The Status of Glaucous Gulls *Larus hyperboreus* in the Circumpolar Arctic

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ABSTRACT. The entire world population of the Glaucous Gull *Larus hyperboreus* breeds in the circumpolar Arctic. Some local populations appear to be declining significantly. In this paper, we summarize the current state of knowledge on Glaucous Gull populations and trends. The total Arctic population is estimated at 138 600 to 218 600 breeding pairs (277 200 to 437 200 breeding individuals) distributed among at least 2768 colonies (many not documented). Population declines may be attributable to egg harvest, contaminants, or food shortages, but other factors operating outside the breeding season should not be excluded. We recommend collaborative conservation efforts that will include better population estimates in most countries, as well as standardized monitoring programs.

Key words: Glaucous Gull; *Larus hyperboreus*; Arctic; population status; population trends; monitoring; conservation concerns

INTRODUCTION

The entire global population of the Glaucous Gull *Larus hyperboreus* (Fig. 1) breeds in the Arctic, with a widespread, circumpolar distribution (Burfield and van Bommel 2004; Fig. 2). Although most also winter within the Arctic region, some birds disperse south towards Japan and California in the Pacific or towards northwestern Europe and the Carolinas in the Atlantic (Cramp, 1983; Gilchrist, 2001). During the non-breeding season, birds may disperse in offshore waters, where they are often associated with sea ice or the ice edge, and in association with walrus *Odobenus rosmarus* and seals near open leads and polynyas (K.J. Kuletz, unpubl. data).

Four subspecies of the Glaucous Gull are generally recognized: *hyperboreus* in the European Arctic and western Siberia, *leuceretes* in West Greenland and most of the Canadian Arctic, *barrovianus* in Alaska and east to the Mackenzie River in Canada, and *pallidissimus* from eastern Siberia to the Pribilof Islands (Banks, 1986; Liebers et al., 2004; de Knijff et al., 2005).

Glaucous Gulls breed primarily on or near the coast, sometimes a few kilometers inland. On the Taimyr Peninsula, Russia, they can breed along riverbanks more than...
100 km inland (Rogacheva, 1992; Yudin and Firsova, 2002). Breeding sites may be used by a single pair or up to more than 1000 pairs (Mineev and Mineev, 2000; Gilchrist, 2001; Strøm, 2006a; Zöckler et al., 2009). Glaucous Gull nest locations are highly variable, including grassy slopes, low islands on lakes near the coast, tops of rock stacks, and ledges on steep, inaccessible cliffs, where the gulls often nest together with other seabirds (Gudmundsson, 1955; Gilchrist, 2001). Level ground is also used on the mainland where mammalian predators are uncommon, for example, in Alaska, Arctic Canada, and Franz Josef Land, Russia.

The Glaucous Gull is a species of international responsibility for the Arctic countries, some of which (United States, Canada, Greenland, Iceland, Norway, Russia) harbour the entire world breeding population. Evidence of recent declines prompted biologists in these countries to review available published and unpublished information on this species, to examine the distribution, status, and trends of breeding Glaucous Gulls in the circumpolar Arctic. They have also examined current monitoring activities to see how well changes in the different populations are documented and to evaluate the main concerns for Glaucous Gulls.

**METHODS**

The U.S. Fish and Wildlife Service conducts the Aerial Breeding Bird Survey, a population monitoring program that includes Glaucous Gulls, in the Yukon-Kuskokwim Delta coastal region and the Arctic Coastal Plain region. The Survey has indexed the abundance, population trend, and distribution of Glaucous Gulls since 1992. The North Pacific Pelagic Seabird Database (NPPSD, 2014) includes data since 1975 on distribution of Glaucous Gulls at sea. Seasonal and spatial aspects of survey effort, which were largely opportunistic vessel-based surveys, need to be addressed before long-term trends in at-sea distribution can be examined. Pelagic survey effort in Alaska increased in 2006 and continued through 2014.

Environment Canada has also monitored Glaucous Gull breeding populations at five locations in the Canadian Arctic. However, this monitoring is typically auxiliary to focal research on other seabirds and is generally not systematic. Although research has been conducted recently on Glaucous Gulls in the Canadian Arctic (Allard et al., 2010; Wayland et al., 2010), reproductive success is monitored only once a year on Coats Island and every 2–3 years on Prince Leopold Island (Gaston et al., 2005, 2009). Distribution of Glaucous Gulls away from the breeding colonies is also recorded during opportunistic at-sea surveys (Fifield et al., 2009; McKinnon et al., 2009).

In Greenland, no monitoring program covers Glaucous Gull colonies, and data on population trends are fragmentary and not systematic. However, Glaucous Gulls are included in programs that monitor contaminants in Greenland taxa (Cleemann et al., 2000; Riget and Dietz, 2000; Riget et al., 2000; AMAP, 2005; Vorkamp et al., 2012).

In Iceland, no organized monitoring program exists for Glaucous Gulls. Individual colonies have been surveyed for numbers at irregular intervals, but until a recent census, coverage for larger areas during the same time period was limited (Petersen et al., 2014). Winter numbers and distribution are monitored annually as part of the Icelandic Christmas Bird Counts (Petersen, 1983), but no other population parameters are monitored.

In Bjørnøya, Svalbard, the number of breeding pairs (from 1986), adult survival, and breeding success are monitored annually by the Norwegian Polar Institute. In 2012 monitoring was started in Kongsfjorden, Spitsbergen (Descamps et al., 2013). Glaucous Gulls are also included in contaminant monitoring programs for Svalbard taxa.
Russia has no specific monitoring programs for Glau
cous Gulls, although some repeated surveys of abundance
have been undertaken in several locations as parts of gen-
eral seabird surveys. The recently established Russian Arc
tic National Park includes Glaucous Gulls on the list of its
seabird monitoring network.

RESULTS

Breeding Distribution

In the United States, the subspecies *L. h. barrovianus*
occurs along the coast and inland in northern and western
Alaska (Fig. 3). Moving east into Canada, the subspecies
*L. h. leuceretes* occurs throughout coastal parts of Yukon,
the Northwest Territories, and Nunavut, as well as in Nuna-
vik (northern Quebec) and northern Labrador (Fig. 4). The
Glaucous Gull *L. h. leuceretes* is a widespread breeder
throughout Greenland (Fig. 5), occurring mainly in small
colonies and solitary pairs, often within or close to colo-
nies of other seabird species (Boertmann, 1994). In Iceland,
the species currently breeds principally in the northwest
(Fig. 6), in the regions of Vestfirðir, Breiðafjörður, and

Faxaflói, but the breeding range contracted considerably
through the 20th century from its former extent around
the country (Ingólfsson, 1982; Petersen, 1998; Petersen et
al., 2014). The Norwegian breeding population of Glaucous
Gulls is found on the islands of Jan Mayen (*L. h. leuc-
eretes*; Fig. 7) and Svalbard (*L. h. hyperboreus*; Fig. 8).
In Russia, the breeding range is not well documented, so only
the better-known sites are depicted in Fig. 9. Gulls breed
along the mainland coast and throughout the Russian Arctic
archipelagoes (Kokhanov, 1981; Yudin and Firsova,
2002). Two subspecies are found in the Russian Arctic: *L. h.
hyperboreus*, in the western part towards East Taimyr, and
*L. h. pallidissimus* east of the Lena Delta (~ 126° E), with an
intergrade zone between these areas (Stepanyan, 2003).

Wintering Distribution in the Arctic

During winter, Glaucous Gulls are reported in the pack
ice and polynyas of the Bering Sea as well as near the
Aleutian and Pribilof Islands (U.S. Fish and Wildlife Ser-
vice, 2009), along Newfoundland and Labrador (Brown et
al., 1975; Allard et al., 2010), and in polynyas of southern
Hudson Bay, Canada (Gilchrist and Robertson, 2000). Many birds from Canada, Svalbard, and Iceland may winter along the more or less ice-free coasts of West Greenland (Gilchrist, 2001; Lyngs, 2003; Boertmann et al., 2004). In the European Arctic, Glaucous Gulls winter along the coast and offshore in mainland Norway, the Faroes, and Iceland, and in the ice-free parts of the Barents and Greenland Seas (Petersen, 1998; Bakken et al., 2003; Strøm, 2006a).

**Population Estimates**

Population estimates for Glaucous Gulls are difficult because of the large extent and remote nature of the breeding range, and their numbers are poorly known, except for Iceland. The most up-to-date information suggests that there are more than 2768 colonies in the circumpolar Arctic, supporting between 138,600 and 218,600 breeding pairs of gulls (Table 1). Many seabirds skip breeding in some years (Hamer et al., 2002), so the total breeding population could be more than 437,200 breeding individuals, and there are also many immature birds and other non-breeders.

Probably 100,000 individuals have been reported for Alaska (U.S. Fish and Wildlife Service, 2009), but only 158 colonies have been documented (Seabird Information Network, 2012). Of these, 132 colonies have population estimates that total about 8000 individuals, and only 36 of these colonies have been surveyed since 1992.

Gilchrist (2001) estimated 69,000 individuals distributed in at least 1000 colonies in Canada, but this estimate was based on coarse data from the 1970s and probably included some Iceland Gulls *Larus glaucopterus*. Gaston et al. (2012) revised this estimate downward to 25,000 individuals, acknowledging that this number is likely a minimum estimate.

The Greenland Seabird Colony Register includes 830 colonies or breeding sites, totaling approximately 12,000 pairs. However, like the Canadian figure, this is an underestimate, as many solitary breeding pairs and colonies smaller than five pairs are not included. Thus, the population estimate of 20,000–100,000 pairs given by Boertmann et al. (1996) is still the best available for Greenland.

In Iceland, the breeding population was estimated at 3500 pairs in 1955 (Gudmundsson, 1955), and two decades later it was thought that the Breiðafjörður region alone...
supported 3500 breeding pairs (Gardarsson, 1973). The population estimate later increased to 10000 pairs (Ingólfsson 1982), but by 1995 it was reassessed downwards to 8000 breeding pairs (Asbirk et al., 1997; Petersen, 1998), with the largest colony supporting 1400 pairs. In 2005–09, a new census of Glaucous Gulls in the principal breeding areas in Iceland suggested only 2400 breeding pairs, distributed among 245 breeding locations, which includes sites of single pairs and some of possible hybrid pairs with Herring Gull Larus argentatus (Petersen et al., 2014).

In Svalbard, a total 230 colonies are known (SCRIB, 2009), most of which are on the west coast of Spitsbergen and Bjornoya. Estimates based on the 1980s and 1990s censuses in Svalbard suggest a total breeding population of up to 10000 pairs (Mehlum and Bakken, 1994; Strom, 2006a), but new surveys in 2005–12 indicated a population size close to 4000 pairs (Strom, 2006b; H. Strom and S. Descamps, unpubl. data). On Jan Mayen, a census in 2010 documented a minimum of 181 breeding pairs in 40 colonies (H. Strom, unpubl. data).

Only a rough population estimate of approximately 50000 breeding pairs can be provided for the entire Russian Arctic, with more than 20000 hyperboreus and 30000 or fewer pallidissimus. No overall historical estimates are available, nor have broad-scale surveys been conducted in the western part of the species’ range. Most regional population estimates must be considered crude at present (summarized in Table 2). On the basis of data from 1936 to 1994, Bakken and Tertitski (2000) estimated that on Novaya Zemlya, there are at least 55 colonies with at least 1000 breeding pairs, which is undoubtedly an underestimate since many areas were not surveyed. An estimate based on data collected before the 1990s gave more than 100 colonies with ~500 pairs on Franz Josef Land (Bakken and Tertitski, 2000). A recent estimate gave more than 70 colonies with probably 2000–3000 pairs (M. Gavrilo, unpubl. data). The previous estimate for the southeastern Barents Sea was at least 1500 pairs (Bakken and Tertitski, 2000), but a recent update provided data for up to 1900 pairs in two locations (Mineev and Mineev, 2000; Zöckler et al., 2009). Farther east, in the Kara Sea, the limited data suggest more than 75 recorded colonies, most of them in the Severnaya Zemlya archipelago (Gavrilo and Bakken, 2000), and numbers estimated at under 1000 pairs (de Korte et al., 1995).
Population Trends

Since 1992, aerial breeding bird surveys of the Arctic Coastal Plain (northwestern Alaska east to the Alaska–Canada border) have documented Glaucous Gull populations, providing indices between 10,000 and 20,000 birds, with a mean population index of about 13,000 that was considered stable from 1992 to 2006, but increased from 2001 to 2010 (Larned et al., 2011). Over this same time period (1992 to 2010) in western Alaska, estimates of the population have fluctuated around a mean of about 38,000 birds (annual range 21,000–67,000; Platte and Stehn, 2009).

Surveys in Canada have not been conducted systematically or annually, as in Alaska, but sporadically and often ancillary to other research. Around the Belcher Islands (56° N, 79.5° W), Gilchrist and Robertson (1999) found a 50% decline in breeding numbers from 1985 to 1997. At Diggles Sound (62.5° N, 78° W) from 1980 to 2008, A.J. Gaston (unpubl. data) documented a decrease of about 50% from the initial ~55 nests at this colony. On nearby Coats Island (63° N, 82° W), one of two colonies has remained stable (Gaston et al., 2009) while at the other, Glaucous Gulls disappeared between 1979 and 1995 (Gaston and Ouellet, 1997). At Prince Leopold Island (74° N, 90° W), monitoring has suggested an 80% decrease in breeders from 1975 to 2008, and only a few tens of pairs remain at present (A.J. Gaston, unpubl. data). Annual Christmas Bird Counts in eastern Canada suggest a 6.6% (± 1.6%) annual decline in Glaucous Gull numbers during the period 1980–2010. While the population had seemed to be increasing through the 1980s and into the 1990s, declines appeared to occur in the mid-1990s. On the other side of the North Atlantic, numbers of wintering birds in the United Kingdom have remained relatively stable over a similar time period (Balmer et al., 2013). In the western Canadian Arctic, anecdotal evidence suggests that numbers have declined, but these estimates are not based on systematic surveys.

In contrast to the declining population trends near Canadian seabird colonies, informal interviews with Inuit hunters in several local communities in Nunavut (Resolute Bay, Grise Fiord, Iqaluit, Arctic Bay) indicate that there are now many more Glaucous Gulls resident through the spring and summer than was the case in the past several decades (M.L. Mallory, unpubl. data). However, neither aerial surveys nor interviews give evidence of new breeding colonies appearing near communities.

In West Greenland, 86 colonies were surveyed more than once in the period 1988–2008, with 45 (52%) colonies unchanged, 17 (20%) increasing, and 24 (28%) declining. Local surveys provide more insights. In Upernavik municipality (72°–75° N), 15 colonies supported 329 pairs in 1965, but this number had increased to 419 pairs by 1994 (Joensen and Preuss, 1972; Boertmann et al., 1996). Surveys of the fjords south of Disko Bay (67°–69° N) between 1954 and 2005 suggested overall increases in gull numbers (Boertmann, 2006). In southwest Greenland (south of 61° N), three colonies decreased in numbers since the previous survey, while six new colonies were established, resulting in an overall increase of almost 100% in the number of pairs (Boertmann, 2004). Collectively, the few data available on Glaucous Gulls in West Greenland indicate a slight positive trend, an impression also shared with biologists by people living in Greenland during collaborative research work or informal interviews in communities.

In Iceland, data suggest that a serious decline occurred concurrent with climatic amelioration during the first half
of the 20th century (Gudmundsson, 1955). An increase occurred in the latter half of the 20th century until the mid-1990s (Petersen, 1998), after which a decline took place. In 2005 a census was carried out in one of two main breeding regions in Iceland, along the coast of the Breiðafjörður Bay in the west. A major decline had occurred (from 3500 pairs in 1973 to 1210 pairs in 2005), but during part of that period the population increased (Petersen, 1998). In the northwest peninsula, only 1081 pairs were estimated in 2007 – 09, although this area had previously supported an estimated 3500 pairs (Gardarsson, 1973). Around 2007, the total Icelandic Glaucous Gull population was estimated at 2400 breeding pairs, representing a population decline of around 75% since 1995 (cf. Asbirk et al., 1997).

Little is known about trends in the Svalbard population as a whole. The population on Bjørnøya has declined since 1980, when it was estimated at 2000 breeding pairs (Franeker and Luttik, 1981; Bakken and Mehlum, 1988). A survey in 2006 gave approximately 700 pairs, or a 65% reduction (Strøm, 2007). A survey of the island Hopen in 2012 indicated a 75% reduction in the number of breeding pairs, from 1000 pairs in 1985 to 239 in 2012 (S. Descamps, unpubl. data). In northern Chukotka, the population is increasing (Belyaka Spit in Kolyuchinskaya Bay; Tomkovich and Soloviev, 2012) or stable (Chaun Delta; Solovyeva, 2012). In the Chaun Delta, a stable population was observed even under conditions of increasing numbers of the Vegae Gull Larus vegae but decreasing numbers of Sabine’s Gull Xema sabini (Solovyeva and Zelenskaya, 2015).

Conservation Concerns

Various conservation concerns exist for this species and differ by location across the circumpolar North.

In Alaska, Glaucous Gulls face few conservation concerns from humans primarily because of their remote breeding locations. The harvest of birds and eggs is the main issue at present, but rural residents can legally harvest Glaucous Gulls for subsistence purposes. Between
1995 and 2005, the total estimated annual harvest of Glaucous Gull eggs increased from 17700 eggs and 800 birds to 36700 eggs and 2100 birds (these figures may include Glaucous-winged Gulls *L. glaucescens*). This harvest, which takes place primarily in Bristol Bay and the Aleutian and Pribilof Islands, represents about 25% of the total seabird egg harvest and about 1% of the total seabird harvest in Alaska (Wohl et al., 2008).

Glaucous Gulls are taken incidentally in groundfish fisheries in the Aleutian Islands and Bering Sea regions, although mortality estimates combine all large gull species. Bycatch of these gulls decreased from 2400 birds per year (22% of seabird bycatch) in 1993 to 800 birds per year in 2010 (derived from NOAA, 2006, 2011).

In the Aleutian Islands, increasing vessel traffic through the Great Circle route could increase the risk of shipping accidents and spills. At the northern end of the Bering Sea, longer periods of ice-free conditions, oil and gas exploration, and predicted increases in vessel traffic could increase impacts and risks.

In Canada, changes in numbers, especially the steep decline at Prince Leopold Island, have created concern. Reproductive success at Prince Leopold Island has been low compared to Coats Island, where the population is stable (Gaston et al., 2005, 2009). Among Canadian Arctic marine birds, Glaucous Gulls have relatively high contaminant levels (Braune et al., 2002; Buckman et al., 2004), but not as high as those in Svalbard, where negative effects on physiology and behavior have been found (Bustnes et al., 2003; Bustnes, 2006; Verreault et al., 2007, 2008).

Studies from two Canadian colonies suggest relatively low survival rates for Glaucous Gulls (Gaston et al., 2009; Allard et al., 2010). Some years with high mortality have been reported, perhaps related to gulls’ scavenging on carcasses infected with avian cholera (Allard et al., 2010). Some Glaucous Gulls have also been found dead but apparently in good physical condition, with no obvious cause of mortality (Mallory et al., 2009a).

There are no immediate concerns for the Glaucous Gull population in Greenland. Hunting is allowed outside the breeding season, and egg collecting is allowed until 15 June. Commercial egging of gulls (Great Black-backed Gulls *Larus marinus* and Glaucous Gulls) was allowed in spring 2009, which may give reason for some concern, but no information is available on the numbers harvested. In the long run, climate change may negatively affect the population in the southwestern parts of Greenland, where the temperate Herring Gull, and especially Lesser Black-backed gull *L. fuscus*, have established breeding populations in recent decades (Boertmann, 2008).

In Iceland, the large decline in Glaucous Gulls remains unexplained. Adults and eggs are harvested, but this harvest has diminished in recent decades. From 1995 to 2002, on average 3847 birds (range: 2471–5496) were killed annually as pest species, but this average declined in 2004–11 to 1722 birds (range: 1124–2407). This harvest was less than half that in the preceding period and mirrors the observed population decline (Petersen et al., 2014). Better care of community dumps, closure of offal disposals from fish processing plants, and better control of offal and bycatch from fishing vessels may have contributed to the observed decline of gulls in recent decades by reducing food availability. Declines at some colonies are believed to be due to Arctic foxes *Vulpes lagopus*, the population of which has greatly increased in recent decades (Hersteinsson, 2004). However, fox predation of eggs and chicks is not believed to have caused the population decline, but rather to have resulted in re-distribution of breeding pairs. The hybridization of Herring Gulls with Glaucous Gulls (Ingólfsson, 1970; Vigfús dóttir et al., 2008; Pálsson et al., 2009) and Glaucous Gulls’ continually approaching the core Glaucous Gull breeding regions (Petersen, 1998) are causes for real concern regarding the status of Glaucous Gulls as a separate species.

In Norway, contaminants and food shortages have been suggested as the main causes for concern. Glaucous Gulls on Bjørnøya, especially those specializing on eggs and chicks of other seabirds, accumulate high levels of organic contaminants. Effects on hormone production and the immune system have been documented, as well as reduced reproductive success and adult survival (e.g., Bustnes et al., 2003; Verreault et al., 2010; Erikstad and Strøm, 2012). Significant numbers of dead or dying birds have been found annually near the breeding colonies on Bjørnøya. Autopsies and analyses of environmental contaminants have shown that the birds were emaciated and contained high levels of OCP, PCB, and PBDE in the liver and brain (Sagerup et al., 2009). The high levels of contaminants may contribute to the death of weakened individuals, although it is not known whether the emaciation is triggered by high levels of contaminants or by environmental factors such as food shortage (Sagerup et al., 2009). Changes in food availability and predation or competition by a growing population of Arctic foxes and Great Skua *Stercorarius skua* may also be factors influencing the decline of the Bjørnøya Glaucous Gull population (Strøm, 2007; Erikstad and Strøm, 2012). Nothing is known about trends in the Jan Mayen breeding population.

In western Russia, most gulls breed in remote, uninhabited regions, and thus there have been few concerns for their populations. Much of the population breeds within specially protected areas (strict nature reserves or refuges) such as the Franz Josef Land Refuge, the Great Arctic Reserve, the Lena Delta Reserve, or the Wrangel Island Reserve. However, in recent years several adult Glaucous Gulls found dead on Franz Josef Land had no visible external signs explaining mortality (M. Gavrilov, unpubl. data). It is suspected that toxic contamination may explain these deaths in a situation similar to that on Svalbard.

In eastern Russia, gulls breed in regions of low human activity. Bycatch in long-line fisheries has increased in winter, mainly in the Kamchatka waters (Artukhin, 2010b). Eggs are harvested in seabird colonies in Chukotka near some settlements, but the scale of the Glaucous Gull egg harvest is unknown (Portenko, 1989).
DISCUSSION

Despite the position of the Glaucous Gull at the top of Arctic marine food webs and its role as a sentinel species for the health of the Arctic marine ecosystem (Braune et al., 2002; Sagerup et al., 2009), we have little knowledge of its population size and breeding distribution in the Arctic countries. The main exceptions are Svalbard and Iceland, where new censuses have led to better knowledge. In Alaska, Russia, and Canada, colonies are widely scattered in remote areas and often consist of single pair or a few pairs, which makes full coverage of distribution and population size difficult, even impossible, to achieve. At present, the total Arctic population is estimated at 138,600 to 218,600 breeding pairs (277,200 to 437,200 individuals); possibly the largest proportion is in Greenland, but significant populations are also found in Russia and Canada.

Although some overriding factors appear to drive consistent, long-term population trends in Arctic marine birds (Irons et al., 2008), shorter term, regional differences in population trends within a species appear typical, as do simultaneous, different trajectories among species. For example, Thick-billed Murre Uria lomvia populations are increasing in Canada (Gaston et al., 2012) but declining in Greenland (Merkel et al., 2014), while Lesser Black-backed Gulls are increasing in Greenland (Boertmann, 2008) and Ivory Gulls Pagophila eburnea have declined in both Canada (Gilchrist et al., 2008) and Greenland (Gilg et al., 2009). Black-legged Kittiwake Rissa tridactyla numbers have declined in Greenland (Labansen et al., 2010), Norway (Krasnov et al., 2007; Curry et al., 2011), and northwestern Russia (Krasnov et al., 2007), but in Arctic Canada they are apparently increasing (Mallory et al., 2009b). Northern Fulmar Fulmarus glacialis numbers appear to be in slow decline in Canada (Gaston et al., 2012), and perhaps across the North Atlantic (e.g., JNCC, 2013). Several seabird species have shown serious declines in Iceland in recent years, such as European Shag Phalacrocorax aristotelis, Northern Fulmar, Black-legged Kittiwake, Razorbill Alca torda, Thick-billed Murre, Common Murre Uria aalge, and Black-headed Gull Chroicocephalus ridibundus (Petersen and Thorstensen, 2005; Gardarsson, 2006; Gardarsson and Petersen, 2009). Conversely others have increased, such as Northern Gannet Morus bassanus, Great Cormorant Phalacrocorax carbo, and Mew Gull Larus canus (Gardarsson, 2008a, b; Thorstensen and Petersen, 2013).

In the case of the Glaucous Gull, the population has declined drastically in Canada, Iceland, and Svalbard (at least on Bjørnøya) in recent decades, although undocumented redistribution may account for some local changes. Reasons for the Glaucous Gull declines remain largely unexplained, although some possible causal factors have been identified. On Bjørnøya (Svalbard), the population decline has been related to contaminants (Bustnes et al., 2003; Sagerup et al., 2009; Verreault et al., 2010; Erikstad and Strom, 2012). At some sites in Canada, apparent adult annual survival is 84%, which is somewhat low for a large gull (Gaston et al., 2009; Allard et al., 2010). Moreover, a significant number of adult-plumaged birds have been found dead near colonies without obvious signs of cause (e.g., Mallory et al., 2009a), as was similarly observed in Svalbard. No autopsies have been performed on the Canadian birds, but these mortality events could be related to contaminants. The first analogous cases of potential contaminant mortality were observed in recent years in the Russian part of the northern Barents Sea. In Iceland, both redistribution and declines seem to have occurred; the latter are probably due to reduced food availability resulting from better controls on fish offal and bycatch.

In contrast to examples from the North Atlantic region, the limited information from the North Pacific suggests different trends. The Russian situation remains largely unknown, but there are indications of stability or even local increases in Glaucous Gull numbers. In Alaska, the available information, though limited, indicates a stable breeding population.

Clearly there are changes underway for some breeding regions or subpopulations of this species, that may be related to proximate anthropogenic factors (e.g., development of community dumps, changes in fishery discards; Bicknell et al., 2013), local conditions (e.g., increased food base, such as Barnacle Goose) and other factors that may be attributable to broader, regional environmental change (e.g., competition with other gulls due to range shifts with global warming; Boertmann, 2008). The Glaucous Gull is a top predator and scavenger and a species that can play a major role in local ecosystems (e.g., Gilchrist and Gaston, 1997; Gaston and Elliott, 2013); therefore, a better understanding of Glaucous Gull populations and trends will yield greater insights into the status of Arctic marine ecosystems.

We therefore recommend that future research should:

- Undertake more extensive and systematic surveys of Glaucous Gull colonies for better information on distribution, numbers, and trends. This information is needed to establish and improve management (Greenland, Iceland, Russia) and to enhance programs that monitor breeding (Alaska, Canada, Norway).

- Examine Glaucous Gull biology during the non-breeding period to determine the extent to which factors that affect birds during that part of their annual cycle may be responsible for population declines. Such studies could include winter (including at-sea) surveys, tracking studies for population connectivity, and studies of non-breeding ecology, such as food habits and exposure to contaminants. Studies of the non-breeding season may be particularly important as climate change reduces annual sea ice extent and duration in the Arctic.

- Enact research and monitoring programs on two of the poorly studied subspecies of Glaucous Gull, hyperboreus (in the European Arctic) and leuceretes (in
West Greenland. Both are listed on the Action Plan of the African-Eurasian Waterbird Agreement (AEWA, 2012) as requiring international attention. In particular, delineation between subspecies needs to be revisited.

The Glaucous Gull is one of 22 Arctic seabird species proposed for priority circumpolar monitoring by the Arctic countries as a species of international responsibility (Petersen et al., 2008). Collaborative conservation efforts, especially by the Arctic countries, are needed to obtain a better understanding of the population changes taking place in Glaucous Gull populations and possible causal factors. Given the regional differences in its population trends, the Glaucous Gull should be a suitable species through which to examine the factors affecting these different trends.

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