The Ross's Gull (*Rhodostethia rosea*) in North America

by

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Plate 1 An adult Ross's gull - one of the rarest and least studied seabirds in the world

ABSTRACT

The population, distribution and range of the Ross's gull in North America remain poorly understood, as does almost every aspect of its ecology and biology. It breeds at a few disparate locations in the Canadian Arctic and is an annual fall migrant in northern Alaska where tens of thousands occur in the nearshore waters of the Beaufort and Chukchi Seas, but little else is known about the distribution, habitat requirements, migratory routes and wintering areas used by this species.

In order to clarify the status of the Ross's gull in North America I sought to discover new breeding sites in the Canadian High Arctic in order to characterize nesting habitat requirements, develop a predictive model with which to identify suitable nesting habitat for Ross's gulls, and refresh outdated estimates of the number of individuals migrating past Point Barrow, Alaska. Taken together, my findings provide a comprehensive account of the current status of the Ross's gull in North America.

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GENERAL INTRODUCTION

Justification of Research

The Ross's gull was first described almost 200 years ago, and since then its reputation as an enigmatic and mysterious icon of the Arctic has only grown. Although its beauty and rarity have always captured the imagination, there is also a growing realization that this poorly known species deserves closer scientific attention despite the difficulty of studying it across its remote range. Ross's gulls are listed as a Threatened Species in Canada, and both breeding sites and possible wintering areas could be negatively affected by industrial development. One of the key mandates of the federal Species At Risk Act under which Ross's gulls are listed in Canada is to learn more about the distribution, habits, and population dynamics of this species. Given the extremely small number of known breeding sites and current lack of information on where these birds spend the non-breeding season, research on Ross's gulls has understandably been limited. This problem is compounded by the high cost and logistical difficulty of reaching even the few known sites where studies could feasibly be conducted. Compared to other North American species, the Ross's gull is still almost as poorly known as it was nearly 200 years ago. Its breeding range remains mostly speculative, its wintering grounds remain unknown, and how the Canadian population fits into the global picture is currently an unanswerable question. Despite these limitations, the need to better understand this species is a pressing and relevant concern. From a conservation standpoint, a clearer understanding of where and when Ross's gulls occur and what niche they fill in the Arctic ecosystem is an essential first step in developing relevant measures to protect and preserve this species and the habitats it relies on. As one of the very few species thought to spend its entire life cycle in the Arctic, a more detailed understanding of the ecology of Ross's gulls could also shed light on how both natural and anthropogenic changes in the environment might affect other birds living there. Finally, from a scientific point of view the Ross's gull is unique among Larids, and a better idea of how it relates to other gulls is necessary if we are to understand how and why certain traits have evolved within this group.

Historical records

The Ross's gull was first described from a specimen secured on June 23d, 1823 in Foxe Basin, Nunavut (Richardson 1825, p. 359). A second specimen was secured four days after the first, and these remained the only well-known specimens for over half a century. There is an even earlier documented (but not formally published) record of a specimen obtained in 1813 near Disko Bay, Greenland (Egevang & Boertmann, 2008), and Densley (1999, p. 31) notes that this species was mentioned as early as 1765 "in the literature of Greenland" (1999, p.30). The first well-documented specimens from the Palearctic were secured on October 14, 1879 off of Herald Island in northeastern Siberia, and although five birds were taken, only three specimens survived. "[A]t least three or four" additional Ross's gulls were secured from the same area in June and July of 1880 (Densley 1999). The next notable mention of this species in the literature is particularly significant since it described for the first time observations of flocks of birds rather than individuals or small groups. On September 28th, 1881, while stationed at Point Barrow, Alaska, Murdoch (1899) described several small flocks of Ross's gulls (and subsequently "thousands" more over the following month) all flying northeast along the coast. Although Murdoch maintained that Ross's gulls did not breed anywhere near Point Barrow, this was the first indication that a significant breeding population may exist somewhere in the eastern Palearctic. This surmise was further supported by Nansen's collection of eight juvenile Ross's gulls in the first week of August, 1894 while at sea approximately half-way between the North Pole and the Lena Delta. Nansen also recorded observations of "large numbers" of adult Ross's gulls in breeding plumage in early August, 1895 north of Franz Josef Land (Nansen 1898, p. 343).

The first published record of breeding Ross's gulls came from the Kolyma River Delta, where Buturlin (1906) found several small colonies scattered across the taiga floodplain of the lower delta in 1905. Interestingly, this record is preceded by anecdotal accounts of breeding pairs from Disko Bay in 1880 and 1895 (Egevang & Boertmann 2008). Buturlin (1906) subsequently found several more colonies in similar habitat along the Alazeya and Indigirka Rivers, and additional records followed from the Lena River delta (Degtyaryev et al. 1987), the Taimyr peninsula (Yésou 1994), and the Chaun River delta (Pearce et al. 1998). Although it is assumed that the majority of the world population of Ross's gulls nest in northeastern Russia, published records of breeding birds are still relatively few and far between, and there has been no attempt to consolidate this information. The most qualified current population estimate puts the Siberian breeding population between 45,000 - 55,000 individuals, but this is an extrapolation based on observations of only 400 individuals over three years, across an area of approximately 236,000 km^2 (Degtyaryev 1991). Based on published records, only about 1% of this estimated Siberian population can be accounted for at known colony sites. Although several known colonies in Russia have never been described in publication, the actual number of documented nesting records is certainly in the low hundreds at most (P. Tomkovitch, S. Holohan, *pers. comm.*). A more recent estimate puts the Russian population in the Russian Far East (which includes most known colony sites) at "not more than 1,000 individuals" (Nettleship et al. 2000), but this number is not explained or justified, and it seems unrealistically low particularly when considering the numbers of individuals observed on migration in Russia and Alaska (Densley 1999; Divoky et al. 1988).

Although most of the early records of Ross's gulls consist of adults in breeding plumage secured or observed during the spring or early summer in the Nearctic (e.g. Richardson 1825; Densley 1999; Egevang & Boertmann 2008), almost 150 years passed before the first published account of a confirmed breeding record from North America; a vague description of "three pairs" of Ross's gulls from Penny Strait, NU in 1976 (MacDonald 1978). This record is known to pertain to the discovery of three nests with eggs on either Middle or South Cheyne Island (M. Mallory, *pers. comm*.).

Taxonomy and phylogeny

The taxonomic placement of Ross's gull has been revised several times since its initial description. Interestingly, the species' earliest classification was surrounded by some controversy, as MacGillivray's brief initial description (1824, p. 249) pre-empted a thorough formal description of the actual type specimen commissioned and prepared (but not yet published) by Richardson (1825). MacGillivray assigned a "temporary" designation of *Larus roseus*, which as the first formally published binomial for this species remained the official name in accordance with nomenclatural protocol, superceding Richardson's subsequent description of the "Cuneate-tailed Gull" (*L. Rossii*) (1825, p. 359), which following the principle of prioirty was considered to be a junior synonym of *L. roseus*. The species was originally named to honour

James Clark Ross "in compliment to his exertions for the advancement of ornithology" (Richardson, 1825, p. 360), although the reference to Ross is now borne by the common name of the species rather than the latin binomial. This is only the case in English however, as in other languages the common name of the species invariably refers to the colour of its plumage and translates to some variation of "rosy gull" or "pink gull". The species was initially assigned to the new monotypic genus *Rhodostethia* by MacGillivray (1824, p. 249) (again, superseding Richardson's *Larus rosii*), and finally amended by Bruch (1853) to its current form, *Rhodostethia rosea.* Superficially, the Ross's gulls is unique among Larids in many respects; its plumage, ecology, behaviour and vocalizations all appear to be either completely unique or shared with only one other species (e.g. little gull (*Larus minutus*)). The Ross's gull is the only gull to have a full collar but no hood and to invariably show a distinct pink coloration; it is one of only two species thought to regularly spend its entire life-cycle in the Arctic (along with ivory gull (*Pagophila eburnea*)); and it exhibits a unique behavioural repertoire including sexual displays and vocalizations which have no counterpart in any other Larid.

Due in large part to a lack of specimens there had been relatively few attempts to assess the taxonomic placement of the genus *Rhodostethia* prior to the advent of molecular techniques. Dwight (1925), suggested that certain plumage characteristics were similar to those of the little gull (*L. minutus*). Moynihan (1955), examining behavioural traits among the Laridae briefly acknowledged the lack of available observations with which to deduce the possible relation of *R. rosea* to the other gulls in his discussion of "aberrant members of the hooded gull group" (i.e. *Hydrocoloeus*), and subsequently suggested that *R. rosea* be grouped with *L. minutus*, but reiterated that this placement could not be justified by the currently available evidence. More recently, Chu (1998) determined the phylogeny of the Laridae based on both osteological and integumentary characteristics, and determined that the clade formed by *L. minutus* and *R. rosea* exhibits a shared pattern of reduced skull ossification unique in the Laridae, and together these two species are most closely related to *L. philadelphia* (Bonaparte's gull). Based on integumentary characteristics however, he placed *R. rosea* in its own group of which it is the only member, but still retained *L. minutus* as its closest relative. The relationship between *L. minutus* and *R. rosea* as sister species was further strengthened by an analysis of mitochondrial DNA which determined that these two species form a monophyletic group, tentatively assigned to the new genus *Hydrocoloeus* (Pons et al. 2005). The proposed reassignment of *Rhodostethia rosea* to the genus *Hydrocoloeus* was rejected by both the British Ornithologists' Union (Sangster et al. 2007) and the American Ornithologists' Union (Banks et al. 2008) on the grounds that the two species are considerably diverged in most aspects of their plumage, ecology and behaviour.

Beyond the relative taxonomic placement of *Rhodostethia rosea* within the Laridae, of far greater ecological relevance is the genetic structure of the species. Although the range and distribution of Ross's gull remains largely conjectural, evidence of a stable and quite possibly reproductively isolated population in Canada raises the question that perhaps Nearctic and Palearctic populations of this species are genetically distinct. An analysis of genetic samples from specimens of *R. rosea* from both Russia/Alaska and Canada revealed that Canadian birds are weakly differentiated from, and have a lower haplotype and nucleotide diversity than, birds from Russia/Alaska (Royston 2007). Future work is needed to clarify these findings however, as several samples in this study were of unknown origin; specimens from Alaska were of migrating birds presumed to originate from Russia, but this could not be confirmed. It is particularly important to determine if the Canadian population exhibits less genetic variability because it is a recent founder population, or rather a historically isolated population whose size has been limited by environmental or other ecological constraints (e.g. Royston 2007).

Breeding range and distribution

The Ross's gull appears to breed across a circumpolar range, albeit an extremely patchy one. There are published breeding records from Canada (MacDonald, 1978; Cooke & Taylor, 1980; Béchet et al. 2000; Mallory et al. 2006), Greenland (Egevang & Boertmann 2008), at least two probable records from Svalbard (Egevang and Boertmann, 2008; Densley 1999), and from across a fairly wide range in eastern Russia (Buturlin 1906; Pavlov & Dorogov 1976; Degtyaryev et al. 1987; Yésou, 1994; Pearce et al. 1998; Densley, 1999). Remarkably, Ross's gulls in the Nearctic appear to nest in a completely different habitat than those in the Palearctic. In both Canada and Greenland, Ross's gulls often nest on gravel islands near polynyas in the High Arctic (Mallory et al. 2006), while in Russia, breeding colonies are confined to areas of heavily vegetated coastal or inland taiga within river deltas in the Low Arctic (Ilyichev & Zubakin 1988; Densley 1999). Despite the presence of both habitat types across the most of the circumpolar range of the species, there seems to be very little overlap between these two possibly discrete populations. The few exceptions include the two probable records from Svalbard of birds nesting in habitat similar to that described in records from the Nearctic, and a series of breeding records from Churchill, MB from habitat very closely matching descriptions of typical colony sites in Siberia (Chartier & Cooke 1980). Given that both Canada and Russia have extensive areas of both High Arctic marine island habitat as well as coastal taiga floodplain, it seems unusual that these two geographically isolated breeding populations should also be limited to such disparate habitat types. Furthermore, descriptions of breeding birds from Russia (and Churchill) describe individuals feeding extensively in freshwater ponds, and some nesting colonies are over 100 km from the nearest salt water (Buturlin 1906; Densley 1999; Chartier & Cooke 1980), while in the Canadian High Arctic breeding birds forage exclusively in the marine environment (Maftei et al. 2012), as they do during the winter when they appear to be entirely pelagic, and feed on a variety of small vertebrates and invertebrates (Divoky 1976). While it appears that Palearctic and Nearctic populations of this species are associated with different habitats in which they occupy different ecological niches, it should be noted that both habitat types in Russia and Canada are extremely poorly surveyed, and several thousands (if not tens of thousands) of breeding pairs could easily be overlooked (Degtyarev, 1991; Gaston et al. 2012). While suitable nesting habitat for this species in Greenland is limited to the High Arctic habitat type, it is equally conceivable that greater numbers of Ross's gulls than currently assumed nest there as well and have similarly gone undetected (Egevang & Boertmann 2008).

Wintering areas

The wintering areas of the Ross's gull remain essentially unknown, and there has never been a formally published first-hand account of any appreciable concentration of individuals outside of the breeding season barring the well-documented passage of large numbers of migrants past Point Barrow, Alaska (Murdoch, 1899; Divoky et al. 1988). Anecdotal accounts suggest that Ross's gulls may winter in polynyas along the southern Chukchi peninsula and into the Bering Sea, as well as in the Sea of Okhotsk, ranging as far as Sakhalin Island, and very rarely as far as Hokkaido (Ilyechev & Zubakin, 1988). Densley (1999, p. 43) cites an unlisted source claiming local natives report "not less than one hundred thousand birds" along the southern coast of the Chukchi peninsula between Kresta and Providenya Bays in March. There are also unsubstantiated reports of Ross's gulls wintering in polynas around the New Siberian Islands (Ilyichev & Zubakin, 1988). Although it certainly seems likely that at least a portion of world population of Ross's gulls do occur in these areas, the lack of any confirmed seasonal concentrations is notable. Despite the presence of large numbers (tens of thousands) of Ross's gulls in the Beaufort and Chukchi Seas in late fall, there have never been reports of even modest numbers of birds from anywhere in North America during the winter. A lack of survey effort or even casual presence in the remote and generally inaccessible habitats used by wintering Ross's gulls could belie such concentrations.

In North America, Ross's gulls have only been reported in the winter as vagrants (e.g. Sibley & Bledsoe 1985), but several small groups of birds, including juveniles, have been reported from Foxe Basin as late as October (M. Mallory, *pers. comm*.). The relative frequency with which Ross's gulls appears as vagrants in western Europe, particularly the U.K. (Densley 1999; BirdGuides 2013) where they are recorded almost annually, is suggestive of a wintering area somewhere in the north Atlantic or the Norwegian Sea, although these records could represent wanderers from Davis Strait or the Labrador Sea. The fact that most European records occur in December and January further supports the possibility that a North Atlantic wintering area exists.

Migratory movements

Given the largely conjectural breeding range and even more speculative wintering range of the Ross's gull, it is difficult to discuss potential migratory movements except to make inferences based observations of birds in the spring and fall at times of year roughly corresponding to the pre- or post-breeding part of the annual reproductive cycle. Most of the early records of Ross's gulls from the journals of Arctic explorers (e.g.Richardson 1825; Nansen 1898; Parry, Ross, Andrée, De Long, Newcombe in Densley 1999) pertain to observations of lone individuals or small groups encountered at sea during either the spring or fall, but occasionally in the summer as well. Congregations of non-breeding Ross's gulls are also known to occur in the central Arctic Ocean in July and August, particularly along the shelf-break north of Franz Josef Land (Hjort et al. 1997). It is likely that a portion of the population, perhaps a substantial one, defers (or fails) breeding in some years and congregates instead in localized areas of high marine productivity in the Arctic Ocean (Meltofte et al. 1981; Hjort et al. 1997).

Ross's gulls breeding in the Palearctic move in an easterly direction along the continental coast in the late summer and early fall, and it has been noted that groups of Ross's gulls congregate at staging grounds along the northern coast of Siberia before moving east (Ilyichev & Zubakin 1988), with similar reports coming from as far east as Svalbard (Meltofte et al. 1981). Densley (1999, p. 40) reports "large concentrations" of failed or non-breeding birds gathering in Kolyuchin Bay and east towards Uelen by mid June, and "large gatherings" of birds in the New Siberian Islands and around Wrangel and Herald Island from mid-September until the third week of October. Presumably these are breeding birds, but this has not been verified. Juvenile Ross's gulls presumed to originate from the Siberian mainland have been observed on the New Siberian Islands as early as 1 August (Lindström et al. 1998).

It has been long known that significant numbers of Ross's gulls occur in the southern Beaufort and Chukchi seas in late autumn, most notably around Point Barrow, Alaska (Murdoch 1899), suggesting that this species actually undertakes what appears to be a well defined easterly migration past northern Alaska. Although this annual movement of birds, often numbering into the tens of thousands, has been well documented (Divoky et al. 1988) it is still not clear what the origins or the ultimate destinations of these individuals are. Divoky (1988) proposed that this passage of birds from west to east in late fall represented the Siberian breeding population moving into the southern Beaufort Sea in late September and early October to feed on seasonally abundant zooplankton before eventually returning west to wintering grounds somewhere in the north Pacific basin, possibly the Sea of Okhotsk as had been earlier suggested (Ilyichev & Zubakin 1988; Blomqvist & Elander 1981). This hypothesis does not explain why (a) the movement of Ross's gulls is generally to the northeast and into North America, and (b) there is no corresponding return passage of birds to the southwest.

Breeding biology

The breeding biology of the Ross's gull were first described by Buturlin (1906), and his descriptions of the general ethology and behaviour of the species remain the most comprehensive available. Accounts from Siberia indicate that Ross's gulls are loosely colonial (Degtyaryev et al. 1987; Buturlin 1906), nesting in wet or marshy areas typically in polygon pond complexes or flooded taiga (Densley 1999) or occasionally on the shores of large tundra lakes (Kondratyev et al. 2000). Colonies range in size, but the average number of nests per colony is 13 in the Kolyma delta (Andreev & Kondrateyev, 1981), and 1-18 nests in the Khroma and Indigirka River deltas (in some years colonies of 40-50 nests occur) (Ilyichev & Zubakin 1988). Birds arrive at breeding colonies in late May and early June (Buturlin, 1906; Kondratyev et al. 2000), and the first egg is laid between 1-15 June (Nettleship et al. 2000). Clutches contain one or two eggs (occasionally three), and chicks hatch after roughly 19-20 days, between 21 June to 6 July. The young fledge at 18 to20 days of age (Andreev & Kondrateyev, 1981). Adult birds begin to depart nesting colonies around 20 July, and juveniles begin to depart in early August (Nettleship et al. 2000; Lindström et al. 1998). Generally breeding success is low, and the fledging rate is around 20% (Nettleship et al. 2000).

In the Canadian High Arctic, Ross's gulls arrive on the breeding grounds in early June and form colonies of one to five pairs; the first egg is laid between 12-18 June (Maftei et al. unpubl. data). Clutches contain one to three eggs and are incubated for 21-23 days. Both adults share in the incubation and incubation shifts are about 3 hours long during incubation (M. Maftei, unpubl. data). During the years of this study, no young were observed to survive to fledge. Ross's gulls nesting at Churchill, Manitoba lay eggs 14-29 June, which adults incubate for 21-22 days. Fledging has been observed there, though the age of fledging was not noted (Chartier & Cooke 1980). Little information on the ethology of Ross's gulls breeding in Greenland is available; one nest with two pipping eggs was observed on 28 June, 2004 and another nest was found in 2006 with three chicks estimated to have hatched 22-26 June (Egevang & Boertmann 2008).

Ross's gulls often appear to nest in close association with arctic terns (*Sterna paradisaea*), and to a lesser extent, with Sabine's gulls (*Xema sabini*) and ivory gulls (*Pagophila* *eburnea*) (Buturlin 1906; Blomqvist & Elander 1981; Ilyichev & Zubakin 1988; Egevang & Boertmann 2008). It is unclear whether this association represents a specific selection of nesting sites within arctic tern colonies by Ross's gulls or just the concentration of species with similar nesting requirements in limited areas of suitable habitat. Buturlin (1906) reported frequent agonistic encounters between arctic terns and Ross's gulls in Russia, and arctic terns are known to kill Ross's gull chicks in Canada (S. MacDonald in Cooke & Taylor, 1980; Densley, 1999). In fact, multiple observations of chicks being pecked to death suggest that arctic terns are responsible for a very high proportion of Ross's gull chick mortality at colonies in the Canadian High Arctic (M. Maftei, unpubl. data). It is possible that an ancestral tendency for nesting in association with arctic terns, which may confer some defense against predators, has led isolated populations of Ross's gulls in the Canadian High Arctic into an evolutionary trap; the high density of arctic tern colonies in the High Arctic appears to promote an extremely aggressive nest defense strategy (M. Mallory, *pers. comm.*) and arctic terns have been observed attacking and killing the chicks of Ross's gulls as well as other terns and a variety of other bird species, and even lemmings (Mallory et al. 2010).

The vocalizations, displays and behavioural postures of Ross's gulls during the breeding season have seldom been observed and have therefore received very little attention. Buturlin (1906) provided detailed albeit highly anthropomorphic descriptions of several of the unique postures and vocalizations Ross's gulls exhibit, and these were subsequently discussed by Moynihan (1955) who concluded that displays of the species differed substantially from the displays of other Larids. Vocalizations of Ross's gulls have been briefly described by a number of authors (e.g. Buturlin, 1906; Ilyichev & Zubakin, 1988, Densley, 1999), but they have never been analyzed or compared to those of any other Larid. Similarly, Ross's gulls perform several unique sexual displays which have been mentioned (Ilyichev & Zubakin, 1988; Densley, 1999), but which have not been formally described or compared to those of any other Larid.

A curious behaviour of Ross's gulls during the breeding season is the systematic courtship of heterospecific birds. Densley (1999) mentions several anecdotal reports of Ross's gulls in breeding condition displaying to Black-headed gulls (*Chroicocephalus ridibundus*) and Bonaparte's gulls (*C. philadelphia*), and studies in Canada reveal that more than half of Ross's gull courtship displays at breeding sites are directed towards black-legged kittiwakes (*Rissa tridactyla*), including attempts at forced copulation (Maftei et al. *in prep*.).

Conservation status

The Ross's gull is listed as a species of Least Concern by the IUCN Red List (IUCN), but the criteria on which the species was evaluated are debatable (e.g., probable range was based on the assumption of equal distribution across an unrealistically large area, while population trends are unknown, as is annual reproductive success). Ross's gulls are fully protected in Greenland and Russia, and they are listed as a Threatened or Endangered species in Russia's Red Book (Nettleship et al. 2000). The species is listed as a Threatened Species in Canada (COSEWIC 2007b), and the most recent Recovery Strategy highlights the urgent need for more information on the species' distribution and population status in Canada (COSEWIC 2007a). It was assumed that the remote areas that Ross's gulls inhabit in Canada conferred some degree of protection from human disturbance, but this may not the case. Most of the Canadian breeding range (and all the known currently active colonies) of this species lie within Queens Channel and immediately adjacent to the Sverdrup Basin, an area with significant reserves of natural gas proposed for potential large-scale industrial development over the next several decades. Disturbance caused by ground-based operations and increased shipping through Queens Channel could detrimentally impact the breeding population (Boadway & Mallory 2010).

Research objectives

By all accounts the Ross's gull is very poorly known. Given its apparently unique taxonomy and ecology, as well the concerns regarding its protections and conservation, clarifying the status of this species is a top priority, particularly in North America where it has been almost entirely overlooked.

In order to fill in some of the major gaps in our knowledge of this species I sought to collect baseline data on population size and distribution in North America as well as develop a model with which to assess and survey breeding habitat. Although there have been a small number of published articles describing specific records or incidental observations of Ross's gulls in North America there has been no concerted effort to study this species on a broad scale. While recognizing the limitations imposed by the logistical difficulties of studying a rare species occurring in remote areas where it breeds in small numbers the work described in this thesis seeks to lay a foundation for future research.

Although there is still much to learn about Ross's gulls, my work indicates that there is likely a stable and self-sustaining population in the Canadian High Arctic (Chapter 1), that this species relies on a distinct type of nesting habitat which can be identified based on a suite of basic physical and ecological characteristics (Chapter 2), and that a significant proportion of the global population of the species known to occur in North America during the autumn may include a significant number of individuals which either breed and/or winter in Canada (Chapter 3).

The presence of a discrete and perhaps reproductively isolated population of Ross's gulls in the Nearactic, ecologically distinct from that found in the Palearctic (Chapter 1) opens the door to future studies of the genetic structure of the global population, and offers the potential to examine how this and other northern breeding species may have evolved behavioural adaptations to overcome the unique constraints and challenges faced in the High Arctic.

Despite the fact that many millions of seabirds breed in the Canadian Arctic each year the distribution and habitat requirements of many species remain poorly understood. The logistical difficulties of conducting thorough and regular surveys means that our ability to assess populations and trends is severely hampered. The development and testing of a basic model with which to identify, classify and rank suitable breeding habitat for ground nesting seabirds in the High Arctic (Chapter 2) could provide opportunities to increase the efficiency and success of targeted surveys of Arctic breeding species, including rare or poorly known species nesting in low densities such as Ross's gulls.

Finally, one of the best known albeit still poorly understood aspects of Ross's gull biology is the annual movement of large numbers of birds through the Beaufort and Chukchi Seas along the northern coast of Alaska in the fall. Although this phenomenon has been well documented for over a century, investigations into the specific timing and extent of migration have been limited, and the only census to date is almost 30 years old. A comprehensive survey of migrating Ross's gulls past Point Barrow (Chapter 3) is not only an update of stale data, but provides a new insight into the possible origins and destinations of Ross's gulls observed in Alaska.

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1.

BREEDING HABITAT AND NEW BREEDING LOCATIONS FOR ROSS'S GULL (*Rhodostethia rosea*) IN THE CANADIAN HIGH ARCTIC

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Abstract

Published accounts list only four breeding sites for Ross's gull (*Rhodostethia rosea*) in North America, but the discovery of additional breeding sites in Queen's Channel, Nunavut add to growing evidence that this species is established as a regular breeder in the Canadian High Arctic despite its current status as a Threatened Species in Canada. I present nine breeding records of Ross's gull in Canada, five from Queen's Channel alone, including two from sites newly discovered in 2011. The geographic proximity and similarity in topography, microhabitat, and interspecific nesting associations that characterize Ross's gull nesting sites in the Canadian High Arctic suggest that additional surveys of surrounding suitable habitat could confirm a stable breeding population of this poorly known species in North America.

Key words: Ross's gull, *Rhodostethia rosea*, breeding site, High Arctic, threatened species, polynya, biogeography

Introduction

Although the type specimen of Ross's gull (*Rhodostethia rosea*) was secured in Foxe Basin, Nunavut in 1823, the breeding grounds of the species remained unknown for over 80 years until a few small colonies were discovered scattered across the Kolyma River Delta in Siberia (Buturlin 1906). Other colonies were subsequently discovered in the deltas of the Alazeya, Yana, Indigirka, and Lena rivers (Dementiev and Gladkov 1969; Degtyaryev et al. 1987). Breeding has also been recorded on the Taimyr Peninsula (Pavlov and Dorogov 1976; Yésou 1994), and the Chaun River Delta (Pearce et al. 1998). Several breeding records from Greenland and Canada have also been described, but were assumed to represent opportunistically nesting vagrant or nomadic birds rather than a stable and self-sustaining population (Hjort et al. 1997; Béchet et al. 2000). Egevang and Boertmann (2008) collected and presented an extensive list of previously unpublished or poorly documented breeding records from Greenland, suggesting that this species is a rare but regular breeder there. In Canada, Ross's gull is listed by the Committee on the Status of Endangered Wildlife in Canada as a Threatened Species (COSEWIC, 2007). Known and suspected breeding sites are remote and difficult to access and even casual surveys have been infrequent.

The Ross's gull is the least known of all larids, and even basic information concerning the life history and general ecology of the species is still lacking. It is still unknown where Ross's gulls spend the winter, and even descriptions of the breeding range of this species are speculative. The most recent and qualified estimate puts the Russian breeding population of Ross's gulls at a minimum of 45,000 – 55,000 adults (Degtyarev 1991), but less than 1% of this estimated population can be accounted for in known breeding colonies. The geographic range and number of birds breeding in the Nearctic are unknown.

A better understanding of where Ross's gulls breed and their habitat requirements are necessary first steps in generating accurate population estimates and when developing practical and relevant management plans in areas of their range where they may be susceptible to disturbance. Here, my objectives were to summarize previously known breeding records in the Nearctic, describe recently found breeding sites, and define a suite of specific habitat conditions characterizing all High Arctic breeding sites of Ross's gull which should be used as a basis for future surveys.

Methods

Historical Records

Records of Ross's gulls breeding in the Nearctic were collected from a variety of published sources as well as unpublished material and personal communications. All published material regarding previous breeding records is listed in the References. Additionally, the provenance and history of museum specimens in the Canadian Museum of Nature was incorporated into Table 1.

Aerial Surveys

I conducted aerial and ground surveys in an area of suitable nesting habitat in Queen's Channel, Nunavut. Aerial surveys were made from a Bell 407 helicopter on 26 June 2001. While flying around the perimeter of small islands or transects over larger ones from an altitude of approximately 100 m, three observers independently recorded all birds seen on or in the immediate vicinity of each island, and I also surveyed four islands on foot (Nasaruvaalik, Kalivik, Emikutailaq, and an area of suitable habitat on Milne).

Results

Historical Records

To summarize breeding records of Ross's gull in the Nearctic, I collected information regarding 32 records from 9 Canadian breeding sites as well as 15 previously described Ross's gull records for 9 additional breeding sites in Greenland (Table 1-1).

Aerial Surveys

On 26 June 2011, while conducting an aerial survey for breeding Ross's gull in Queen's Channel and Penny Strait, Nunavut, two pairs of Ross's gull, one of which was associated with a nest, were discovered on Emikutailaq Island (75º29'N, 97º14'W); and a single Ross's gull was also seen on Kalivik Island (75º32'N, 97º12'W). Eight individuals including a nesting pair were also seen at a known breeding site on Nasaruvaalik Island (76º49N', 96º18'W) which has previously been described in detail (Mallory et al. 2006). Emikutailaq and Kalivik islands had never before been surveyed (Fig. 1.1).

Emikutailaq Island is small (1 km^2) and supports a lush, abundant substrate of mosses, sedges and herbaceous vegetation. The name of the island is derived from the Inuktitut word for "tern", reflecting a long-term recognition of this site as an important arctic tern (*Sterna paradisaea*) colony. Extensive vegetation as well as Thule tent rings and scattered whale bones reflect the historical importance of Emikutailaq Island as a base from which the rich marine resources nearby could be exploited by humans and birds alike.

After surveying about half of the island on foot, a Ross's gull was observed hovering and flying slow and tight circles in one spot and subsequently alighting on a nest containing three eggs. The nest was constructed on a gentle slope of gravel running up from an expanse of deep green moss to a low ridge that dropped abruptly off into a small pond. The substrate consisted of gravel interspersed with scattered pieces of dry, dead moss. The nest was lined with grass, feathers, and small fragments of lichen, consistent with other Ross's gull nests in the High Arctic (Mallory 2007). While on Emikutailaq Island, we also observed a second pair of Ross's gulls that were bathing, preening and displaying to each other in a pond close by the first nest, but due to time constraints we were unable to search the island to locate more birds or nests.

Kalivik Island (9 km^2) is mostly unvegetated gravel, but a small (0.5 km^2), sparsely vegetated gravel dome is connected to the main island by a very narrow isthmus. This part of the island contained a dense colony of arctic terns, Sabine's gulls (*Xema sabini*) and at least single pairs of long-tailed duck (*Clangula hyemalis*) and red-throated loon (*Gavia stellata*). One breeding plumage Ross's gull was seen exhibiting nest defense behaviour, but despite a brief search, we were unable to find a nest or a second bird.

Ross's gulls have been observed nesting on Nasaruvaalik Island every summer since 2005 when the island was first surveyed, and up to five pairs have nested there in a single year (Environment Canada 2007). In 2008, two male Ross's gulls were trapped during the breeding season and marked with unique colour bands. One of these birds has been seen every year since it was banded, and in 2011 was observed mating with a female while on Nasaruvaalik Island and presumably nested nearby, as it returned to Nasaruvaalik Island in August. The second bird was not seen in 2009 or 2010, but returned to breed in 2011.

Discussion

Throughout their range Ross's gulls nest in remote areas that receive little attention from biologists, and prior to the discovery of breeding birds on Kalivik and Emikutailaq islands, every

North American nesting site had been discovered opportunistically during surveys for other species. Although determining the breeding distribution and habitat requirements of this species is a recognized conservation science priority in Canada where Ross's gull is listed federally as a Threatened Species (COSEWIC, 2007), the high cost and considerable logistical difficulty inherent in flying aerial surveys in the High Arctic poses a great challenge. Observations of colour-marked birds on Nasaruvaalik Island indicate that most individuals attempt to breed annually and are faithful to nesting areas, although they may nest on multiple neighbouring islands in response to yearly fluctuations in snow and ice cover, or the presence of Arctic foxes in the early season.

On a large scale, breeding sites in the High Arctic in both Canada and Greenland are located near polynyas or consistent leads in the sea ice (Stirling 1997). Ross's gulls breeding on Nasaruvaalik Island and Emikutailaq Island make extensive use of a small polynya in Crozier Channel for up to two weeks before breeding, during which time they engage in extensive courtship displays, mating, feeding and nest-site prospecting (unpubl. data).

The association between Ross's gulls and arctic terns has been well documented in the High Arctic (Mallory et al. 2006; Egevang and Boertmann 2008). Even in Siberia and Churchill, Manitoba where Ross's gulls nest inland, they are invariably found in association with arctic terns (Buturlin 1906; Cooke and Taylor 1980; Densley 1999).

All known Ross's gull nests in the High Arctic are situated on near-level ground, usually in mossier areas of islands. The apparent association with moss may be an artifact of their habit of nesting within the outer periphery of arctic tern colonies, which are invariably characterized by such vegetative growth, fertilized through biotransport of nutrients in droppings and food waste (Michelutti et al. 2010). Proximity to fresh water does not seem to be a major factor affecting nest placement. Ross's gulls nesting in the High Arctic do not feed in freshwater ponds but rather exclusively on marine invertebrates around the islands they nest on. In contrast, Ross's gulls breeding near Churchill nest in a wet and boggy area of inland coastal taiga (Cooke and Taylor 1980). This latter site closely resembles the nesting habitat used by Ross's gulls in Siberia which form small colonies in areas of polygon ponds in taiga floodplains, and feed almost exclusively in fresh water during the breeding season (Buturlin 1906; Densley 1999).

Ross's gulls prefer nesting on small islands surrounded by mostly ice-free waters. This is true for all sites in Greenland (Egevang and Boertmann 2008) and most sites in Canada, although Prince Charles Island is a very large island and the breeding site at Churchill was on the mainland (MacDonald 1979; Cooke and Taylor, 1980; Béchet et al. 2000; Mallory et al. 2006).

Mammalian predators such as arctic fox (*Alopex lagopus*) and polar bear (*Ursus maritimus*) are purportedly less likely to pose a predation risk to ground-nesting birds breeding on small islands. However, in five years of monitoring breeding birds at Nasaruvaalik Island polar bears frequently visited the island, swimming considerable distances across open water before coming ashore and subsequently eating significant numbers of eggs and fledglings, mostly of common eiders (*Somateria mollissima*). Although nesting on islands may reduce the risk of predation by mammalian predators like foxes (Clark and Shutler, 1999), an alternative explanation for the general preference Ross's gulls and many other species show for nesting on small Arctic islands is that they offer the greatest available area for foraging within a minimum radius around a nesting site. Our observations of arctic terns, Sabine's gulls and Ross's gulls at Nasaruvaalik Island indicate that the vast majority of individuals of all three species forage within a few hundred meters from the colony at most. Minimizing commuting time between feeding areas and nesting sites is especially important for arctic terns since they are particularly susceptible to kleptoparasitism on account of their inability to swallow and regurgitate food for their chicks. The preference ground-nesting arctic larids show for nesting on peninsulas and points, even when better or safer alternatives are available farther inland on the same islands suggest that the benefit of a nest site with access to the ocean in multiple directions and a larger area of shallow water where prey is abundant within a minimum radius outweighs the cost of nesting on low-lying and exposed areas which are invariably where predators make landfall.

Indirect support for this theory can be inferred from the primary defensive strategy of terns and small Arctic gulls which consists of colony-wide mobbing of predators, which is most effective if a large number of birds are present at all times. This advantage is quickly lost if half the nesting population of a colony and a considerable number of non-breeding birds which also participate in defensive mobbing are foraging too far from the colony to be able to react quickly to a disturbance.

Typically Ross's gulls arrive at breeding sites up to two weeks before all other species except common eiders and king eiders (*Somateria spectabilis*), and they subsequently lay their eggs approximately 7 to 11 days ahead of Sabine’s gulls and arctic terns. Why Ross's gulls arrive and start nesting so far in advance of other species is unclear, but may result from a shorter travel distance from nearby Arctic wintering areas.

Given that all currently known Ross's gull nesting sites in the High Arctic exhibit a suite of conspicuous and easily assessed physical and ecological characteristics, I propose that future surveys within the currently known range of this species should be based on targeting suitable habitat. The two areas that show the greatest potential to host significant numbers of breeding

Ross's gulls in the Canadian Arctic are the islands in Foxe Basin, and the islands in Queen's Channel, Penny Strait, and McDougall Sound (Fig. 1.1). Within these areas, surveys should focus on small islands known or suspected to be used by arctic terns, particularly those that are located in or around polynyas or consistent leads in the ice. To maximize chances of detecting Ross's gulls surveys should be conducted in the early season (25 May – 15 June) to exploit the early arrival of Ross's gulls at breeding sites. During this time they are among the few birds present and perform conspicuous aerial and ground-based courtship displays. While Ross's gulls are easily observed at a distance from the air, they are susceptible to disturbance caused by fixed wing aircraft and helicopters (Degtyarev 1991; Boadway and Mallory 2010). Ground-based surveys on foot are recommended as a more reliable and less disturbing method of locating Ross's gulls at nesting sites.

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Table 1-1 Summary of Ross's gull (*Rhodostethia rosea*) breeding records in the Nearctic

Country	Site	Year	# Birds	Source	Notes	With ARTE
Canada	Churchill	1978	1	MacDonald, in Chartier & Cook (1980)	breeding unconfirmed	yes
		1980	6	Chartier & Cook (1980)	breeding unconfirmed	yes
		1982	10+	Koes in Env. Canada (2007)	5 nests	yes*
		1992	4+	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		1993	4	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		1994	6	Koes and Chartier, in Env. Canada (2007)	1 nest	yes*
		1995	3	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		1997	2	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		1998	?	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		1999	1	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		2000	2	Koes and Chartier, in Env. Canada (2007)	breeding unconfirmed	yes*
		2001	3	Koes and Chartier, in Env. Canada (2007)	1 nest, I juvenile seen	yes*
		2002	10	COSEWIC (2007)	breeding unconfirmed	yes*
		2004	2	Koes and Chartier, in Env. Canada (2007)	breeding confirmed	yes*
		2005	5	COSEWIC (2007)	1 nest, 1 juvenile seen	yes*
	Middle Cheyne Is.	1974	1+	Mallory & Gilchrist (2003)	breeding unconfirmed	yes
		1976	6	MacDonald (1979)	breeding unconfirmed	
		1978	12	MacDonald (1979)	breeding unconfirmed	yes*
		2006	8	Mallory et al. (2006)	breeding unconfirmed	yes*
	South Cheyne Is.	2006	2	M. Mallory, unpubl. data	breeding confirmed	yes
	Milne Is.	1981	7	M. Mallory, unpubl. data	breeding unconfirmed	unknown
	Seymour Is.	1974	3	M. Mallory, unpubl. data	breeding unconfirmed	no
	Prince Charles Is.	1997	2	Béchet et al. (2000)	1 nest	yes
	Nasaruvaalik Is.	2005	9	Env. Canada (2007)	5 nests	yes
		2006	2	Mallory et al. (2006)	1 nest	yes
		2007	12	Env. Canada (2007)	2 nests, 1 chick	yes
		2008	6	*This paper*	2 nests	yes
		2009	6	*This paper*	1 nest	yes
		2010	5	*This paper*	2 nests	yes
		2011	8	*This paper*	1 nest	yes
	Emikutailaq Is.	2011	4	*This paper*	1 nest	yes
	Kalivik Is.	2011	1	*This paper*	breeding unconfirmed	yes
Greenland	Qasigiannguit	1880	?	Egevang & Boertman (2008)	breeding confirmed	unknown
	Ikamiut	1885	?	Egevang & Boertman (2008)	breeding confirmed	yes
	Nuussuaq pen.	1973	?	Egevang & Boertman (2008)	breeding not confirmed	yes
	Kitsissunnguit	1979	1	Kampp and Kristensen, in Egevang & Boertman (2008)	1 nest	yes
		1996	2	Frich , in Egevang & Boertman (2008)	breeding not confirmed	yes
		2004	2	Witting, in Egevang & Boertman (2008)	1 nest	yes
		2006	6	Egevang, in Egevang and Boertman (2008)	1 nest, 3 chicks hatched	yes
		2007	1	Holst and Larson, in Egevang & Boertman (2008)	breeding not confirmed	
	Henrik Kroyer Holme	1993	1	Egevang & Boertman (2008)	1 nest	yes
		2003	1	Gilg et al. in Egevang & Boertman (2008)	breeding unconfirmed	yes
	Kilen	1984	2	Jensen, in Egevang & Boertman (2008)	breeding unconfirmed	unknown
		1993	2	Elander, in Egevang & Boertman (2008)	breeding unconfirmed	unknown
	Kap Eiler Rasmussen	1979	1	Hjort, in Egevang & Boertman (2008)	1 nest, 1 chick	no
	Aavertuut	1984	1	Egevang & Boertman (2008)	breeding unconfirmed	unknown
	Godthaabsfjorden	1927	1	Egevang & Boertman (2008)	breeding unconfirmed	unknown

*assumed 'yes' based on previous records

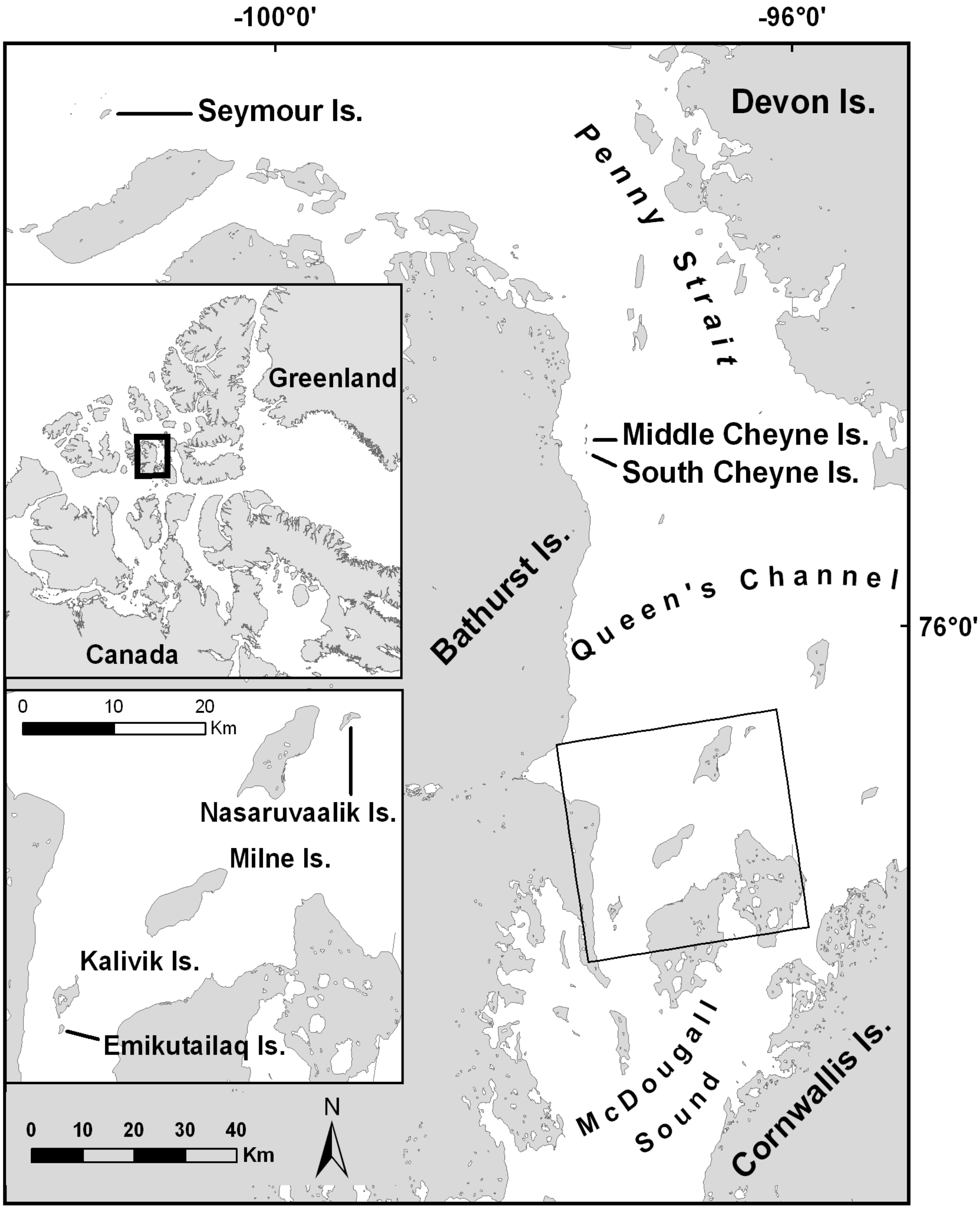

Figure 1.1 Ross's gull (*Rhodostethia rosea*) breeding area in the Canadian High Arctic

Plate 2 A breeding Ross's gull near its nest. Nasaruvaalik Island, Nunavut

Plate 3 Typical Ross's gull nesting habitat. Nasaruvaalik Island, Nunavut

2.

ASSESSING REGIONAL POPULATIONS OF GROUND-NESTING SEABIRDS IN THE CANADIAN HIGH ARCTIC

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Abstract

The Queens Channel region of Nunavut is an ecologically distinct area in the Canadian High Arctic consisting of an extensive archipelago of small, low-lying gravel islands throughout which form several localized but highly productive polynyas. Previous surveys suggested that this habitat supports substantial numbers of several species of colonial ground-nesting seabirds, including rare species like Ross's gull (*Rhodostethia rosea*) and ivory gull (*Pagophila eburnea*). In June 2012, I surveyed 30 islands in Queens Channel and contiguous areas of Penny Strait and MacDougall Sound and counted 4451 individuals of 20 species. My observations suggest that high inter-annual variability in the extent of sea-ice results in fluctuations in attendance at island breeding sites. Comprehensive, broad-scale surveys are more likely to generate accurate data with which to assess ground-nesting seabird populations at the regional level, and dramatic fluctuations at individual colonies probably belie the overall stability of regional metapopulations.

Keywords: ground-nesting, seabirds, metapopulations, High Arctic, Nunavut, common eider, arctic tern

Introduction

Knowledge of the distribution and abundance of most avian species nesting in the Canadian High Arctic remains patchy and incomplete, in part because of the extreme remoteness and large size of the region as well as the logistical difficulties inherent in conducting surveys there. Some catalogues of large seabird colonies in the Canadian Arctic are available, particularly of cliff-nesting species (Nettleship, 1973; 1980; Mallory et al. 2004) but species nesting in low densities or only in isolated areas of suitable habitat have probably been largely overlooked (Gaston et al. 2012).

Current estimates of ground-nesting seabird populations in the Canadian Arctic remain uncertain on account of partial or incomplete survey coverage, extrapolation from small sample sizes, and a general lack of understanding of how local habitat suitability may affect annual numbers of breeders (Gaston et al. 2012). In the Arctic, mammalian predators exert strong predation pressure on ground-nesting birds (Birkhead and Nettleship, 1995; Smith et al. 2010), and most species have adapted a strategy of nesting in low densities over large areas. This tendency makes most populations difficult to survey and monitor effectively, a problem further complicated by unpredictable changes in local abundance (Clark and Shutler, 1999; Egevang and Frederiksen, 2011) and reduced detectability of cryptic or easily overlooked species (Meltofte 2001).

The ocean passage that extends from Penny Strait through Queens Channel to MacDougall Sound (hereafter collectively referred to as Queens Channel) contains an extensive archipelago of small, low-elevation gravel islands. The shallow bathymetry and strong tidal currents in this area lead to the formation of several localized and highly productive polynyas (Hannah et al. 2009), which provide important foraging habitat for many bird and mammal species (Stirling 1997). This region is unique within the Canadian High Arctic, and contains nesting habitat for several ground-nesting bird species which exploit the rich foraging opportunities provided by polynyas in the early breeding season when most of the surrounding water remains frozen (Mallory and Gilchrist, 2003; Mallory and Fontaine, 2004; Maftei et al. 2012). This area had already been recognized as an important breeding area for Ross's gull after the first nests in North America were found on the Cheyne Islands in northwestern Queens Channel (MacDonald, 1978), and more recent surveys have identified other islands in the area used by this species for nesting (Maftei et al. 2012). A partial survey of Queens Channel in 2002 and 2003 (Mallory and Gilchrist, 2003) revealed that substantial numbers of arctic terns (*Sterna paradisaea*) and common eiders (*Somateria mollissima*) also nest throughout the islands in this archipelago. The northernmost known North American colonies of Sabine's gull (*Xema sabini*) and the largest known ivory gull colony are also found in the Queens Channel region.

The objectives of this study were to (1) identify key physical and ecological characteristics of islands known to support ground-nesting seabird colonies in Queens Channel, (2) develop a habitat suitability index to predict the quality of nesting habitat across all of the islands in Queens Channel, (3) conduct a comprehensive survey of Queens Channel, focusing on ideal habitat as predicted by our index, and (4) assess the numbers and distribution of ground-nesting seabirds in this poorly known region.

Methods

Study Area

I defined a study area extending between 74°60'N and 76°55'N in latitude and 102°40'W and 93°47'W in longitude, encompassing an archipelago of approximately 120 islands which run from southern Penny Strait through Queens Channel and MacDougall Sound into northern

Barrow Strait. This area is bound by Bathurst Island to the west, Devon Island to the northeast and Cornwallis Island to the southeast (Fig. 2.1). I used ArcGIS software (Version 10, Environmental Systems Research Institute, Redlands, California) to compile topographic and ground-cover maps of the study area. Digital Elevation Models (DEMs) and digital scans of 1:50,000 topographic maps of the study area were compiled (Appendix 1), as were the approximate central points of all known polynyas in the region (Hannah et al. 2009).

Habitat Criteria

Based on previous surveys of habitat in the Queens Channel area (Mallory and Gilchrist, 2003; Maftei et al. 2012), I selected three physical criteria with which to assess each island within the study area: 1) mean island elevation; 2) island area; 3) euclidean distance from the centres of recurring polynyas. Values for each island were incorporated into a weighted overlay analysis (ArcGIS, Spatial Analyst Extension) in which each criterion was given equal weight and the three criteria were subsequently ranked together. Island area and elevation are to some degree correlated, and while an equal-weight ranking would not have necessarily skewed results, assessing these two variables independently allowed for a more informative analysis, e.g. highlighting suitable habitat on low-lying peninsulas of islands also containing a clearly defined high-elevation plateau. A fourth criterion (euclidean distance from nearest larger island) was selectively applied after the initial analysis to eliminate small, low-lying islands (n=12) located near polynyas but immediately adjacent to much larger islands. Such islands often remain directly connected to their larger neighbours by ice bridges during the spring and summer, allowing arctic foxes (*Alopex lagopus*) and polar bears (*Ursus maritimus*) to easily cross between them (Birkhead & Nettleship, 1995; Smith et al. 2010). The disruptive presence and predation risk posed by these predators is considerable, and ground-nesting birds are rarely found in such habitats despite their apparent suitability (Mallory and Gilchrist, 2003).

Habitat Analysis

I identified 120 islands within the study area (defined as areas of land completely surrounded by water at low tide), although several very small islands are not charted, several more only emerge from glacial ice as nunataks with no clear indication of whether they are islands or peninsulas at sea level, and other very small and low-lying near-shore islands may remain covered by ice for years at a time and are thus only intermittently detectable. Such exceptions (n = 19) were deemed to be unsuitable habitat and were excluded. Three very large islands partially included within the extent of the study area (Devon, Bathurst and Cornwallis) were similarly expected to consist of entirely unsuitable habitat (because mammalian predators could reside there year-round) and were also omitted from the analysis. The remaining 98 islands were weighted and ranked according to the habitat criteria (Appendix 2). Thirty islands were selected to be surveyed based on suitability and accessibility.

Surveys

I surveyed 30 of the islands in Queens Channel from a Bell 206 L4 helicopter on 19 and 23 June 2012. Seventeen of these islands had never been surveyed before, 10 had been previously surveyed by Mallory and Gilchrist (2003), and one, Nasaruvaalik Island, has been surveyed and monitored with varying intensity of effort annually since 2002. Figure 2.1 illustrates all islands referred to in this paper. While flying around the perimeter of small islands or transects over larger ones from an altitude of approximately 100 m, three trained observers independently recorded all birds seen on or in the immediate vicinity (<200m) of each island, and high counts for each species were recorded. I also surveyed six islands on foot while searching for Ross's gull nests on the same dates as above. Observations from Nasaruvaalik Island were recorded on 25 June 2012 by three ground-based observers.

Assessment of regional populations

I compared the difference in observed numbers of breeding birds at 10 islands surveyed in both 2002 and 2012, and also compared the variation in annual maximum and mean numbers for 25 regularly observed species over six years at Nasaruvaalik Island. I calculated mean values based only on July observations in order to more accurately reflect the numbers of breeding birds. Although non-breeding birds are present throughout the summer, all incubating birds would certainly be present and incubating during July. The yearly maximum is a more accurate index of the total number of birds (including non-breeders) using the island. For each year, I determined the total annual abundance representing the sum of the maximum high count for each of the 25 species, as well as a total mean representing the mean of daily counts in July for each species. I then compared these values between years and across all six years (Table 2-2). I also compared the variation in annual maximum and mean observed numbers for arctic terns and common eiders separately (Figs 2.5-6). All means are presented ± SD.

Results

Habitat Analysis

Based on the habitat suitability criteria, I identified 51 Ideal and/or Suitable islands within the study area. The criteria were not constrained by island boundaries, so some islands contained both Ideal and Suitable habitat, e.g., low-lying peninsulas extending from some islands were classified as Ideal, while the remainder of the island was classified as Suitable.

Surveys

I surveyed 30 of the 51 islands identified as Ideal and or/Suitable habitat in 2012, and observed 4451 individual birds of 20 species. These data are presented along with previous observations in Table 2-1. The most abundant and widely distributed species were arctic terns (n = 1546 on 16 islands) and common eiders (n = 1497 on 21 islands), while glaucous gulls (*Larus hyperboreus*), though far less numerous, were also broadly distributed (n = 86 on 16 islands). Seventeen other species were also observed, including Sabine's gulls (*Xema sabini*; n = 60 on five islands), red phalaropes (*Phalaropus fulicarius*; n = 233 on seven islands), brant (*Branta bernicla*; n = 315 on 10 islands), and red-throated loons (*Gavia stellata*; n = 14 on seven islands). Five nesting pairs of Ross's gulls (n = 14 on three islands) were also observed. Seymour Island supports a large colony of ivory gulls and was surveyed in 2010 and 2011.

Habitat Suitability

Abundance and Richness values were log transformed to correct skewing when visually represented. I found that Abundance was negatively correlated with mean island elevation (but not area) (Fig. 2.1: Spearman rank correlation: r_s = -0.23, p = 0.071; Fig 2.2: r_s = -0.26, p = 0.048), and was not correlated with distance to the nearest polynya centre (Fig. 2.3: r_s = 0.17, p = 0.15). Richness was not correlated with any measure of habitat suitability (Fig. 2.1-2.3; all $r_s \leq$-0.13, all p > 0.21). Species richness per island was low (mean 2.9 ± 2.2), with a few notable exceptions: Nasaruvaalik (17 species), South Cheyne (10 species), Emikutailaq (eight species). These three islands also had the highest observed abundance of birds (n=1579, 467, and 383, respectively).

I compared data from 10 islands surveyed in both 2002 and 2012, and determined that there was a 3.8 - fold mean difference in total bird numbers observed per island (Table 2-1). Islands supporting fewer individuals overall exhibited greater fluctuation in attendance (e.g., Des Voeux Island, 18.5-fold difference), while islands supporting larger nesting communities were more stable (e.g., Nasaruvaalik Island, 1.1-fold difference). However, when I compared the inter-annual variation in total bird numbers on Nasaruvaalik Island between 2007 and 2012 (Table 2-2), an average 1.5-fold change in the total number of birds present in consecutive years was noted (maximum difference = 2.1-fold; minimum difference = 1.3-fold).

Assessment of regional populations

My comparison of annual variation in July mean and seasonal maximum numbers for 25 species recorded from Nasaruvaalik Island (Table 2-2) showed that in the year with the highest mean (2012), 2.2 times as many individuals were observed as in the year with the lowest (2007). Variation in maximum counts was even greater with 4.5 times as many birds observed in the year with the highest maximum abundance (2012) as in the year with the lowest (2007). This was attributable to occasional occupation of the island by large flocks of non-breeding birds in some years, such as red phalaropes (n = 2500) in 2012. However even for less variable species (as indicated by lower coefficients of variation - see Table 2-2), numbers still fluctuated considerably between years.

Arctic terns and common eiders were the most abundant breeding species on Nasaruvaalik Island, and they both exhibited considerable fluctuations between years (Fig. 2.5-6). Not only was attendance for both species (as inferred from seasonal maximums) quite variable, but so was the actual number of breeding birds (as inferred from the proportion of the seasonal maximum represented by the July mean). For example, in 2008 only one third of arctic terns observed were presumed breeding, while in 2011, only one third of common eiders were presumed breeding.

Discussion

All islands surveyed in the Queens Channel area had at least some breeding seabirds, but numbers of some species fluctuated dramatically. (Table 2-2). At Nasaruvaalik Island, comparison of data from 2002 and 2012 suggested a modest increase in 2012 to about 1.1 times the number of breeding birds present in 2002 (Table 2-1), but a more detailed comparison over six years reveals that annual fluctuations between consecutive years were more dramatic (1.2 - 2.1-fold changes, Table 2-2). Some of the inter-annual variation in nesting populations of these species is attributable to environmental factors such as variability in the timing of sea-ice breakup or the extent of polynyas, as well as related ecological factors such as the presence of arctic foxes (Mallory and Gilchrist, 2003; Gaston et al. 2005a; Levermann and Tøttrup, 2007). Given that these species migrate to the site from disparate locations, it suggests that regional environmental conditions play an important role in determining annual numbers of breeding birds at this site. However, a lack sufficient multi-year data precludes an analyses of trends in overall populations, and thus differences in observed numbers at individual colonies should not be used as an index of change in the metapopulations of species nesting within the Queens Channel area.

Most of the islands supporting larger numbers of birds in Queens Channel shared a suite of easily assessed physical and ecological characteristics; the greatest abundance and richness of nesting birds were found on small, low-lying islands either surrounded by or very close to open water during the early breeding season. Such habitat offers ground-nesting seabirds easy access to productive foraging areas (Maftei et al. 2012), while also conferring some degree of protection from mammalian predators (Mallory and Gilchrist, 2003). While these features correspond with intuitive assumptions of what would constitute favourable habitat, the high cost and logistical difficulty of conducting aerial surveys demands a more rigorous and scientifically valid system of prioritization. Furthermore, a predictive model with which to assess unsurveyed habitat is relevant in efforts to determine the large-scale spatial distributions of species. Current information describing the distribution and habitat preferences of most ground-nesting Arctic seabirds is incomplete, however. Predicting their presence in unsurveyed areas relies heavily on presence data from the few areas which have been previously surveyed, and excludes absence data which is greatly limited in any case. The uncertainty which even comprehensive presence-only models suffer from is increased when applied to large and homogeneous habitats such as the High Arctic (Hirzel et al. 2002) but despite these limitations, there is still evidence that Ecological Niche Factor Analysis (ENFA) approaches such as the one employed here can provide useful information based on even limited, presence-only general distribution data in geographically limited or homogeneous habitat (Danks and Klein, 2002; Hirzel et al. 2002; Long et al. 2008).

In the variable and unpredictable climate of the High Arctic, islands, consisting of discrete patches of variable nesting habitat may be suitable for nesting in one year and unsuitable in the next. As such, densities of nesting birds on islands are likely to vary significantly between years, more so than would be expected in more homogeneous mainland habitat. Colonies of arctic terns for example (the most abundant species in our surveys), often fluctuate dramatically in numbers between years in response to local changes in habitat suitability, while the regional metapopulation remains stable (Egevang and Frederiksen, 2011). Similar patterns have been reported for a variety of other Arctic species (Gaston et al. 2005b; Mallory and Forbes, 2007; Moe et al. 2009). Long-term monitoring on Nasaruvaalik Island (M. Mallory, unpubl. data, 2007-2012) suggests that several species such as Ross's gulls, Sabine's gulls, brant, and red phalaropes may defer breeding in years when overall conditions are sub-optimal, or may nest on neighbouring islands if local conditions are unfavourable (e.g., Reed et al. 1998; Hatch, 2002, Levermann and Tøttrup 2007). Our observations of banded Ross's gulls suggest that individuals move between nesting islands from year to year and probably also skip breeding altogether in some years. In some years, large numbers of adult red phalaropes and brant congregating in feeding flocks during the middle of the breeding season also probably indicate widespread breeding deferral or failure by these species (MacDonald et al. 1998; Latour et al. 2005).

Detectability is another factor that limits the accuracy of estimates of regional populations of some ground-nesting species. Some species can be difficult to detect even during ground-based surveys, and are probably even more drastically under-represented by aerial surveys. For example, female eiders are highly cryptic and may remain undetected on their nests even when closely approached on foot. In 2012, a one-time aerial survey of Nasaruvaalik Island recorded approximately 200 common eiders, and daily high counts made by ground-based observers never exceeded 600 individuals, in contrast, thorough and more comprehensive searches on foot during the same year found 799 nests, indicating that at least 1600 individuals used this island in that year (unpubl. data). Even accounting for the departure of most male eiders by the time surveys were conducted in late June, the overall number of females present would include a significant number of non-breeding females (Schmutz et al.1982), and the estimated total number of eiders present during the survey period was at least 900 individuals (pers. obs.). Thus, a substantial proportion of these individuals went undetected (33-78% during ground-based and aerial surveys respectively). Numbers of nesting arctic terns can also be difficult to assess in one-time surveys (Egevang and Frederiksen, 2011), and daily average colony counts conducted simultaneously by multiple observers on Nasaruvaalik Island sometimes differed between consecutive days by a factor of four or more (M. Mallory, unpubl. data).

Ground-nesting seabirds in the Queens Channel area are particularly dependent on a highly variable marine environment. In 2012, the distribution of open water (i.e. polynyas) during surveys was clearly different than predictions based on the polynya centres derived from Hannah et al. (2009), which would influence the annual suitability of different islands for nesting birds. Even assuming that the average centre points of annually recurring polynyas remain stable, there is no way to accurately predict what the actual extent of the polynyas will be throughout the season. This makes it impossible to predict what the minimum distance to open water from each island would be ahead of time. Since ground-nesting marine birds in the High Arctic appear to be plastic in their fidelity to specific breeding sites within a larger region, and are strongly influenced by inter-annual fluctuations in ice cover and its effect on both food availability and associated increased predation risk (Egevang et al. 2004; Egevang and Frederiksen, 2011; Maftei et al. 2012), future surveys in similar habitat would likely benefit from using current satellite imagery of sea ice to prioritize survey targets based on local conditions at the time that surveys are being conducted.

My surveys in 2012 combined with the results obtained by Mallory and Gilchrist (2003) a decade earlier confirm that the Queens Channel area is an important breeding area for a variety of species. While regional metapopulations of most breeding species probably remain stable, partial surveys are unlikely to reflect actual numbers of breeding birds, and extrapolating data obtained from partial surveys is likely to significantly misrepresent actual metapopulations. One-time, comprehensive surveys provide more accurate and reliable breeding population estimates than regular surveys of partial samples of suitable habitat.

Of the 37 islands surveyed in Queens Channel, three in particular, Emikutailaq (75°29'N, 97°14'W), South Cheyne (76°29'N, 97°52'W) and Nasaruvaalik (76°49N', 96°18'W) appear to support an unusually high abundance and richness of birds. Nasaruvaalik Island and its adjacent polynya may be one of the most important breeding and foraging sites for birds in the entire region, and supports one of the highest diversities of regularly occurring species (28) recorded at this latitude anywhere in the North American Arctic.

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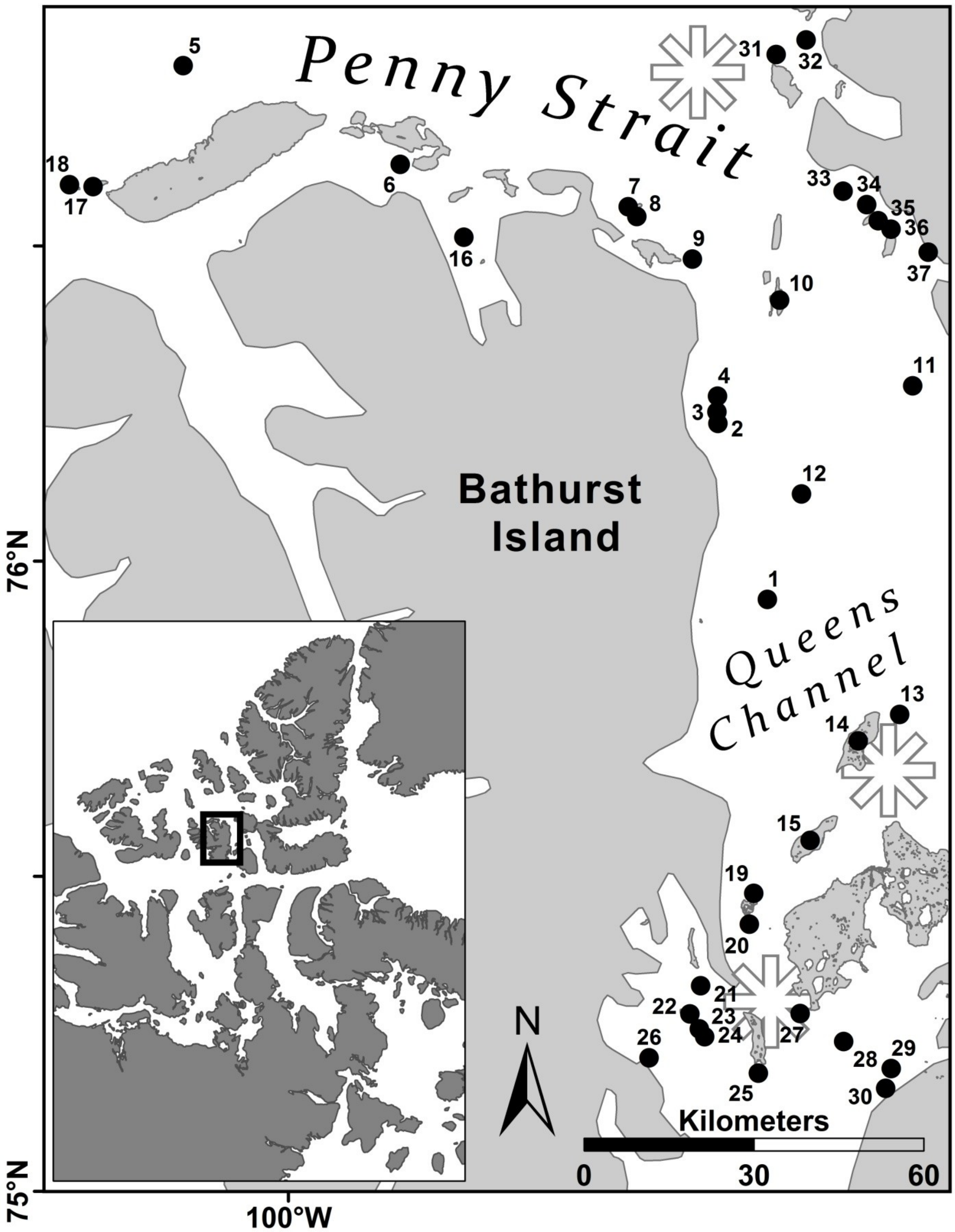

Figure 2.1 Overview of study area in Queens Channel. Numbers correspond to Islands in Table 1. Approximate centers of recurring polynyas are indicated by stars.

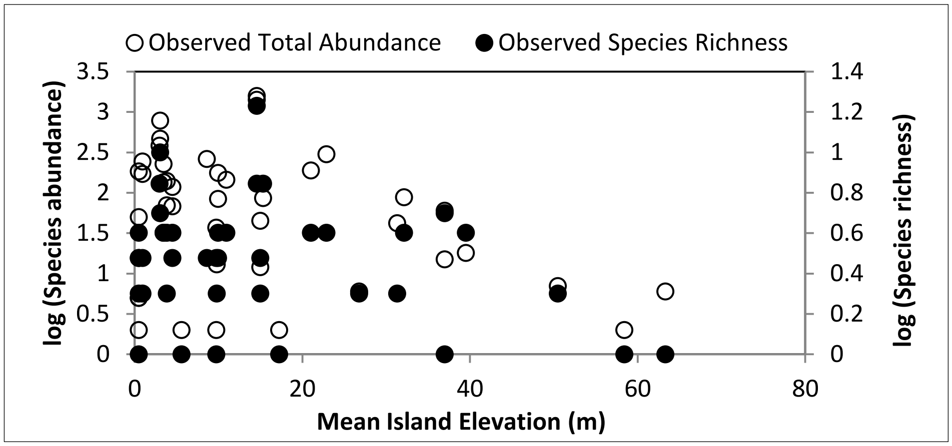

Figure 2.2 Correlation between mean island elevation (km^2) and observed richness and abundance of birds

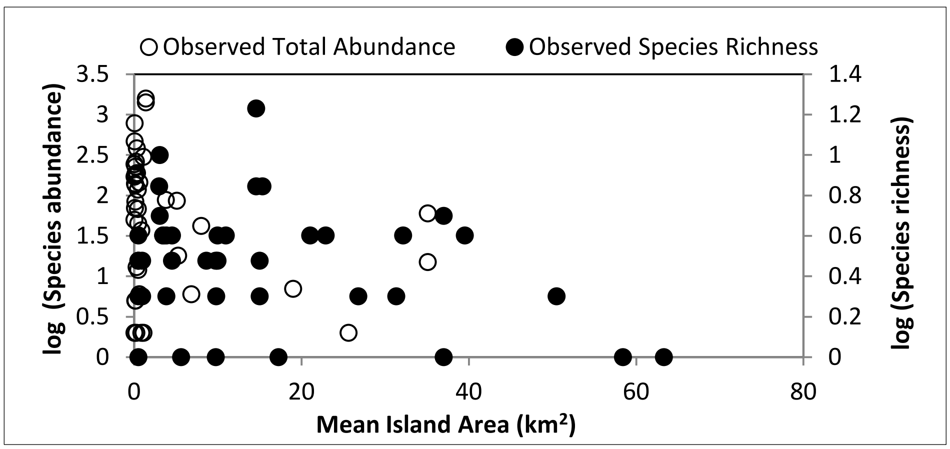

Figure 2.3 Correlation between island area (km^2) and observed richness and abundance of birds

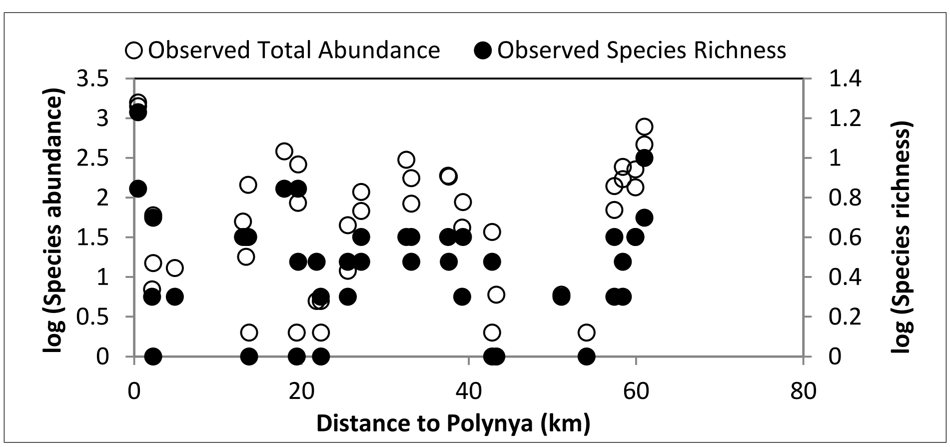

Figure 2.4 Correlation between distance to nearest polynya centre (km) and observed richness and abundance of birds

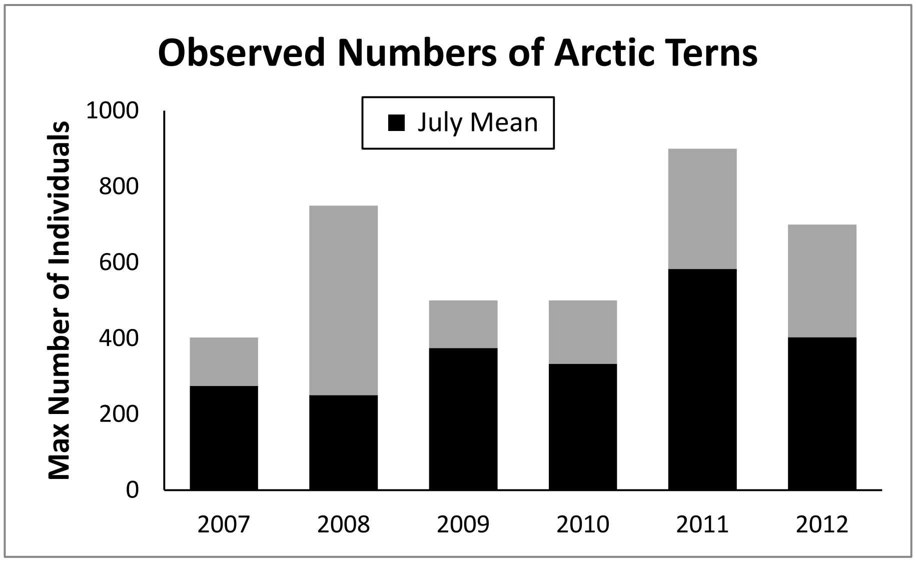

Figure 2.5 Comparison of maximum (entire bar) and July mean (black) numbers of arctic terns on Nasaruvaalik Island in each of six years of study

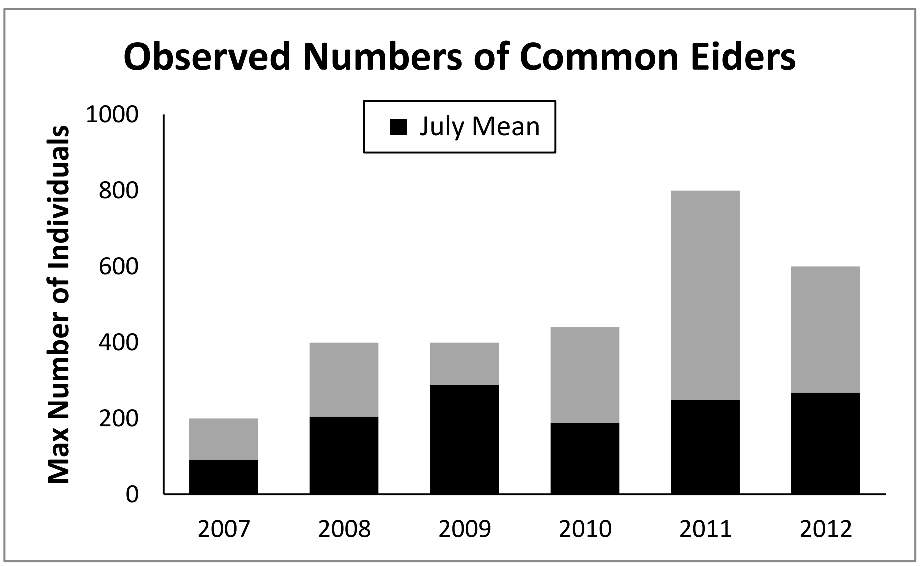

Figure 2.6 Comparison of maximum (entire bar) and July mean (black) numbers of common eiders on Nasaruvaalik Island in each of six years of study

Table 2-1 Observed numbers of birds on islands in Queens Channel in 2002 and 2012

MAP	COORDINATES		ISLAND	SURVEY YEAR		SPECIES	BIRDS	% Change	SPECIES OBSERVED (AOU species abbreviations)											
#	N °	W °		2002	2012				RTLO	BRAN	COEI	KIEI	LTDU	GLGU	SAGU	ROGU	BLKI	ARTE	REPH	OTHER
1	76.01	97.16	Reid	X		**3**	**184**				14							100	70	
2	76.29	97.51	South Cheyne*	X		**5**	**782**	-67%	2		164		10	6				600		
					X	**10**	**467**		2	60	175	60		11	2	4		50	100	BASA(3)
3	76.31	97.52	Middle Cheyne*	X		**4**	**227**	-41%	2									212	11	PAJA(2)
					X	**4**	**135**		2		50			2					81	
4	76.33	97.52	North Cheyne	X		**4**	**70**	+100%			2			2				16	50	
					X	**2**	**140**				30							110		
5	76.81	101.26	Seymour	X		**0**	**0**													
6	76.68	99.73	Harwood	X		**1**	**2**											2		
7	76.63	98.16	North Hooker	X		**2**	**12**	+275%										11		CORA(1)
					X	**3**	**45**			23	21			1						
8	76.61	98.10	South Hooker	X		**4**	**118**	-74%			13		3					100	2	
					X	**3**	**68**				65			2				1		
9	76.55	97.72	Irving	X		**3**	**176**	-110%			12			24				140		
					X	**4**	**84**			1	50			31						SNGO(2)
10	76.49	97.12	Hyde Parker	X		**2**	**42**				34							8		
11	76.35	96.22	Assistance	X		**2**	**244**	-43%			4							240		
					X	**3**	**171**				20			1				150		
12	76.18	96.95	Des Voeux	X		**1**	**2**	+1750%						2						
					X	**3**	**37**				6							30	1	
13	75.83	96.30	Nasaruvaalik*	X		**7**	**1417**	+11%	3	6	375				30			900	100	CORA(3)
					X	**17**	**1579**		3	175	400	20	8	2	60	8	520	350	22	SESA(3);PUSA,CORA, SNBU(2);IVGU,PAJA(1)
14	75.79	96.56	Crozier	X		**1**	**60**	-300%		60										
					X	**5**	**15**						2	1	5			6		PAJA(1)
15	75.63	96.86	Milne		X	**1**	**2**				2									
16	76.57	99.27	Young Inlet	X		**2**	**180**			120								60		
17	76.60	101.80	Mallory	X		**0**	**0**													
18	76.60	101.96	Gilchrist	X		**0**	**0**													
19	75.54	97.21	Kalivik*		X	**7**	**86**		2		9	1	1		1			65	7	
20	75.49	97.23	Emikutailaq*		X	**7**	**383**						1	9	10	2		350	7	SNBU(4)
21	75.39	97.53	Chip		X	**1**	**2**				2									
22	75.35	97.59	Big Neal		X	**4**	**18**		2	12										SNBU(3);PAJA(1)
23	75.32	97.53	Neal polynya		X	**4**	**141**		2		130		8	1						
24	75.31	97.50	Little Neal		X	**0**	**0**													
25	75.25	97.16	Truro		X	**2**	**7**				4			3						
26	75.27	97.84	Outlier		X	**2**	**5**				4									PUSA(1)
27	75.35	96.91	Thomas Honey		X	**2**	**13**							1				12		
28	75.31	96.64	Ikagguaq		X	**4**	**50**		1					2				36		BLGU(11)
29	75.26	96.34	Tadman		X	**3**	**5**					2	2							BLGU(1)
30	75.23	96.37	Little Tadman		X	**1**	**2**						2							
31	76.88	97.18	Hornby		X	**4**	**145**			5	65							60	15	
32	76.90	96.97	Russel*		X	**3**	**262**			2	60							200		

33	76.66	96.70	Cracroft		X	**4**	**300**		12	180			8				100		
34	76.64	96.54	Toms		X	**4**	**189**		8	170			5				6		
35	76.62	96.46	Kerr		X	**4**	**88**		17	50							20		PAJA(1)
36	76.60	96.38	Fairholme		X	**1**	**6**						6						
37	76.57	96.12	Walrus		X	**2**	**6**			4									PAJA(2)
	TOTAL OBSERVED			**3516**	**4451**	**Avg. 3.3**	**1796**	**20**	**7967**	**2115**	**83**	**37**	**120**	**108**	**14**	**520**	**3935**	**466**	**47**

Table 2-2 Annual maximum and mean numbers of commonly observed species on Nasaruvaalik Island, NU, from 2007 to 2012. Solid boxes indicate maximum observed values across all six years. * species breeding in all years; ** species breeding in at least one year; CV=Coefficient of Variation

	2007		2008		2009		2010		2011		2012		Across All Years				
Species	Year Max	July Mean	Year Max	July Mean	Year Max	July Mean	Year Max	July Mean	Year Max	July Mean	Year Max	July Mean	Max	Max Year	July Mean	SD +/-	CV
Red-throated Loon*	6	3	4	3	5	3	9	3	15	4	13	4	15	2011	3	1	20
Brant*	48	5	15	6	92	40	100	21	80	10	180	50	180	2012	22	15	68
Snow Goose**	4	1	4	0	11	0	8	0	2	0	16	0	16	2012	0	2	N/A
Common Eider*	200	91	400	205	400	288	440	188	800	249	600	268	800	2011	215	50	23
King Eider*	60	24	18	1	7	1	50	1	130	1	150	1	150	2012	5	18	361
Long-tailed Duck*	65	14	40	20	51	26	30	12	120	25	50	17	120	2011	19	5	28
Glaucous Gull*	4	2	11	2	5	2	53	4	15	3	5	3	53	2010	3	3	99
Ivory Gull	0	0	2	1	1	1	1	0	4	2	1	0	4	2011	1	0	55
Sabine's Gull*	30	20	20	14	26	17	38	21	300	41	68	44	300	2011	26	14	52
Ross's Gull*	12	5	6	4	6	3	5	1	7	3	12	6	12	'07/'12	4	1	17
Black-legged Kittiwake	160	47	30	2	6	1	30	0	48	5	520	21	520	2012	13	39	301
Arctic Tern*	402	275	750	250	500	374	500	333	900	583	700	403	900	2011	370	30	8
Parasitic Jaeger*	5	3	5	3	5	3	16	4	5	2	4	2	16	2010	3	1	19
Long-tailed Jaeger	2	2	2	1	3	1	5	1	10	2	6	2	10	2011	1	1	59
Pomarine Jaeger	2	0	2	2	2	1	26	7	2	1	2	1	26	2010	2	3	130
Peregrine Falcon	0	0	1	0	1	0	1	0	0	0	0	0	1	N/A	0	0	N/A
Red Knot	30	9	20	10	20	13	35	7	47	14	18	9	47	2011	10	3	27
Ruddy Turnstone	23	4	2	1	1	1	2	0	8	1	13	1	23	2001	1	3	213
Purple Sandpiper**	4	2	2	1	6	6	2	0	120	2	7	2	120	2011	2	10	472
Sanderling	2	2	3	3	0	0	0	0	35	1	6	3	35	2011	1	3	248
Baird's Sandpiper	0	0	6	0	1	1	0	0	11	0	2	0	11	2011	0	2	N/A
Red Phalarope	18	7	16	6	14	3	7	2	160	10	2500	284	2500	2012	52	196	379

Common Raven	2	1	3	2	2	1	4	1	2	2	2	1	4	2010	1	0	N/A
Lapland Longspur	2	0	1	0	5	1	2	0	0	0	1	1	5	2009	0	1	N/A
Snow Bunting**	2	1	4	2	4	2	2	1	9	1	8	1	9	2011	1	1	52
Total	**1083**	**516**	**1368**	**537**	**1175**	**791**	**1378**	**607**	**2876**	**961**	**4906**	**1125**	**4906**		**755**		

Appendix 1. Metadata for ArcGIS raster layers

Dataset	Source	Download Source	Scale	Cell Size	Projection
Island Maps	CanVec, Natural Resources Canada	http://geogratis.cgdi.gc.ca/geogratis/en/index.html	1:50,000	5 m	NAD 83 UTM Zone 14N
DEM	GeoBase	http://geobase.ca/geobase/en/data/cded/index.html	1:50,000	5 m	NAD 83 UTM Zone 14N

Appendix 2. Additional Methods for ArcGIS Analysis

(1) Euclidean distance from centres of recurring polynyas was determined by assigning a percent distance value to the range of distances from the centre of each polynya (0%), to the limit of the borders of the study area at the maximum distance from any of the centre points (100%).

(2) Island Area was calculated as the product of latitudinal and longitudinal degree values of each island (with a resolution of 0.0001 seconds), with permanent bodies of water such as non-ephemeral ponds or lakes excluded. Island area is presented in km^2.

(3) Euclidean distance from nearest larger island was calculated by measuring the shortest straight-line distance between islands.

(4) The three main criteria (Area, Elevation, Distance to nearest Polynya) were ranked and islands were sorted into four categories; 1) Ideal, 2) Suitable, 3) Marginal, and 4) Unsuitable. Elevation was ranked as: 0-10m (Ideal); 10-20m (Suitable); 20-30m (Marginal); >30m (Unsuitable). Divisions between the other criteria were based on Jenks Natural Breaks within the data ranges (Classify Tool in ArcGIS 10.1), and assessed by comparing values on an undefined scale with previous observations of habitat types and associated avian nesting communities within this region (Mallory & Gilchrist, 2003; Maftei et al. 2012).

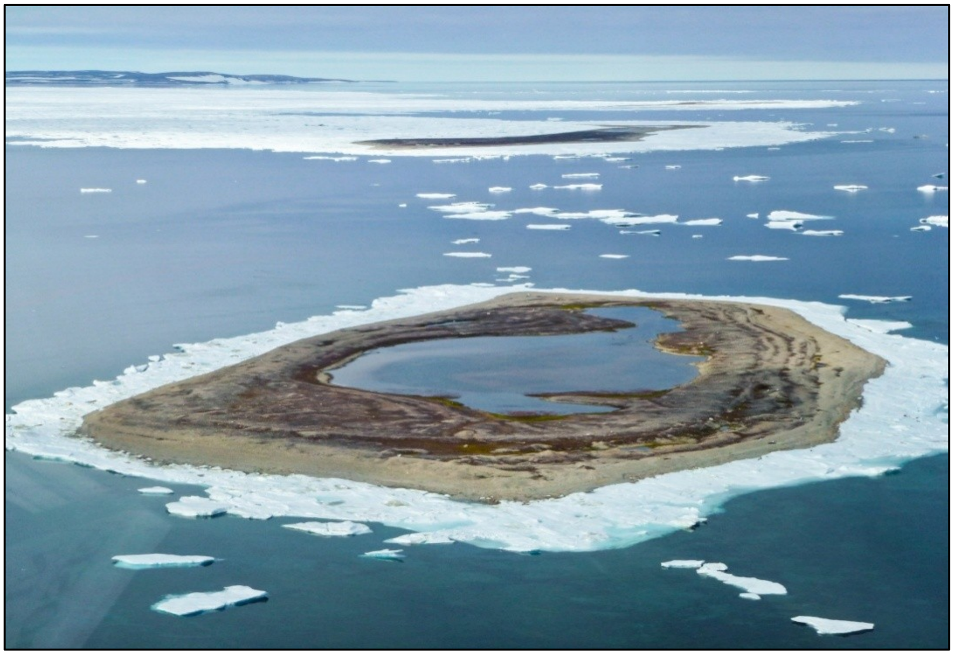

Plate 5 Ross's gull nesting habitat in the Canadian High Arctic. A view looking north over South, Middle and North Cheyne Islands. Bathurst Island is on the far left horizon

Plate 6 An aerial view of Nasaruvaalik Island. The densest concentration of nesting birds is near the tip of the southern peninsula - to the right in this image

3.

QUANTIFYING FALL MIGRATION OF ROSS'S GULLS PAST POINT BARROW, ALASKA

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Abstract

The Ross's gull (*Rhodostethia rosea*) is a poorly known seabird of the circumpolar Arctic. The only place in the world where the species is known to occur in considerable numbers is in the near-shore waters around Point Barrow, Alaska where birds undertake an annual passage in late fall. Ross's gulls seen at Point Barrow are presumed to originate from nesting colonies in Siberia, but neither their origin nor their destination has been confirmed. Estimates of the global population of Ross's gulls are based on highly speculative extrapolations and the only reliable minimum population estimate is based on previous counts conducted at Point Barrow, but these data are now over 25 years old. In order to update and clarify the status of this species in Alaska, I quantified the timing, number, and flight direction of Ross's gulls passing Point Barrow in 2011. This survey recorded 27,428 Ross's gulls over 39 days.

Keywords: Ross's gull, *Rhodostethia rosea*, migration, survey, Barrow, trans-Beringian

Introduction

For over a century, scientists have known that Ross's gulls (*Rhodostethia rosea*) occur in large numbers around Point Barrow, Alaska in the fall (Murdoch 1899). In fact, this species was known primarily as a fall migrant well before its first breeding colonies were discovered in the early 20th century (Buturlin 1906). A report by Divoky et al. (1988) described and quantified the annual passage of Ross's gulls through the Beaufort and Chukchi Seas over several years, and by combining data from aerial, marine and ground surveys, began to clarify the extent and timing of Ross's gull movements in Alaska. The breeding range and distribution of Ross's gulls remains largely speculative, but most purportedly breed in Siberia (Degtyarev 1991; Blomqvist & Elander 1981; Densley 1999) with smaller populations in Greenland (Egevang and Boertmann 2008) and Canada (Maftei et al. 2012). Recent discoveries of stable colonies in Canada and Greenland suggest that Ross's gulls are a true circumpolar species with established population in the Nearctic (Egevang & Boertmann, 2008; Maftei et al. 2012) rather than a Siberian endemic as previously believed (Dementiev and Gladkov 1968; Degtyaryev 1991). The non-breeding distribution of this species remains unknown, but small numbers have been reported from Foxe Basin, Nunavut in the late fall (Mallory et al. 2001), in the Sea of Okhotsk (Ilyichev and Zubakin 1988), and significant numbers occur briefly in late fall along the north coast of Alaska (Divoky et al. 1988). There are no records of a corresponding spring migration of Ross's gulls from anywhere in the world.

My study was conducted to build upon previous work and fill some of the gaps that remain in our understanding of the biology and ecology of this species. In order to assess the timing of the annual migration, the numbers of birds involved, and the age ratio of the birds undertaking this passage, I conducted a continuous survey of Ross's gulls at Point Barrow over 39 days in September and October, 2011, the most thorough survey of this species to date.

Materials and Methods

Fieldwork was conducted near Barrow, Alaska from two observation blinds located at the base of a long narrow gravel spit that extends from inland coastal tundra to Point Barrow (71° 19'N, 156° 40' W). Observations of Ross's gulls were made between 20 – 27 September 2011 from "Blind 1" and from 27 September until 28 October, 2011 from "Blind 2" (Fig. 3.1). Both blinds afforded the same general view, and location was only shifted so as not to interfere with the hauling out and butchering of whales on the beach near Blind 1.

I recorded all Ross's gulls seen from the blinds during daylight hours, i.e. between sunrise and sunset, the times of which were obtained from a government chart (NOAA 2012). Observations were made using the naked eye, binoculars, and a 20-60X zoom spotting scope as conditions dictated (i.e. the distance at which birds were flying from the blind). Each individual Ross's gull was counted, and when possible counts were repeated to ensure accuracy. In the very few cases when counts disagreed, they were repeated until the same number was obtained twice in a row. The data presented here reflect a discrete total of individual Ross's gulls and no estimates or extrapolations were made or incorporated in the analysis. Juvenile (i.e., fledged during the 2011 breeding season) Ross's gulls were distinguished by their contrasting wing pattern which could be seen at a considerable distance (e.g., when observed at 60X zoom through a spotting scope), and were counted separately from adult birds. Birds were generally visible to a distance of at least two kilometers from shore. Data were continuously recorded by observers and tallied into hourly blocks and into columns denoting flight heading (northeast or southwest). Northeast was defined as any heading with a northern or eastern component in the flight path of a bird, while southwest was defined as a flight path along any heading with a southern or western component. In all cases birds were followed briefly to confirm their flight direction. The size and species composition of flocks in which Ross's gulls were travelling was also recorded; flock defined as a discrete and cohesive group of birds travelling at the same speed in close proximity to each other. Observations were suspended during periods of extremely limited visibility, i.e., <200m (an approximate total of 6 hr over the course of the census, or 1.6% of the total observation period).

Daily wind and temperature averages were obtained from METAR weather reports provided by the PBAR weather station in Barrow (Weather Underground Inc. 2012).

Results

A total of 27,428 Ross's gulls were observed over 39 days (386 hr, 17 min) between 20 September 2011 and 28 October 2011 (Fig. 3.2). Of these individuals, 27,210 were adults and 218 (0.8%) were juvenile birds. Most birds (23,388; 85%) were observed flying northeast, while 4,040 birds (15%) were observed flying southwest.

The movement of Ross's gulls past Point Barrow took place over at least 5 weeks (Fig. 3.2). Birds were observed flying northeast over 38 days, but most birds (99.6%) passed during a period of 28 days (28 September - 25 October). Southwest migrants were observed over 26 days, but most birds (98.0%) passed during a period of 16 days (30 September - 15 October). Northeast migration consisted of an initial passage of birds in early October followed by a lull of several days after which we observed a major peak in migrants on 16 October, with numbers tapering off by 23 October. Between 15-23 October we observed 18,379 individuals (78.6% of all NE migrants) including 7,501 individuals (32.1 % of all NE migrants) on 16 October alone, 7,116 of which were counted within a three-hour period (Fig. 3.2).

Although day length decreased rapidly over the course of the survey period (maximum day length 12 hr 52min, minimum day length 6 hr 48 min), the mid-day point between sunrise and sunset varied little and occurred at 14:16 (± 5 min). Greater numbers of Ross's gulls were counted in the morning, between sunrise and mid-day (≈84% of all migrants). Hourly totals then declined steadily throughout the afternoon, with a slight increase in numbers just before sunset. On several clear mornings I observed but did not record numerous Ross's gulls already passing the blind before sunrise.

Ross's gulls were typically observed flying 1 – 50 m above the surface of the water in small, loose flocks (mean flock size = 13.1, SD = 36.8, n = 2,091). On several occasions flocks were recorded containing > 100 individuals (n = 18; maximum flock size = 1,060). Ross's gulls occasionally flew in mixed flocks with black-legged kittiwakes (*Rissa tridactyla*) (9.6 % of flocks, n = 200). Most Ross's gulls flew on a direct and level flight path with no deviation or pause. Birds that stopped to feed in the census area subsequently continued along their original heading when they departed. Although I was only able to monitor an area of at most two kilometers from the blind, I did not record any birds reversing their flight path or doubling back over the course of my observations.

Discussion

Timing of migration in Alaska

Ross's gulls pass by Point Barrow in September and October. The earliest date they have been noted in any significant numbers is "early September...abundant by the 21st" (Murdoch 1899). Divoky et al. (1988) first noted Ross's gulls between 27 and 30 September during the three years when shore-based counts were conducted, and I first recorded Ross's gulls on 21 September during this study. This study as well as other accounts (Murdoch 1899; Divoky et al. 1988) indicate that Ross's gull migration persists until late October. In 2011 Ross's Gulls were observed as late as 28 October, but by this point the migration had slowed considerably and from 24 to 28 October only 280 individuals were recorded (≈1% of all birds observed).

It seems unlikely that significant numbers of Ross's gulls spend time staging near Point Barrow. Although I did incidentally observe small numbers of birds feeding along the shoreline of Elson Lagoon and along the Beaufort Sea coast from Point Barrow to Plover Point on some days, virtually all of the birds observed during the survey passed close to shore (<1 km) through the survey area in sustained and direct flight.

Global population

Ross's gulls are one of the least studied seabirds in the world. They breed and winter in extremely remote areas, and their general distribution is still largely speculative. As such, it is difficult to accurately determine the global population. The only current breeding population estimate based on actual survey data puts the Siberian breeding population between 45,000 -

55,000 individuals (Degtyarev 1991), but this is an extrapolation based on observations of only 400 individuals over three years across an area of approximately 236,000 km^2. Divoky (1988), suggested a minimum global population of 20,000 to 40,000 individuals based on estimates of birds present in Alaskan waters in the fall, of which 15,000 to 25,000 were estimated to enter the Beaufort Sea. The population of birds in the Nearctic is unknown.

My observations in 2011 suggest that a minimum of 27,500 Ross's gulls are present in the Beaufort and Chukchi Seas during the fall passage of birds. Given that some birds passed uncounted during periods of limited visibility or before sunrise, the total passage likely exceeded 30,000 individuals. Based on the behaviour of the birds observed, I do not believe that any birds were counted more than once, i.e., northeast and southwest migrants represented different groups of individuals. However, even if it is assumed that all birds observed flying northeast *were* previously counted while flying southwest, the data still indicates a minimum population of 19,348 individuals. It is difficult to account for the presumed passage of additional birds further offshore and out of observer range. The high variability in daily observed numbers of birds particularly when considered in light of corresponding daily variation in wind speed and direction (Fig. 3) suggests that detection probability may increase under conditions in which strong onshore winds drive birds closer to shore, but I have no way of either confirming or correcting for this.

I expect that my estimates reflect the magnitude of the birds following this migration route. It is not known what proportion of the global population this represents, but it is certainly substantial based on current estimates; perhaps up to 67% (Divoky et al. 1988; Degtyaryev 1991).

Age class ratio

Ross's gulls have relatively low reproductive success among larids (COSEWIC, 2007; Densley, 1999), with fledging success regularly as low as 20% in Siberia (Kondratyev et al. 2000). My survey in 2011 recorded a proportion of juvenile to adult birds of only 0.8%. The lowest proportion of juveniles reported from three years of land-based surveys by Divoky et al. (1988) was 5% in 1984, which is still six times greater than the proportion recorded in 2011. Notably, Divoky et al. (1988) reported a much higher proportion (50%) of juvenile Ross's gulls during at-sea surveys in the Chuckchi Sea in 1970, although the total number of Ross's gulls observed was very low (n = 149 over 10 days). These two extremes in observed age ratios suggest two possibilities that are not mutually exclusive; either that Ross's gulls segregate by age after the breeding season and follow different migration routes, and/or that this species can experience near-total breeding failure in some years across wide parts of their breeding range. Further study is needed to determine if either of these factors can account for the low numbers of juveniles seen, as current data are difficult to interpret without a clear understanding of which population(s) or proportion thereof is actually migrating past Point Barrow.

Possible origins of Ross's Gulls in Alaska

There are very few nesting records of Ross's gulls, and since the first colonies were described from northern Siberia (Buturlin 1906), breeding has only been intermittently reported from widely scattered sites (Nettleship et al. 2000; Densley 1999; Maftei et al. 2012). Perhaps fewer than 200 nests have ever been found. Ross's gulls had long been considered endemic to the coastal tundra of northeast Siberia (Dementiev and Gladkov 1968; Kondratyev et al. 2000), but additional breeding records from Greenland (Egevang & Boertmann 2008) and Canada (Maftei et al. 2012) suggest that this species is a circumpolar breeder which has gone undetected on account of the extreme remoteness of its nesting habitat and its irregular occupation of very small colonies. Given that birds at known or suspected breeding sites can only account for about 1% of the estimated global population (Degtyarev 1991; Egevang & Boertmann 2008; Maftei et al. 2012) and there is no clear indication where this species winters, determining the origin and destination of the individuals observed during migration is still largely a matter of speculation.

There is little information describing the post-breeding movement of Ross's gulls besides the passage of birds at Point Barrow. There are anecdotal reports of congregations of birds staging along the Arctic coast of Siberia before heading east in the late summer (Ilyichev & Zubakin 1988), and birds as far west as Svalbard may undertake an easterly migration in the fall (Ilyichev & Zubakin, 1988; Meltofte et al. 1981). Concentrations of presumed non-breeding birds have also been reported from the waters north of Franz Josef Land during July and August (Meltofte et al. 1981). It is unknown where Ross's gulls from colonies in the Nearctic go after the breeding season.

Previous accounts of Ross's gulls migrating past Point Barrow (Murdoch 1899; Divoky et al. 1988) have described two distinct passages of birds; a large movement of birds heading northeast, and a smaller movement of birds heading southwest. In two of three years in which Divoky et al. (1988) conducted surveys, the southwest return flight consisted of fewer birds than were initially observed heading northeast, which was attributed to the formation of near-shore ice which prompted returning birds to fly across a wider front and farther offshore where they went undetected. Divoky et al. (1988) posited that birds originating in Siberia migrated into the Beaufort Sea to feed on zooplankton in the seasonally productive continental shelf waters before returning into the Chukchi Sea a short time later and then continuing on to wintering areas somewhere in the western Bering Sea or the Sea of Okhotsk. Unconfirmed anecdotal reports suggest that congregations of Ross's Gulls may occur in these areas during the winter (Dementiev & Gladkov 1969; Ilyichev & Zubakin 1988).

My observations in 2011 indicated a steady stream of Ross's gulls heading northeast punctuated by a distinct movement of migrants heading southwest roughly halfway through the survey period. Nearly all of the Ross's gulls I observed heading southwest passed well before the peak of the northeast movement (Fig. 3.2). The net movement of Ross's gulls was to the northeast, and there was no indication of a return movement even after the ocean near shore had begun to freeze.

Recent studies have confirmed that significant numbers of many circumpolar species of birds migrate between breeding and wintering areas on opposite sides of the Beringian divide (Alerstam and Gudmundsson 1999; Alerstam et al. 2007). Trans-Beringian migrations have been observed in most families of Arctic breeding birds including passerines (Lehman 2005; Alerstam et al. 2008), waterfowl (Dau et al. 2000; Oppel et al. 2008), shorebirds (Gill et al. 2005; Handel and Gill 2010), and loons (Paruk et al. 2011). My observations of two distinct and temporally separated movements of Ross's gulls are similar to those previously reported by Divoky et al. (1988), but the notable difference in the relative timing of passage of these groups of birds suggests the possibility that Nearctic and Palearctic breeding populations of Ross's gulls may undertake opposing trans-Beringian migrations.

In summary, I found that up to two thirds of the estimated global population of Ross's gulls undertake an annual migration past Point Barrow, Alaska in September and October. The low ratio of juveniles to adults within this migrating population suggests low annual reproductive output in this species, and/or possibly a segregation between adults and juveniles at this time of year. The migration of Ross's gulls past Point Barrow can be differentiated into numerous flocks heading northeast and fewer flocks heading southwest, which may possibly represent movements of birds from two different breeding areas, the numerous northeast-bound migrants originating in Siberia and the smaller southeast-bound movement consisting of birds originating from undiscovered colonies in the Nearctic. My study provides no evidence on which to base predictions as to the ultimate destination of any of these birds.

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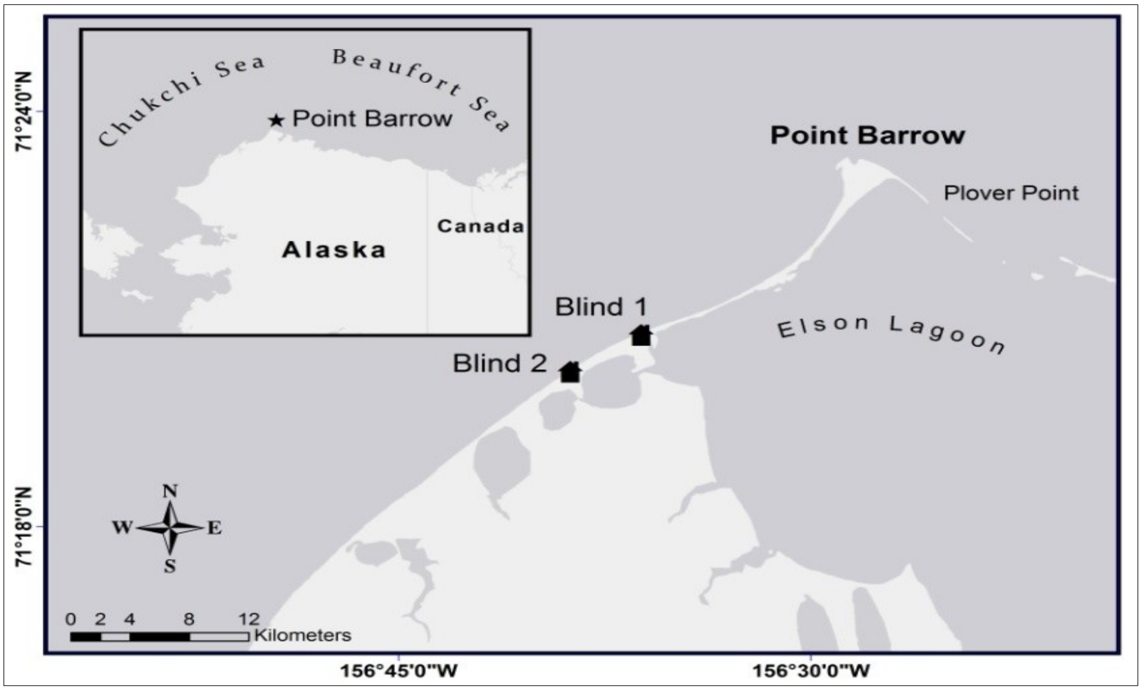

Figure 3.1 Study area near Point Barrow, Alaska (*black star*). The approximate locations of the observation blinds are shown (*black houses*) migration

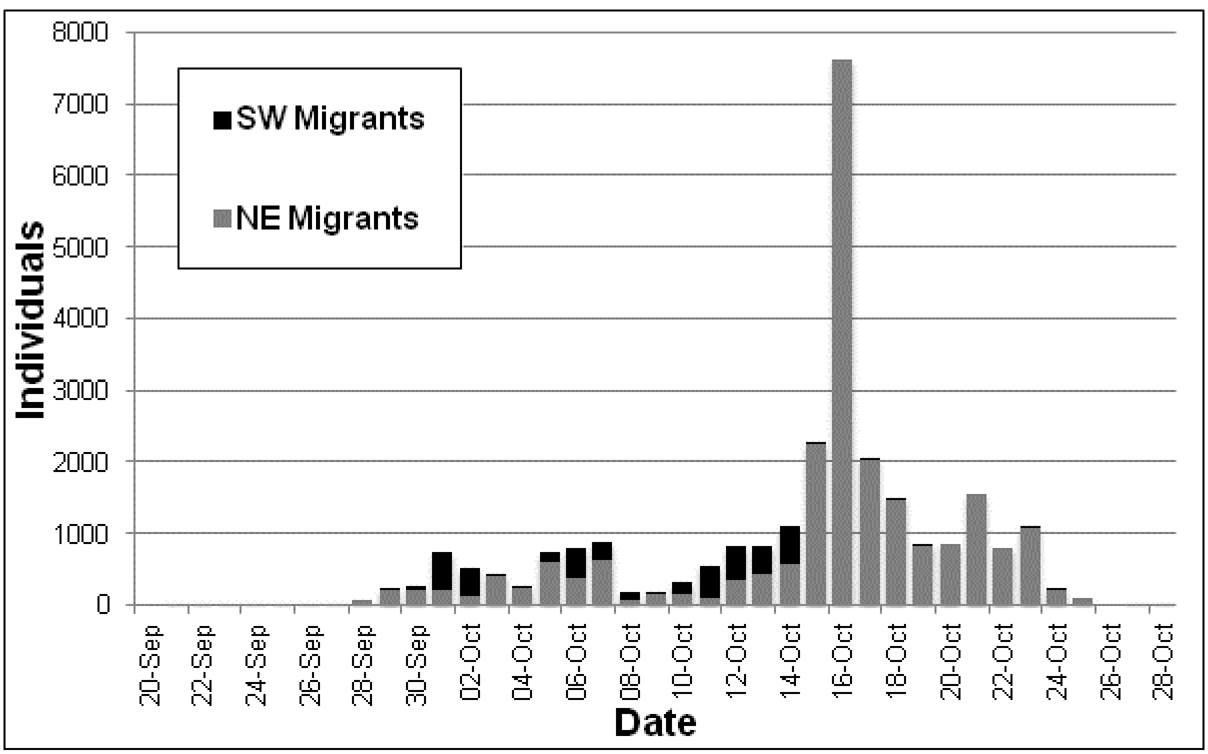

Figure 3.2 Total daily counts of Ross's gulls between 20 September and 28 October, 2011. *Grey* shows northeast migration and *black* shows southwest

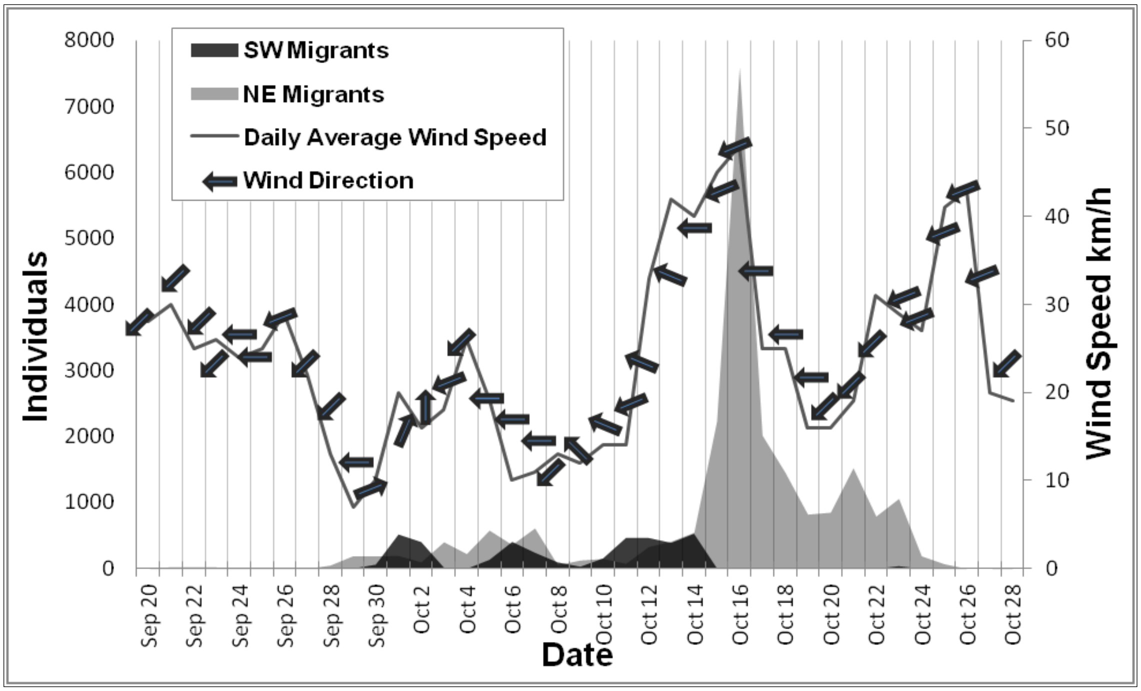

Figure 3.3 Ross's gull migration in relation to daily average wind speed and direction between 20 September and 28 October, 2011 (Weather Underground Inc. 2012). Arrows indicate compass direction of wind origin, with north at top of page

Table 3-1 Multi-year comparison of Ross's gull migration past Point Barrow

Year of observations	**1984**		**1986**		**1987**		**2011**	
Flight direction	NE	SW	NE	SW	NE	SW	NE	SW
Total individuals	16,516*	7,069*	4,679*	10,034*	4,514*	3,553*	23,388	4,040
Total hours of observation	127	127	135	129	95.8	95.8	386.25	386.25
Days of observation	22		23		20		39	
Mean birds/day	750.7	321.3	203.4	436.3	225.7	177.6	599.7	103.6
SD ± birds/day	973.9	448.4	263.8	809.4	633.3	549.5	1280.5	175.9
Birds/hr of observation	130	55.7	34.6	77.8	47.1	37.1	60.6	10.4
Ratio of NE to SW birds	2.33		0.45		1.27		5.79	
Source	Divoky et al. (1988)		Divoky et al. (1988)		Divoky et al. (1988)		This Paper	

*Projected daily totals extrapolated from hourly observations

Plate 7 Part of a large flock of migrating Ross's gulls. Point Barrow, Alaska

Plate 8 Ross's gulls with ivory gull over Elson Lagoon. Point Barrow, Alaska

Plate 9 Ross's gulls feeding in Elson Lagoon, Point Barrow, Alaska

Plate 10 Adult (top) and juvenile (bottom) Ross's gulls. Point Barrow, Alaska

Plate 11 Ross's gull with a small amphipod (*Anonyx nugax*). Point Barrow, Alaska

Plate 12 A juvenile Ross's gull. Point Barrow, Alaska

Plate 13 A non-breeding Ross's gull - an especially pink individual! Point Barrow, Alaska

GENERAL DISCUSSION

Breeding range and distribution

The overall extent and remoteness of both the breeding and possible wintering areas used by Ross's gulls probably preclude any attempt to thoroughly census either the global population or monitor fluctuations at any comprehensive level. Monitoring breeding populations is difficult since this species appears to nest in very low densities, and there is no evidence to date to suggest that wintering birds congregate in any appreciable density, thus at-sea surveys are an unlikely method with which to attempt to track changes in global or even regional populations.

Aerial surveys, although expensive, are ultimately likely to be the most effective means of assessing the breeding distribution of Ross's gulls. Previous efforts (Degtyarev 1991; Maftei et al. 2012) have been successful in differentiating Ross's gulls from superficially similar sympatric species as well as identifying likely habitat as determined by physical and/or ecological characteristics of nesting sites. Furthermore, recent attempts to assess and characterize potential nesting habitat in the High Arctic (Chapter 2) may be further refined and applied in other regions or habitats with comparable success as a means of informing future surveys. Any such predictive model is unlikely to be useful as a means of estimating populations on its own given the very low nesting density and sporadic occupation of breeding sites by Ross's gulls across all habitats within their known range. However, a refined method of classifying habitat combined with a better understanding of typical nesting densities of Ross's gulls in various parts of their range may allow for cautious extrapolation of regional populations.

The breeding range of Ross's gulls in Canada is still unclear. Assuming that the Canadian population is significant as a proportion of the total global population (i.e. thousands of breeding pairs), the vast majority of these nesting birds remain unaccounted for. Based on our current understanding of the nesting habitat used by Ross's gulls in Canada, it seems probable that this putative nesting population has simply been overlooked in largely inaccessible or poorly surveyed areas. Areas of suitable habitat include both the High Arctic marine type as well as the taiga floodplain type, and promising areas for future surveys include the archipelago of islands in Foxe Basin, Nunavut, as well as the river deltas of the Hudson Bay Lowlands in northern Ontario, Manitoba, and southeastern Nunavut.

Wintering range

The wintering range of the Ross's gull remains unknown. Despite a great deal of speculation there have been no reliable observations of any appreciable numbers of birds during the winter season. The edge of the Arctic pack ice (Murdoch 1899), the Sea of Okhotsk (Divoky et al. 1988; Ilyichev & Zubakin 1988), the Gulf of Anadyr, the northern Bering Sea, and other contiguous areas of the northern Pacific (Ilyichev & Zubakin 1988; Divoky et al. 1988; Blomqvist & Elander 1981; Densley 1999; Dementiev & Gladkov 1969) have all been suggested or identified anecdotally as wintering areas used by this species, but as of yet no surveys or even casual observations have supported these claims. To date, the only conclusive evidence indicating the movements of adult Ross's gulls during the winter comes from a very small sample (n=2) of individuals from a Canadian breeding site (Nasaruvaalik Island, NU) tagged with satellite transmitters. These birds wintered in Davis Strait and the northern Labrador Sea (Maftei et al.

unpubl. data). The fact that the data obtained from these birds indicate that they are entirely pelagic, often many hundreds of kilometers from shore in ice filled seas, would in part explain the lack of sightings in this region.

The very low proportion of juvenile birds observed in passage past Point Barrow (Divoky et al. 1988; Chapter1) suggests that either annual reproductive success is very low, or that juvenile Ross's gulls follow different migratory routes and possibly even winter in areas different from those used by adults. Observations from the Chukchi Sea off the coast of Alaska during the post-breeding season of small flocks containing a high proportion of juvenile birds (Divoky et al. 1988) suggest that at least in some areas or at some times Ross's gulls may be geographically segregated by age. Satellite telemetry tracking could conceivably clarify this issue, and tracking both adults and their young would greatly increase our understanding of how the timing and extent of post-breeding movements may differ between adults and juveniles.

Migratory movements

The annual movement of Ross's gulls past Point Barrow, Alaska remains the only known instance of Ross's gulls congregating in significant numbers anywhere in the world, and as such offers a unique opportunity to observe what is thought to be a substantial portion of the total population of this species during a consistent and limited timeframe. Anecdotal reports of similarly large congregations of birds in Siberia (Ilyichev & Zubakin 1988; Densley 1999) should be confirmed, and if accurate, could also serve to clarify the temporal and spatial patterns of dispersal of this species from the breeding grounds in Siberia eastward to Alaska and the Beaufort Sea. Annual or repeated censuses of migrating birds in Alaska (and possibly Russia) could further be combined with satellite telemetry tracking studies to effectively monitor breeding populations and further clarify the distribution of the species during both the breeding and non-breeding season.

Breeding in Canada

The status of Ross's gull in Canada has been surprisingly vague given the number of breeding records over the last 190 years. Based on the number and pattern of confirmed and suspected breeding records as well as the records of birds observed in breeding plumage during the breeding season in likely habitat, it seems overwhelmingly likely that this species breeds regularly but widely dispersed across a large range in the Canadian Arctic. Forty-seven breeding records from 18 sites in both Canada and Greenland have been summarized (Table 1-1), and together suggest that a stable population of Ross's gulls breeds in the Nearctic and specifically Canada.

The low density of birds at breeding sites where they associate with superficially similar species (i.e. other small larids) probably means that even significant numbers may be regularly overlooked even by experienced observers during casual or opportunistic aerial surveys.

Recent studies have shown that Ross's gulls breeding in the Canadian High Arctic occupy an ecological niche and rely on nesting and foraging habitat markedly different from that used by birds in Siberia (Maftei et al. 2012; Densley 1999), but similar to that reported from Greenland (Egevang & Boertmann 2008). The possibility that the global population of Ross's gulls may include multiple geographically or even reproductively isolated populations would account for this disparity, but more work is needed to clarify the genetic structure of the population. Preliminary studies (Royston 2007) are inconclusive, but indirectly support this hypothesis.

Based on historical records as well as a more recent habitat assessment (M. Maftei, unpubl. data), it seems likely that islands in Foxe Basin should also support breeding Ross's gulls given the ecological similarity of this region to other areas in the Canadian High Arctic and Greenland where the species also nests. Future surveys of this region are needed to determine if this is indeed an area used by Ross's gulls. Tagia floodplain habitat in the Hudson Bay Lowlands of Ontario, Manitoba and Nunavut may also support significant numbers of breeding Ross's gulls. Multiple breeding pairs nested near Churchill, MB over a period of almost 30 years (Table 1-1), and it seems likely that the birds observed regularly near the town of Churchill represented only a portion of a larger population distributed across adjacent but less accessible and less frequently surveyed habitat. The similarity between the nesting habitat used by Ross's gulls in Manitoba and that used by birds in Siberia is notable, since it would suggest that perhaps the nesting strategy of birds in both area would be similar in other respects such as colony size and breeding density.

The lack of additional Canadian breeding records from the extensive areas of coastal and inland taiga floodplains around Hudson Bay is probably due to a lack of adequate coverage rather than a scarcity of birds, and aerial surveys and/or telemetry tracking of individual birds may reveal a much larger breeding population in the Low Arctic.

Conclusion

There is still much to learn about the Ross's gull, but recent work has filled in some of the blanks and helped clarify and update historical information regarding this species, particularly its status in North America.

Although any large-scale studies of this species are unlikely to ever prove feasible, several focused efforts to survey likely breeding habitat, track breeding birds and collect behavioural observations have proven that a 'quality over quantity' approach may prove an effective way to answer some of the major questions which still remain about this species, especially in North America. Of course, given that the majority of Ross's gulls breed and possibly winter in Asia, research conducted in North America will only be able to provide part of the picture, and continued research in Russia will be required to conclusively determine the ecology and distribution as well as the genetic structure of the global population.

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Plate 14 ***'This rare mysterious inhabitant of the unknown north, which is only occasionally seen, and of which no one knows whence it cometh or whither it goeth, which belongs exclusively to the world to which the imagination aspires, is what, from the first moment I saw these tracts, I had always hoped to discover as my eyes roamed over the lonely plains of ice.'***

From the diary of Fridthof Nansen, August 3[d], 1894