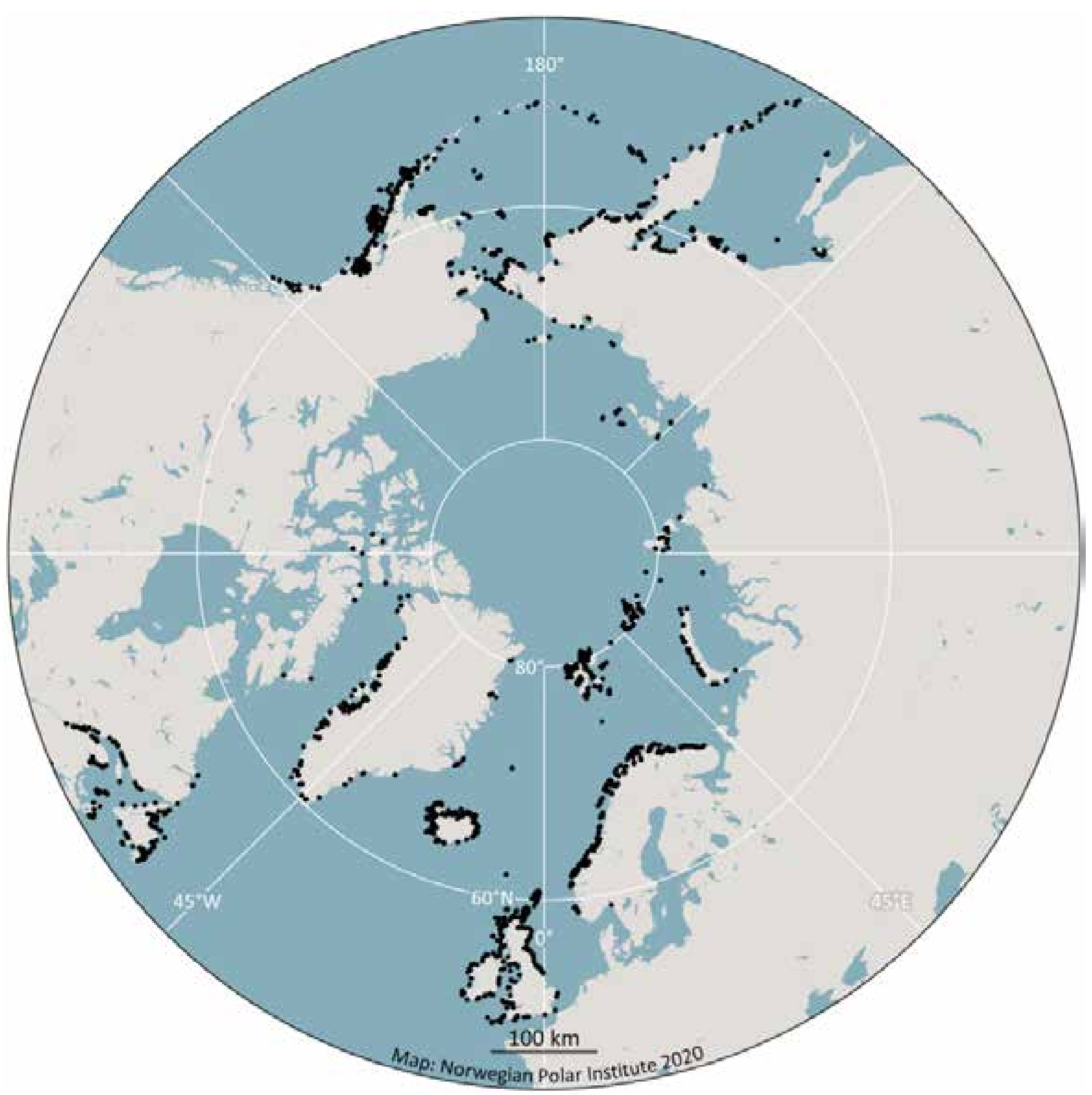

Figure 1. The distribution of kittiwake breeding colonies within the area covered by this plan: Source: CBird (Iceland - Icelandic Institute of Natural History, UK - JNCC, Faroes - TEMA NORD 2010, Norway – SEAPOP, Russia - M. Gavrilo & Y. Arthukin unpublished data, US - USFWS, Canada - Environment and Climate Change Canada, unpublished data, Greenland - Greenland Seabird Colony Database, 2020).

Canada

In Canada, the breeding distribution of kittiwakes is concentrated in two areas, and the total Canadian breeding population is estimated to be 250 000 pairs (Cotter et al. 2012; Gaston et al. 2012). In the Canadian High Arctic, the colonies are located as far west as Barrow Strait, with the largest colonies on Coburg Island, Prince Leopold Island and Bylot Island (Brown et al. 1975; Nettleship 1980; Mallory and Fontaine 2004). Further south-east, colonies are found in Home Bay and near Reid Bay in the Davis Strait (Gaston and Smith 1987). In the Hudson Strait, there are colonies on Hantzsch Island, on the SE part of Baffin Island and on the Button Islands (Nettleship 1980). The second area of concentration is in Atlantic Canada, where 88% of the population is limited to three regions: Newfoundland, Gaspé Peninsula and Anticosti Island. In Labrador, there is one small colony on Gannet Island (Nettleship and Lock 1974). Around Newfoundland, the colonies are largest and most numerous on the east coast, and more scattered on the west coast. Fairly large colonies are found in the Gulf of St. Lawrence, specifically on Anticosti Island, the Magdalen Islands, the Gaspé Peninsula and Bay de Chaleur (Chapdelaine and Brousseau 1989). Only a small portion of the population (750 pairs) breeds in Nova Scotia and New Brunswick (Kehoe and Diamond 2001; Cotter et al. 2012). Kittiwakes ringed in the Newfoundland area have been recovered in the Labrador Sea area in winter, which indicates a relatively short-range movement of Canadian kittiwakes (Gaston 2008). Kittiwakes equipped with geolocators also indicated a winter distribution not far from their colony sites, particularly in the Labrador Sea (Frederiksen et al. 2012).

United States

In the United States, the breeding population of kittiwake is limited to the state of Alaska and is estimated to be 661 000 pairs (Denlinger 2006). The northernmost colonies are found at Cape Lisburne, in the Chukchi Sea, whereas the southernmost is located at Unalga Island in the Andreanof Island group in the central Aleutian Islands (U.S. Fish & Wildlife Service 2007). Kittiwakes tend to nest in clusters of colonies on islands close to shore and on a few offshore islands concentrated in the western part of the Gulf of Alaska and the eastern Bering Sea. Fewer birds nest in South-East Alaska, the Aleutian Islands, or northern Alaska. No kittiwakes nest north of ~69˚ N in the Chukchi Sea, or eastwards into the Beaufort Sea. The Alaska population breeds at approximately 370 colony sites, with about 7% in the Chukchi Sea (7 colonies), 33% in the Bering Sea (86 colonies), 5% on the Aleutian Islands (23 colonies), 43% in Gulf of Alaska (240 colonies) and <4% in South-East Alaska (12 colonies) (U.S. Fish & Wildlife Service 2007). In the Bering Sea, colonies tend to be on offshore islands and are larger than colonies in the Gulf of Alaska on nearshore islands (U.S. Fish & Wildlife Service 2007). Kittiwakes breeding in the Pribilof Islands (St. Paul and St. George islands) spend most of the winter in pelagic sub-arctic Pacific waters at the confluence of the Eastern Subarctic Gyre and Western Subarctic Gyre. This area has a higher primary production than the Gulf of Alaska in winter, and supports a higher diversity of myctophid species (Orben et al. 2015). In Prince William Sound, a fjord-type ecosystem of the northern Gulf of Alaska, kittiwakes are one of the most abundant breeding seabirds in summer, but number drop considerably by October and the species is largely absent until March (Dawson et al. 2015). Kittiwakes breeding in the Gulf of Alaska have three different wintering strategies; resident birds that do not leave the northern Gulf of Alaska, coastal birds that move to coastal and shelf waters as far south as California, and pelagic birds that winter up to 1700 km offshore (McKnight et al. 2011).

Greenland

The kittiwake population breeding on Greenland is widespread, the largest numbers concentrated along the west coast, and fewer on the east coast (Boertmann et al. 1996). In 2008, the total breeding population in Greenland was estimated to 107 000 pairs (Labansen et al. 2010). One third of the West Greenland population breeds in the northern region where there are few but large colonies (only four colonies hold 34.5% of the West Greenland breeding population) (Labansen et al. 2010). There are many more colonies in the NW region, from Upernavik to Kangaatsiaq, but they hold only 29.5% of the West Greenland breeding population. Between Sisimiut and Nuuk (SW region), the colonies house 32.3% of the West Greenland breeding population. Even further south, on the west coast (from Paamiut to Nanortalik), are the smallest numbers of kittiwakes totaling only 3.7% of the West Greenland breeding population. In total, 246 colonies have been registered in West Greenland, and only 30 from East Greenland (Boertmann et al. in press). The colonies in East Greenland are small and numbers from several surveys conducted in 2004–2016 totaled 4800 breeding pairs (Boertmann et al. 2009; Labansen et al. 2010; Boertmann et al. in press). In winter, adult Greenland kittiwakes are found in the Labrador Sea and along the coast of Newfoundland (Lyngs 2003; Frederiksen et al. 2012).

Faroe Islands

Kittiwakes are abundant in the Faroe Islands with an estimated breeding population of 87 000 breeding pairs in 2007–2014 distributed over about 50 colonies (Olsen unpublished). Colonies are spread across the archipelago, with colonies from north to south. Large colonies (>10 000) pairs are found at Hestur, Skúvoy, Sandoy, Mykines, Stóra Dímun and Kalsoy. The kittiwakes breeding in the Faroes start to migrate to the Labrador Sea and along the coast of Newfoundland in the West Atlantic soon after the breeding season, and during the non-breeding period, the median distance from the colony to the wintering area is relatively stable at >2000 km (Frederiksen et al. 2012).

Iceland

Kittiwakes breed around the entire Icelandic coastline with an estimated population of 580 900 pairs distributed over 191 colonies (Garðarsson et al. 2013). In 2007, the largest colonies were in the Hornstrandir region in northern Westfjords, including Riturinn (191 200 nests), Hornbjarg (149 100 nests) and Hælavíkurbjarg (94 700 nests in 2004), and the region contained about half (45.5%) of the total Icelandic population. Five large colonies/clusters (> 10 000 nests around 2007) were found outside Hornstrandir: (1) Látrabjarg in western Westfjords (32 000 nests), (2) Grímsey in the north (32 800 nests), (3) Langanes peninsula in the NE (44 300 nests), (4) Westman Islands (50 200 nests), and (5) Krýsuvíkurberg in southern Reykjanes peninsula (46 600 pairs) (Garðarsson et al. 2013). The Icelandic population migrates westwards into the Atlantic ocean during their non-breeding season, with large numbers moving to the Newfoundland-Labrador shelf area and in the offshore area outside Newfoundland (Frederiksen et al. 2012).

Norway

In Norway, the kittiwake breeds both along the mainland coast and in the Svalbard archipelago. There is also a small population (< 10 000 pairs) on Jan Mayen in the Greenland Sea (Anker-Nilssen et al. 2015). The mainland population spans three different seas, with most colonies situated in the north, from the Lofoten Islands and Vesterålen in the Norwegian Sea northeast to the Russian border in the southern Barents Sea, with smaller colonies spread south to Rogaland on the North Sea coast in South-West (Barrett et al. 2006; Fauchald et al. 2015). The total mainland population was assessed to be approximately 336 000 pairs in 2005 (Barrett et al. 2006), but based on a new census made by the SEAPOP program (www.seapop.no) an estimate for 2013 was only about 87 000 pairs distributed over 360 colonies (Fauchald et al. 2015). The largest part of the Norwegian kittiwake population now breeds in Svalbard, with most birds on Bjørnøya where an estimated 135 000 pairs bred in 2013 (Fauchald et al. 2015). The species is also widespread on Spitsbergen (the largest island of Svalbard archipelago) and the surrounding islands, with numerous colonies in most areas. The total population in Svalbard (which includes Bjørnøya) was estimated at approx. 245 000 breeding pairs in 2013 distributed over 111 colonies (Fauchald et al. 2015). In total there are 340 000 breeding pairs in Norway (Anker-Nilssen et al. 2015). The Norwegian populations differ to some extent in their wintering strategies, with birds from Bjørnøya mainly wintering in Europe south of the North Sea, while most others cross over to the main wintering grounds in the western Atlantic between the Mid-Atlantic Ridge and the Newfoundland and Labrador coasts (Frederiksen et al. 2012; SEATRACK unpublished data).

Russia

In Russia, the kittiwake is the most widespread and abundant gull species and breeds in all the Russian Arctic seas except the White Sea, in the Bering Sea and the Sea of Okhotsk. The total Russian kittiwake population is roughly estimated to about 1.5 million pairs, with slightly fewer than 0.5 million pairs in the Atlantic sector (Barents and Kara seas, including Severnaya Zemlya) and slightly more than 1 million in the Pacific sector (from the Khatanga Bay in Laptev sea eastwards) (Kondratyev et al. 2000; Mitchell et al. 2004; Artukhin unpublished data). Population numbers decrease with a distance from both Atlantic, and Pacific gateways towards central Siberian shelf, i.e. smallest populations are found in the Kara Sea, Laptev Sea, and East Siberian Sea.

In the eastern part of Russia, the kittiwake is distributed from the Taimyr Peninsula (Maud Bay) to the Bering Strait and further south to the Urup Island of the Kuril Ridge and southern Sakhalin (Tyuleniy Island) in the Sea of Okhotsk. In total, there are 262 known breeding sites, but population estimates are unknown for 23 of them. 128 600 pairs (24 sites) nest on the islands and along the mainland coast of the Arctic, 767 700 pairs (129 sites) in the Bering Sea, 27 700 pairs (32 sites) on the southeastern coast of Kamchatka and the Kuril Islandsand 172 500 pairs (77 sites) in the Sea of Okhotsk (Arthukhin unpublished data). The largest colonies are in the Navarin area of the Bering Sea, where 500 000 pairs breed (Syroechkovskiy and Yakushev 2016). They winter mainly in the subarctic waters of the Pacific Ocean and the Bering Sea (Shuntov 1998; Orben et al. 2015) but, due to climate change, some now remain for the winter in the Sea of Okhotsk (Artukhin 2019).

Kittiwake in Lofoten. Photo: Magnus Irgens

In the Atlantic sector, the biggest colonies are along the Barents Sea coast of the Kola Peninsula, with up to 100 000 pairs including the biggest colony at Cape Gorodetskiy (50 000 pairs in 2000) (Krasnov et al. 2007a). More than 70 colonies have been documented along western Novaya Zemlya and in Franz Josef Land with about 300 000 breeding pairs (Strøm et al. 2016). Small populations are found in the Kara Sea offshore islands and on the Severnaya Zemlya Archipelago with about 20 000-30 000 breeding pairs (De Korte et al. 1995; Gavrilo and Bakken 2000; Gavrilo and Volkov 2008; Gavrilo unpublished data). Kittiwakes breeding on Franz Josef Land, Novaya Zemlya and the Murman Coast spend their winter in the Labrador Sea and off the coast of Newfoundland (SEATRACK unpublished). However, some birds from the southern Novaya Zemlya appear to winter in the Bering Sea (SEATRACK unpublished data, Ezhov et al. in prep.).

United Kingdom

In the United Kingdom, the largest and most numerous kittiwake colonies are found along the North Sea coasts of North-East England, eastern Scotland, the Northern Isles of Orkney and Shetland and in North-West Scotland. The total UK kittiwake breeding population (excluding Isle of Man and the Channel Islands) was estimated to be approximately 205 000 breeding pairs in 2015 (JNCC 2019). The largest gaps in their distribution are along the low-lying coastlines of South-East and southern England, North-West England, and South-West Scotland. Colony size varies from less than ten pairs to tens of thousands, but the locations of colonies tend to be traditional over many decades. Although most colonies are on sheer cliffs, in a few instances man-made structures such as buildings, bridges, sea walls and even offshore oil installations have been utilized (Mitchell et al. 2004).

Population trends

Global population estimates

The global population of the kittiwake is approximately 3 800 000 breeding pairs (Table 1). Most breed in eastern Russia and Alaska, with large numbers also in Iceland and Norway. In mainland Norway, Iceland, and parts of Greenland the populations are in massive decline, whereas populations are increasing or stable in eastern Russia. The Alaskan population is also in overall decline.

Table 1. Kittiwake population estimates.

Arctic country	No. of colonies	Historical estimate	Historical survey period	Current estimate (pairs)	Recent survey period	Reference
Canada (Arctic)	9	110 000	1957–1973	123 400	1976–2010	Gaston et al. (2012)
Canada (Atlantic)	163	-	-	123 800	1990–2007	Cotter et al. (2012)
USA	371	-	-	661 000[1]	-	Denlinger (2006)
Greenland	262	-	-	107 100	2007–2008	Labansen et al. (2010)
Faroe Island	50	220 000	1987	87 000	2007–2014	Olsen unpublished
Iceland	191	651 000	1983–1986	580 900	2005–2009	Garðarsson et al. (2013)
Norway (mainland)	360	336 000	2005	87 000	2013	Fauchald et al. (2015)
Norway (Svalbard)	111	270 000	1980-1994	245 000	2013	Fauchald et al. (2015)
Norway (Jan Mayen)	14	-	-	<10 000	2010	Strøm unpublished
Western Russia	181	-	-	430 000	1990s–2018	Gavrilo unpublished
Eastern Russia	262	-	-	1 097 000	1970s–2018	Artukhin unpublished
Total estimate				**3 552 200**		
UK, Ireland and mainland Europe[2]				247 000		Dunn unpublished
Global estimate				**3 799 200**		

Canada

Of the 4 million breeding seabirds in the Canadian Arctic (Nunavut and Arctic Québec – Nunavik), 6% are kittiwakes (Gaston et al. 2012). The Lancaster Sound/Baffin Bay region in Arctic Canada supports large populations of seabirds, but their numbers are poorly known. Most of the knowledge available is from surveys done in the early 1970s (Nettleship 1974; Brown et al. 1975; Gaston et al. 2012; Gaston et al. 2017). The same is true for colonies in the Barrow Strait region, where there was no census between 1970s and early 2000s. A small colony at Separation Point, Cornwallis Island (250 pairs in 1972) was found abandoned in 2005. The colonies at Batty Bay (Somerset Island) and Washington Point (Baillie-Hamilton Island) showed a clear increase in numbers from 700 to 10 007 pairs and from 1000 to 6273 pairs between 1972 and 2007, respectively (Nettleship 1974; Brown et al. 1975; Alliston et al. 1976; Mallory et al. 2009). Kittiwakes breeding at core sites in Atlantic Canada, especially the north shore of the Gulf of St. Lawrence and eastern Newfoundland have had similar population progressions, with an

1 Estimate given in individuals in Denlinger (2006), divided by 2 to be coherent with other estimates given.

2 Estimate derived from multiple sources: Spain, Portugal, France, Germany, Denmark, Sweden, Isle of Man and the Channel Islands from Mitchell et al. (2004); UK (excluding Isle of Man and the Channel Islands) from (JNCC 2019); and Republic of Ireland from (National Parks & Wildlife Service 2015)).

increase between the 1970s and 1990s and declines after 1990 (Cotter et al. 2012). Populations on Îles-de-la Madeleine and in the Migratory Sanctuaries along the Gulf North Shore stabilized in the 2000s. The Great Island colony in Witless Bay, Newfoundland was possibly once the largest colony in Canada with approximately 23 500 pairs between 1968 and 1994. A census in 2003 revealed, however, a substantial decrease in population size, with 64% fewer breeding pairs (Robertson et al. 2004). Other large colonies, Baccalieu Island and Gull Island, also declined extensively, although numbers on Gull Island have increased slightly since 2001 (Cotter et al. 2012). Some smaller colonies (< 1000 pairs) in Newfoundland have showed increasing trends over the last 20 years. In these colonies there are few other seabird species breeding, which may reduce predation pressure from large gulls and habitat competition with other cliff nesting seabirds (Cotter et al. 2012).

United States

In Alaska, there are approximately 370 kittiwake colony sites with 661 000 pairs (Denlinger 2006; U.S. Fish & Wildlife Service 2007). There is a patchwork of contrasting population trends over the last 30 years in the regions of Alaska. Among monitored colonies in the eastern Bering Sea, two colonies are declining, three are stable, and none are increasing. In the Western Gulf of Alaska three are declining, two increasing and three are relatively stable (Dragoo et al. 2019). Interestingly, in northern Alaska, at Cape Lisburne in the Chukchi Sea, the population has increased dramatically, and in the most southern area where there are few kittiwakes, Buldir Island colony in the Aleutian Archipelago has decreased by 50%. Overall the population in Alaska is in decline. The past three years (2016–2018) have been exceptional in that virtually all the colonies in the Gulf of Alaska and many of the others have declined drastically, coincident with the North Pacific marine heat wave, or so called " blob", in the North Pacific Ocean (Bond et al. 2015; Dragoo et al. 2019, unpublished data).

Greenland

The total breeding population in Greenland was estimated to 107 000 breeding pairs in 2008, constituting 4% of the total North Atlantic breeding population (Labansen et al. 2010). The largest colonies in Greenland are in the Qaanaaq area in North Greenland, with an estimated total of 35 000 pairs (2007), which is considerably larger than the earlier estimates of 14 000 from 1987 (Kampp 1990). However, in the 1987 survey the number of pairs were underestimated and the number of breeding birds in Qaanaaq area is considered relatively stable (Merkel et al. 2007). In North-West Greenland, the breeding population has declined significantly, indicated by both huge reductions in colony sizes and the abandonment of many others (Burnham et al. 2005; Boertmann 2006). The numbers of breeding pairs around 2008 (Labansen et al. 2010) had decreased by 79%, 39% and 76% in Uummannaq, Upernavik and the Disko Bay area, respectively, compared to earlier surveys (Boertmann et al. 1996). Limited survey effort has made it difficult to pinpoint when these declines have taken place (Burnham et al. 2005; Boertmann 2006). The Uummannaq area experienced the most drastic decline from 268 000 pairs in 1920 to 1100 pairs in 2000 (Burnham et al. 2005), although the estimate from 1920 is probably too high. Massive declines have also been documented in the Maniitsoq area in South-West Greenland, with a decline of 50% from 1970 to 2003 (Nyeland and Mathæussen 2004) and 60% in South Greenland since 1970–80s (Boertmann 2004). Surveys conducted in 2004 showed a considerable increase in the otherwise small breeding population in North-East Greenland (Gilg et al. 2005). A new survey in 2008 moderated this increase, when six of the North-East colonies were found to have declined from 700 to 302 pairs (Boertmann et al. 2009; Labansen et al. 2010). Unpublished data collected after 2008 indicate that there is no longer a uniform picture of population decline in Greenland; some colonies now appear to be increasing while others are stable or continue to decline.

Faroe Islands

The total estimated number of breeding kittiwake on the Faroe Islands is 87 000 pairs in 2007–2014 spread across about 50 colonies (Bakken et al. 2006; Olsen unpublished), but this population has declined substantially over the last three decades. All colonies have declined since the previous estimate at 160 000 pairs in 1997–1999, in total the decline is 45% (range: -7% to -94%).

Iceland

The Icelandic kittiwake population was estimated at 580 900 pairs between 2005 and 2009 and had declined by 11% (or 0.5% p.a.) since the 1983–1986 population estimate of 651 000 nests (Garðarsson et al. 2013). This decline was widespread throughout Iceland with the exceptions of a 178% increase in Selvogsbanki (Krýsuvíkurberg and Vestmannaeyjar) and Húnaflói rising from 9.54% to 18.9% (Garðarsson et al. 2013). The population increase in Selvogsbanki is probably associated with prevalent blue whiting (*Micromesistius poutassou*) diet (Freydís Vigfúsdóttir pers. com). The colonies with the largest declines are Grímsey, Mýrdalur, Ingólfshöfði and Slétta-Héraðsflói. Colonies on Grímsey and Slétta-Héraðsflói declined from about 155 000 to about 62 000 and 54 000 to 33 000 pairs from 1983 to 2009, respectively (Garðarsson et al. 2013). Population changes documented since the 1980s until late 2000s were regional, with large declines in eastern Iceland, east and south of Grímsey and Mýrdalur. In Vestmannaeyjar and Reykjanesskagi the colonies have increased by 43 000 pairs during the same period, with current population estimates of 50 000 and 53 000 pairs, respectively (Garðarsson et al. 2013). Both the timing and extent of this decline have varied regionally. Between 1993¬–94 and 2005–07, the 65 small colonies in Breiðafjörður bay, North-West Iceland decreased by 44% with the decline starting about a decade earlier than elsewhere in Iceland (Petersen 2010). This decline has been attributed to bottom-up effects as a result of rapid warming of the oceans (Descamps et al. 2017).

Norway

The largest number of breeding kittiwakes is now found on Bjørnøya, where the population is estimated at 135 000 pairs (Fauchald et al. 2015). Here numbers decreased somewhat from the late 1980s to the late 1990s but have later increased. In the rest of the Svalbard archipelago, breeding numbers increased in the 1980s to >200 000 pairs and then decreased to an estimated 109 000 pairs in 2013 (Fauchald et al. 2015). The decline however slowed down in the 2000s and the Svalbard (minus Bjørnøya) population has remained rather stable over the last 10 years (www.mosj.no).

The outlook along the Norwegian mainland is much more drastic. Huge declines in population size have been documented since the 1980s, and the decreasing trend is continuing. The most extreme declines in population size have been observed on the Norwegian Sea coast. At Runde about 60 000 pairs bred in 1980 (Røv et al. 1984) but the colony is now completely abandoned. Over the same period, the 25 000 pairs at Vedøy in Røst dropped to only 93 pairs in 2019. On the Barents Sea coast, the monitoring at Hjelmsøya and Hornøya shows that numbers have dropped by 45% and 65%, respectively, over the last 10 years (Anker-Nilssen et al. 2018). Overall, the total drop in population size since the start of monitoring in 1980 has been fairly similar in the two sea areas, with more than two thirds of the populations lost in less than four decades (Fauchald et al. 2015).

Russia

Population trends across the Russian breeding range vary at different temporal and spatial scales, regionally and locally, although very few monitoring data exist. In the eastern part of Russia, in the only Arctic monitoring point (Cape Uering on Wrangel Island), the current population remains at the level of the 1970s–1980s (Stishov et al. 1991; Babiy 2017). On the Commander Islands, the population of the colony on Ariy Kamen Island quadrupled over the 50-year period 1960–2009. The colony on the neighboring Toporkov Island that was established in the 1980s also grew until the end of the 2000s, after which it began to decline rapidly (Artukhin unpublished data). At the three monitoring points in the Tauyskaya Bay in the Northern Sea of Okhotsk, numbers have increased over the last decades, in the largest colony (Talan Island) – from 20 000 pairs in 1989 to 50 000 in 2008 (Golubova 2018).

Long-term monitoring data from the Kola Peninsula in the Western Russian Arctic has documented a long term increase during the 20th century with a peak in the 1980s (Krasnov et al. 1995; Krasnov et al. 2007b). Since 2000, kittiwakes have been monitored in three colonies along the coast of the Kola Peninsula. All colonies are in decline with interannual fluctuations. The decline was most rapid in the west (3.5% p.a. during 2000–2017 in the Gorodetskiy colony), and slowest in the east (0.2% p.a. during 2003–2013 in Dvorovaya Bay). At Cape Krutik, the decline was 1.6% p.a. during 2000–2017 (Ezhov 2019). Further to the north and east, the populations of Atlantic kittiwakes are more stable. Scarce data are available for Novaya Zemlya, where the largest number of Atlantic kittiwakes in Russia breed but, as on the Kola Peninsula, numbers increased until the 1990s (Krasnov et al. 1995). The limited recent data suggest more stable populations than in the South Barents Sea (Ezhov and Gavrilo unpublished data). In Franz Josef Land, there are long-term monitoring data from one of the large colonies, Rubini Rock, Hooker Island. There numbers increased post 1930, and with small changes over the past decade (Krasnov 2014; Gavrilo, Krasnov and Ezhov unpublished data). For other colonies within the archipelago, there is evidence of different trends, with some colonies showing signs of recent decline (portions of the colonies contain abandoned nests), while other colonies are increasing (Gavrilo unpublished data). In the Kara Sea, there are signs of stable/increasing populations and new colonization of islands (Gavrilo unpublished data). In one of the biggest colonies in the Kara Sea, Sredny Island, the population has increased from about 800 pairs in 1996 to about 2000 pairs in 2006 (Gavrilo and Volkov 2008).

United Kingdom

The first breeding seabird census of the United Kingdom (Operation Seafarer, 1968–70) estimated the UK kittiwake breeding population to be 407 000 breeding pairs (Cramp et al. 1974). By the time of the Seabird Colony Register census (1985–88), the population had increased by 24% to 504 000 breeding pairs (Lloyd et al. 1991). The most recent census (Seabird 2000, 1998–2002) counted 385 400 breeding pairs, representing a 25% decrease since the mid-1980s survey. Recent analysis of data collected on an annual basis by the Seabird Monitoring Programme, estimated that the UK kittiwake breeding population (excluding Isle of Man and the Channel Islands) may have declined by a further 46% since the last census, to approximately 205 000 breeding pairs in 2015 (JNCC 2019). The current census (Seabirds Count, 2015–2020) will provide a more accurate figure. Some of the largest declines recorded since Seabird 2000 have been in colonies in the north and NW of the UK. Colonies in Shetland and Orkney may be heading towards extirpation, with respective declines of 11.3% and 11.6% p.a. Along the east coast of the UK, the average rate of decline is much slower at an estimated 2.6% p.a. In the west of the UK, the average rate of decline is 7.5% p.a. (JNCC 2016).

Photo: Morten Ekker

Chapter 3: Factors affecting adult mortality and breeding success

Harvest

In Alaska, kittiwakes are open for hunting and egging in rural areas. In 2002–2015, an average of 2753 eggs and 1032 birds were harvested annually in Alaska with much of the harvest concentrated in a small area in northwestern Alaska (Naves 2018). Although kittiwakes were traditionally harvested in small numbers by coastal residents in Atlantic Canada, there is no evidence to suggest this practice continues, as kittiwakes are illegal to harvest by non-indigenous hunters in Canada. For indigenous groups, notably the Inuit, who have the right to take seabirds in Canada, kittiwakes are not mentioned in extensive tallies of subsistence harvest (Priest and Usher 2004; Natcher et al. 2011), indicating that harvest of kittiwakes is very low in Canada. In the Faroe Islands, kittiwakes have not been hunted for the last 50 years and the decline of the population is not thought to be due to hunting (Merkel and Barry 2008). In Greenland, there is hunting regulation of seabirds, and the kittiwake is open for hunting 1 September–31 March in the wintering area (shorter season in most other areas). Egg collection was banned in 2002. In the 1990s, around 50 000-60 000 birds were harvested annually in Greenland, but during the 2000s the harvest declined to around 5000-8000 birds a year (2004–2016, data from Piniarneq/LULI, 9 July 2017, Ministry of Fisheries and Hunting, Government of Greenland). In Iceland, the harvest of fully-grown kittiwakes has declined in the last two decades (Figure 2), whereas the egg harvest is higher but poorly documented. Kittiwakes are not harvested in mainland Norway or Svalbard. Seabird harvesting in Russia is not of primary importance for local economies and communities, but surveys have shown that limited egging and hunting of kittiwakes by locals does occur in the eastern Russia Arctic, mostly in South-East Chukotka (Merkel and Barry 2008). Currently, the overall pressure of harvesting on kittiwakes is probably not impacting the global kittiwake populations.

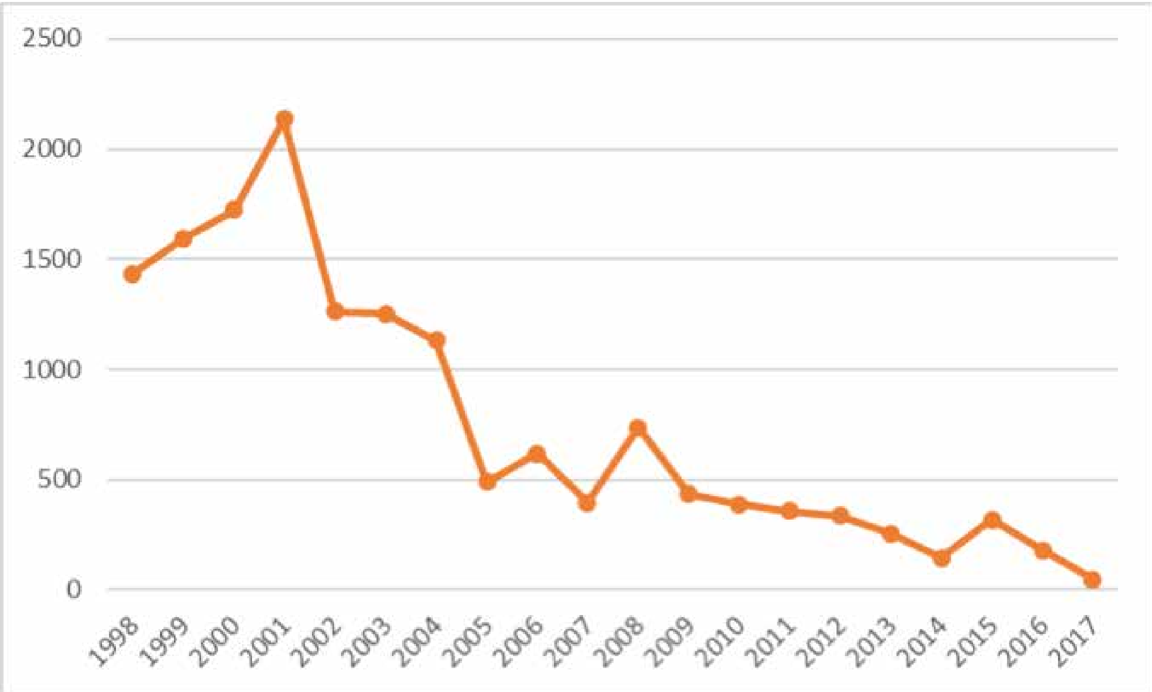

Figure 2. Kittiwake harvest in Iceland 1998-2017. Source: www.ust.is

Pollution

Oil pollution

Petroleum installations may attract and concentrate significant numbers of migratory seabirds, such as the kittiwake, due to artificial light during night, flaring and food concentrations (Tasker et al. 1986; Wiese et al. 2001; Baillie et al. 2005). Kittiwakes are abundant near and likely attracted to oil rigs, making them vulnerable to oil spills (Wiese et al. 2001). Seabirds are also sensitive to sea-surface oil pollution due to their surface-feeding strategy (Camphuysen 1998; Lieske et al. 2014). Compared to other seabirds, the kittiwake is, however, less vulnerable to oil spills; even the massive Exxon Valdez Oil Spill in Prince William Sound, Alaska had only minor, shorter-term effect on kittiwakes (Irons 1996) compared to pursuit-diving birds such as guillemots. Kittiwakes spend less time swimming on the sea-surface and do not tend to aggregate as densely as do e.g. guillemots (Ford et al. 1982). Vulnerability assessments to oil spills carried out for seabirds along the Northern Sea Route (the North-East Passage) did, however, place kittiwake in the highly vulnerable group of seabirds due to regional ecological features of the populations in Siberian seas (Gavrilo et al. 1998). Oil pollution may also have an indirect effect on the kittiwake population via a bottom-up effect, by altering the availability of prey species (Walton et al. 1997). Better legislation and oil pollution controls have, in many areas, including eastern Canada and the North Sea, reduced chronic oil pollution from oil industry and ship traffic in recent years – as reflected in the decreasing rate of oiled beached birds found on nearby coastlines (Camphuysen 2010; Robertson et al. 2014; Camphuysen 2017).

Litter and microplastic pollution

In general, marine litter and microplastic debris pose a major threat to many seabirds both through entanglement and ingestion (Azzarello and Van Vleet 1987; Laist 1997). However, lower incidences of plastic debris have been documented in kittiwakes than in other surface feeders such as northern fulmars (e.g. Poon et al. 2017). Fish often represent an important part of kittiwake diet (Hatch et al. 2009), and this may be a factor explaining the lower incidence of plastic found in kittiwakes because studies have found higher levels of plastic in birds consuming mostly crustaceans and cephalopods (e.g. Moser and Lee 1992).

The incorporation of larger plastic litter in nests has been documented in kittiwake colonies in the UK and Denmark (O'Hanlon pers. comm.; Hartwig et al. 2007). To date, there are no published reports of nest incorporation of plastic by kittiwakes in the Arctic, but it should be noted that more systematic registrations of plastic nest incorporation have recently been carried out at many Arctic colonies (O'Hanlon pers. comm.). In the Russian Arctic, plastic fragments were observed in Franz Josef Land, Novaya Zemlya, and in the Kara Sea islands (Gavrilo et al., 2020 in prep.). Highest occurrence of plastic in the nests was observed in small colonies established on buildings in abandoned polar weather stations in the Kara Sea (Gavrilo unpublished data). In North-West Denmark, plastic incorporation has been observed in up to 57% of kittiwake nests (Hartwig et al. 2007), while the general level in the UK is relatively low (> 10%) except where colonies are located near major sources of plastic pollution (harbors or dumps; O'Hanlon pers. comm.). Current levels of plastic incorporation in nests by Arctic kittiwakes is likely very low (MM, HS, SD, pers. obs.). However, given that such plastic incorporation in nests can be lethal to adults and chicks (Jagiello et al. 2019), tracking this phenomenon over time at Arctic kittiwake colonies will assess this as a potential emerging threat to the species. It will also contribute to efforts to track plastic pollution in the Arctic. Collectively, limited data to date suggest that marine plastic pollution is not a major threat to Arctic kittiwakes, but this environmental threat is expected to increase for all Arctic seabirds in the future, and the monitoring of plastics in kittiwakes and their colonies is needed.

Toxic pollutants

Kittiwake are top predators, feeding on fish and crustaceans, and are thus at risk of exposure to biomagnified toxic contaminants. Persistent organic pollutants (hereafter POPs) and heavy metals, such as mercury, can have negative effects on physiological, developmental and immune functions and have been shown to reduce both survival and breeding probability in kittiwakes (Tartu et al. 2013; Goutte et al. 2015). Large spatial variations in mercury levels in seabirds have been observed with higher concentrations found in the Canadian Arctic and Pacific waters than in Greenland and the European Arctic (Kirk et al. 2012; Albert et al. 2019). However, no spatial pattern has been revealed for mercury in kittiwake eggs sampled from the Canadian high Arctic and northern Norway (Braune 2007). Long range transported mercury and other toxic pollutants reach the Arctic along several transportation routes, including atmospheric and oceanic currents (Gabrielsen and Henriksen 2001).

High concentrations of mercury have been found in kittiwakes breeding in Svalbard, and this burden affects their breeding behavior with high levels of mercury being associated with a higher probability to skip breeding (Tartu et al. 2013). There is no evidence of decreasing levels of mercury in the Svalbard biota (Jæger et al. 2009). On the contrary, levels of mercury in Arctic seabirds have been increasing (Mallory and Braune 2012), which can impact the recruitment rate of kittiwakes (Tartu et al. 2013). Concentrations of total mercury in kittiwake eggs from Lancaster Sound (1975–2003), Canada, and northern Norway (1983–2003) have been stable. Furthermore, levels of legacy POPs in kittiwake eggs have decreased in the period 1983–2003 in northern Norway (Helgason et al. 2008; Rigét et al. 2011), and from 1975–2013 in high-arctic Canada (Braune et al. 2019).

Photo: Hallvard Strøm

Predation

One of the advantages of nesting in colonies and in cliffs is predation avoidance (Coulson 2001). Kittiwakes most often nest in locations that are relatively remote and inaccessible to mammalian predators. Avian predators such as larger gulls, ravens and raptors, may, nevertheless, have a large impact on kittiwake productivity, and can take large portions of eggs and young from nest sites. For example, the white-tailed eagle (*Haliaeetus albicilla*) population has increased greatly after being protected in Norway in 1968, and has become an indirect cause of reduced breeding success of kittiwakes and several other seabirds in many colonies in northern Norway (Hipfner et al. 2012). In Alaska, the growing Bald Eagle (*Haliaeetus leucocephalus*) population has been documented to wipe out egg production at some large kittiwake colonies year after year (Robbins 2009). Birds of prey, skuas and corvids can pose a direct threat both to adult survival and reproduction in certain areas, and can also create panic flight of adults, leaving the nest site unprotected and open for gulls and other aerial predators to take chicks or eggs (Suryan et al. 2006; Robbins 2009).

Non-native mammalian predators also pose a threat for seabirds; the most predominant are the American mink (*N. vison*) and brown rat (*Rattus norvegicus*), which have had large negative impacts especially on ground-nesting seabirds (e.g. Buckelew et al. 2011; Daunt and Mitchell 2013). As mentioned, the cliff-nesting strategy of kittiwakes has protected them from most of the predation pressure from mammalian predators. Nevertheless, in areas where mammalian predators may reach the nests, egg and chick predation does occur.

Climate change

Global climate change is more rapid in arctic regions than in the rest of the world (Meredith et al. 2019). The atmosphere and oceans are warmer, sea-surface temperature is rising, sea-ice thickness is declining and the distribution of sea-ice is changing (Meredith et al. 2019). In Alaska, warm water events have affected the Bering Sea marine ecosystem (Duffy-Anderson et al. 2019) and resulted in declines in abundance and quality of prey (Thompson et al. 2019; von Biela et al. 2019), which has likely led to large seabird mortality events (Piatt et al. 2020).

The direct effects of climate are generally rare in kittiwakes, where overheating and flooding of nests would be of low concern (Frederiksen 2010). Mass mortalities of seabirds due to extreme weather events do, however, occur and such meteorological phenomena are expected to increase in both frequency and intensity with climate change. A series of years (2015–2018) with anomalously warm ocean temperatures and little sea ice corresponded to an unusual string of large seabird die-offs in Alaska, with kittiwakes (and unidentified gull species) accounting for a small proportion of birds washed onshore. In 2018, during the second year of die-offs occurring in the Beringia region (northern Bering and southern Chukchi seas), kittiwakes accounted for 1% of dead birds (total of 1140) in June, and 28% of birds (n=67) recorded in August (COASST and USFWS, unpublished data).

For all birds examined over these four years, starvation appeared to be the cause of death, although toxins from harmful algal blooms (HABs) could not be ruled out as a contributing factor (USGS Wildlife Health Center, unpublished data). An examination of the role of HABs in the massive seabird die-off of 2015–2016 in the Gulf of Alaska found the presence of the toxin saxitoxin in the bodies of both deceased and apparently healthy common guillemots and kittiwakes, as well as in their prey (Van Hemert et al. 2020). However, the saxitoxin levels were low, and the sensitivity of seabirds to such toxins is unknown. Van Hemert et al. (2020) concluded that the impact of these toxins, which have been increasing with warmer waters, should be monitored as a potential impact to seabird populations.

Although seabirds are highly mobile, they are not always capable of escaping bad weather, especially if already in poor body condition because of limited energy supply. For pelagic seabirds in arctic areas, massive die-offs outside the breeding season may be difficult to detect, let alone to explain – as illustrated by the extreme population crash of common guillemots in the Barents Sea in the 1980s (Mesquita et al. 2015). In Alaska the large common guillemot die-off of 2015–2016 was attributed to lack of high-quality prey resulting from anonymously warm water (Piatt et al. 2020).

In general, the main impact due to changing climate is likely indirect through trophic interactions and associated changes in the abundance and distribution of main prey species (Frederiksen 2010; Ezhov 2019). Kittiwakes feed mainly on fish and crustaceans, organisms that tend to have a narrower temperature tolerance than seabirds. Hence, increasing temperatures can affect the abundance and distribution of kittiwake main prey with cascading consequences on their breeding success, productivity and phenology (Hunt Jr et al. 2002; Frederiksen et al. 2006; Moe et al. 2009; Sandvik et al. 2014). A study on long-term changes in kittiwake diet from Svalbard showed a clear increase in the abundance of sub-Arctic and Atlantic species in the chick's diet, but these changes did not appear to have any negative effect on breeding success (Vihtakari et al. 2018). A recent marine heat wave in the North Pacific, termed "the blob" (Bond et al. 2015) had devastating effects on kittiwake colonies: many declined by 50% or more and most failed to raise chicks for three years, but by 2019 more birds began to attend colonies and some bred successfully (Irons unpublished data).

Commercial fisheries

Bycatch

Fisheries may be detrimental to kittiwakes through both direct and indirect effects. Direct mortality from bycatch in fishing gear is a widespread threat to seabirds. For kittiwakes, the frequency of bycatch in various fishing gear (e.g. longlines and gill-nets) is, however, generally low compared to northern fulmars and other procellariids, and alcids, although "gull species" recorded as bycatch may include kittiwakes (Bakken and Falk 1998; Christensen-Dalsgaard et al. 2008; Anderson et al. 2011; Hedd et al. 2016).

Depleted food resources due to over-fishing

Increased industrial fisheries of pelagic forage fish such as capelin, herring, and sandeel likely pose a much larger threat to kittiwakes than mortality from bycatch. The global landings of forage fish fisheries have averaged 20 million metric tons annually since the mid-1990s (Smith et al. 2011), and a large depletion of small pelagic fish that represent the main prey for kittiwakes may be detrimental by reducing the abundance of prey available for successful foraging, offspring provisioning and survival (Sydeman et al. 2017). Unfortunately, studies on resource competition between seabird and fisheries are limited. However, a ground-breaking global study on seabirds, including kittiwakes, and fishing found a strong correlation between prey abundance and seabird breeding success and concluded that one third of the maximum recorded prey biomass is needed for seabirds to breed successfully (Cury et al. 2011). This is not because they consume that much fish, but because prey abundance needs to be above a certain threshold for the birds to feed efficiently. A study from the North Sea provided evidence of interference competition; intense fisheries on the forage fish, sandeel, in the 1990s were associated with low kittiwake breeding success (Frederiksen et al. 2004; Frederiksen et al. 2008).

Human disturbance

Disturbance from human activity may affect breeding success and survival in kittiwakes. Human presence may cause kittiwakes to desert their nests for the season or for a shorter period, giving opportunistic predators the opportunity to raid the nests (Frederiksen 2010). Direct and indirect effects of humans on kittiwake survival stem commonly from tourism and hunting/harvesting activities and could include increased commercial vessel traffic in the future.

Tourism and increased human activity

Tourism is a rapidly growing industry in the Arctic and small boats from large cruise ships bring tourists close to colonies with occasional landings (Chardine and Mendenhall 1998). Industrial development is increasing throughout the Arctic and has a large potential to disturb breeding seabirds through different effects such as pollution, noise and nearby aircraft overflights. Increasing vessel traffic through "choke points" between the Arctic Ocean and the Pacific or Atlantic sectors could affect nearby colonies as well as birds foraging at sea (Humphries and Huettmann 2014). In the Pacific, high densities of kittiwakes occur in the Bering Strait area (Kuletz et al. 2015), thus vessel activity, accidents, and spills may affect prey and foraging behavior in this narrow and important Arctic gateway. Similarly, the opening of new sea routes in the Arctic may pose additional risks to kittiwakes in many formerly pristine areas.

The overall effects of human disturbance are widespread, but not easy to quantify. Direct effects of human disturbance will most likely only affect a small portion of the total population (Chardine and Mendenhall 1998; Frederiksen 2010). Other human interactions during the breeding period occur with kittiwakes moving more and more into urban areas and nesting on man-made infrastructures. This increases the interactions between humans and kittiwakes, and may cause breeding failure mainly through increased disturbance or removal of nest sites by humans (Coulson 2011).

Human traffic may also have a positive effect, e.g. keeping avian predators away from colonies established on buildings in human communities, which in places, such as along the Norwegian mainland, may serve as breeding refuges for kittiwakes when there is an increased predation pressure from avian predators in colonies on natural cliffs (Anker-Nilssen and Aarvak 2009; Hipfner et al. 2012). Kittiwakes are thought to be at risk of collision with offshore renewable energy developments (windfarms) and, in the North Sea in particular, the scale of windfarm development may be responsible for several thousand kittiwake collisions annually. Future development of offshore windfarms might increase this risk (Trinder 2017).

Research activities

In order to assess kittiwake populations, further research and monitoring are necessary. Different census methods are used to estimate population sizes, and these have different disturbance levels. When assessing breeding success, some methods used can be interpreted as intrusive because repeated visits are required. Usually, only a small sample of individuals are studied in detail and is unlikely to have a negative impact on the kittiwake population. Obviously, any representative study presupposes a good design to minimize disturbance, a challenge that in general is easier to accomplish with kittiwakes than for many other seabirds.

Chapter 4: Management Issues and Actions

Direct problem:	Objective 1: Increased adult mortality	
Underlying problems	**Goal**	**Action**
Unsustainable harvest	Goal 1.1. Ensure sustainable harvest.	1.1.1. Regulate hunting/harvest of adults to ensure sustainable outtake, and to implement hunting/harvest moratorium for populations in decline.
		1.1.2. Reduce bycatch in hunting and accidental harvest.
		1.1.3. Monitor harvest of kittiwakes and conduct surveys to assess the impact on populations.
Illegal killing	Goal 1.2. Reduce the threat from illegal killing.	1.2.1 Support education materials and/or law enforcement efforts in support of existing regulations to prevent illegal killing.
Pollution	Goal 1.3. Reduce the threat from environmental pollution.	1.3.1. Collaborate with the Arctic Monitoring and Assessment Program (AMAP) to study and monitor contaminants that potentially can cause mortality or reproduction problems and seek ways to reduce their adverse impacts.
		1.3.2. Improve techniques and procedures preventing oil spills at sea (operational, accidental and chronical) and/or reducing ecological consequences.
		1.3.3. Introduce ship traffic regulations in order to facilitate a shift to light fuel in sensitive areas. Encourage adoption and implementation of a ban to use heavy oil fuel in Artic waters by International Maritime Organization (IMO).
Predation	Goal 1.4 Reduce predation.	1.4.1 Remove non-native predators in key breeding colonies.
Climate change	Goal 1.5. Improve the understanding of large-scale ecosystem effects of climate change by using the kittiwake as a model species.	1.5.1 Improve the understanding of the ecosystem effects of fisheries interactions and how to adjust maximum sustainable yields in terms of climate-induced changes in the food web that leads to insufficient food supply for adults.
	Goal 1.6. Increase understanding of impacts of harmful algal blooms (HABs), either through kittiwake food or direct contact with toxins associated with HABs.	1.6.1. Establish monitoring practices to track presence of HABs in marine environments and prey used by kittiwake. Conduct tests to determine dose levels of HABs toxins that affect kittiwake behavior or health, using proxy species where applicable. Work to reduce sources of HABs, such as nearshore development or discharge.
Unsustainable commercial fisheries	Goal 1.7. Reduce the negative impact of commercial fisheries on adult survival.	1.7.1. (Connected to 1.5.1.) Address how to develop sustainable commercial fisheries considering the added effects of rapid ecosystem changes due to climate change.
		1.7.2. Ensure that the management of commercial fisheries on key prey species as well as key ecosystem components is based on best available knowledge and a precautionary approach.
		1.7.3. Assess and reduce bycatch in commercial fishing activities, in possible collaboration with AMBI.
Harmful human activities	Goal 1.8. Minimize adverse effects of human activities.	1.8.1. Evaluate effects of detrimental human activity on kittiwakes and prepare guidelines to industry operations to minimize their impacts on kittiwakes.
Diseases	Goal 1.9. Monitor occurrence of diseases in seabird populations.	1.9.1. Monitor bird flu and other diseases and minimize their impacts.
Wind turbine collisions	Goal 1.10. Avoid constructing windfarms near breeding and foraging sites.	1.10.1. Ensure key feeding grounds and breeding sites are identified and taken into account in environmental risk assessments of the development of wind farms (on land or at sea).

Direct problem:	Objective 2: Increased breeding success	
Underlying problems	**Goal**	**Action**
Unsustainable harvest	Goal 2.1. Ensure sustainable harvest.	2.1.1. Strict regulations of egg collecting; collaboration options with AMBI should be considered.
Predation of eggs and chicks	Goal 2.2. Reduce predation.	2.2.1 Remove introduced invasive species.
		2.2.2. Perform risk analyses/assessments to identify and prioritize areas with introduced species.
Disturbance	Goal 2.3. Limit human disturbance to a level that does not decrease breeding success.	2.3.1. Identify significant risks of disturbance activities and sensitive locations.
		2.3.2. Develop guidelines (codes-of-conduct) for potentially harmful organized activities near colonies e.g. tourism, research (all fields), harvest, air- and ship traffic as well as individual activities such as kayaking, fishing etc.
		2.3.3. Introduce area restrictions for high risk activities and promote regulations in adequate formats.
		2.3.4. Improve and standardize methods for Environmental Impact Assessments.
		2.3.5. Increase the knowledge on impacts of marine installations on seabirds (noise, light, pollution etc.).
		2.3.6. Execute spatial planning and environmental assessments taking seabird management priorities into account.
		2.3.7. Create no-conflict artificial nesting sites in locations where kittiwakes have moved into human settlements.
Competition with fisheries	Goal 2.4. Reduce the negative impact of commercial fisheries on breeding success.	2.4.1. Ensure industrial fisheries of pelagic forage fish such as capelin, herring and sandeel are not at a level that limits kittiwakes' food supply.
		2.4.2. Increase research into the resource competition between seabird and fisheries and how this should influence quotas.
Climate change	Goal 2.5. Reduce anthropogenic influence reinforcing the negative consequences of climate change.	2.5.1. Regulate fisheries in key feeding areas must be regulated (see 2.4.1.) as alteration in food availability and quality due to climate change and increasing sea-surface temperatures emphasize the importance of minimizing anthropogenic influence.
Pollutions	Goal 2.6. Reduce the threat of anthropogenic pollution.	2.6.1. Reduce marine litter and plastics by raising public awareness, and through facilitation of environment-friendly handling of garbage etc.
		2.6.2. Reduce the risk of local oil spills close to breeding colonies by regulating nearby human activities.

Direct problem:	Objective 3: Prevent habitat loss/degradation	
Underlying problems	**Goal**	**Action**
Direct effects of climate change	Goal 3.1. Secure breeding cliffs from erosion and sea level rise.	3.1.1. Create alternative breeding sites for kittiwakes where breeding cliffs are threatened by erosion. This might also benefit kittiwakes in terms of reduction of predation and/or human conflicts.
Habitat degradation due to offshore energy constructions	Goal 3.2. Ensure that new offshore energy development does not come in conflict with foraging habitat use by kittiwakes.	3.2.1. Use tracking and population data to prevent construction of offshore structures close to breeding sites/foraging grounds/wintering sites.
Habitat loss due to human developments	Goal 3.3. Protect and manage key habitats on land and at sea as a significant contribution to safeguard populations.	3.3.1. Prepare a summary of protected areas containing important kittiwake habitats.
		3.3.2. Evaluate the potential of ongoing tools such as the Framework for a Pan-Arctic Network of Marine Protected Areas and other mechanisms to protect habitats important to kittiwakes.
		3.3.3. Identify important kittiwake habitats on land and at sea still requiring protection and designate them under national and international systems of protected areas (e.g. Birdlife International's Important Bird Areas or OSPAR).
		3.3.4. Identify, evaluate and implement additional conservation mechanisms such as treaties, agreements, regulations, and policies of value. Consider also collaboration with AMBI.

Direct problem:	Objective 4: Improve knowledge of limiting factors	
Underlying problems	**Goal**	**Action**
Food deficiency	Goal 4.1 Improve feeding conditions.	4.1.1. Systematically identify important feeding grounds throughout the year.
		4.1.2. Identify and quantify diet during breeding and non-breeding season.
		4.1.3. Conduct comprehensive, multidisciplinary studies of environmental drivers in wintering grounds (climate and food availability).
		4.1.4. Assess the direct and indirect effects of fisheries on kittiwakes.
Lack of knowledge considering demographic parameters	Goal 4.2. Improvement of knowledge on limiting demographic factors.	4.2.1. Develop a comprehensive research agenda for each population specifying what information is most needed, how it will be used, and which countries will be involved. Relate this to the Circumpolar Seabird Monitoring Plan and evaluate if necessary.
		4.2.2. For each major kittiwake breeding population, estimate population size, productivity, adult survival rates, and identify migration routes and wintering grounds. Also investigate survival rates and distribution of the immature birds.
		4.2.3 Investigate the breeding success and population estimates for a larger proportion of the circumpolar population.
		4.2.4. Investigate the genetic structures in the different populations.
		4.2.5. Implement the Circumpolar Seabird Monitoring Plan (CBird 2015) throughout the circumpolar Arctic.
Climate change	Goal 4.3. Increase knowledge about the effects of climate change and, if possible, reduce the impact.	4.3.1. Increase research efforts considering climate change and its effect on survival and reproduction rates (seawater acidification, increased water temperatures, increased frequency of storms etc.)
		4.3.2. Increase research into the effect of diseases and parasites.
		4.3.3. Compensate climate change impact by reducing the effect of other negative drivers
Lack of information on distribution	Goal 4.4. Increase knowledge about the colonies in the Arctic.	4.4.1. Finalize an overview of the location of all breeding colonies in the Arctic.
		4.4.2. Identify important areas and generate sensitivity maps around the Arctic.
Need of information about the effects and levels of predation	Goal 4.5. Determine predation rates and the best mitigation measures to reduce the impact.	4.5.1. Investigate the magnitude and effect of predation at population level.
Need for information about the potential damage on man-made structures by breeding kittiwakes	Goal 4.6. Increase the knowledge base on damages made by kittiwakes breeding on man-made structures and the potential conflict.	4.6.1. More research is needed in order to reduce damage by kittiwake on construction and reduce conflicts with operators.

Chapter 5: Implementation Guidelines

Setting priorities

Guidelines

- √ Identify which actions are already being addressed, which actions deserve highest priority, and which of these high priority actions require or can benefit from international collaboration.
- √ Give high priority to actions likely to reveal the causes of kittiwake declines or to reverse such declines.
- √ Among new work to be initiated under the Strategy, give high priority to implement the Circumpolar Seabird Monitoring Plan (CBird 2015).
- √ Identify tasks needed to be undertaken in order to achieve priority tasks and implement this into the CBird Group Workplan.

Collaboration

Guidelines

- √ Each country should prepare a national implementation plan for the strategy giving special attention to international collaboration.
- √ Ensure that regional, local, and indigenous governments participate in developing a National Implementation Plan.
- √ Enlist the participation of local residents, indigenous communities and technical specialists at an early stage in deciding how to implement the Strategy.

Reporting

Guidelines

- √ Provide appropriate opportunities for communication between those involved in carrying out the Strategy.
- √ Report regularly to CAFF summarizing actions taken or planned by States under the Strategy.
- √ Identify mechanisms and fora to disseminate results to managers, decision-makers and the public both nationally and internationally.
- √ Provide regular national reports to CAFF on the status of national actions to implement the strategy.
- √ Assess the need to update the strategy and the national implementation plans if needed.

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