

Status of High Arctic Black-Legged Kittiwake (*Rissa tridactyla*) Colonies in Barrow Strait, Nunavut, Canada

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ABSTRACT. We used aerial survey estimates, photographic censuses, and plot counts to examine trends in the size of five black-legged kittiwake (*Rissa tridactyla*) colonies around Barrow Strait, eastern Nunavut, Canada, between 1972 and 2007. During these three decades, one small colony disappeared, two medium-sized colonies showed no overall trend, and one moderate and one large colony appeared to increase in size. Collectively, the number of kittiwakes breeding in this region may have increased by over 40%. Counts of kittiwakes at some colonies were markedly low in 2003, following two consecutive years of late, extensive sea ice, although overall there was no significant relationship between numbers of kittiwakes attending colonies and sea-ice extent in Barrow Strait and Lancaster Sound. It is not known why kittiwake colonies in High Arctic Canada have apparently increased while those in West Greenland and elsewhere have declined, or what factors influenced these changes.

Key words: black-legged kittiwake, *Rissa tridactyla*, Arctic, population trend

RÉSUMÉ. Entre 1972 et 2007, à l'aide d'estimations effectuées à partir de levés aériens, de recensements photographiques et de dénombrements, nous avons examiné les tendances caractérisant la taille de cinq colonies de mouettes tridactyles (*Rissa tridactyla*) dans les environs du détroit de Barrow, dans l'est du Nunavut, au Canada. Pendant ces trois décennies, une petite colonie a disparu, deux colonies de taille moyenne n'ont affiché aucune tendance générale, tandis que la taille d'une colonie de taille modérée ainsi que celle d'une colonie de grande taille ont semblé augmenter. Collectivement, le nombre de mouettes tridactyles se reproduisant dans cette région pourrait s'être accru de plus de 40 pour cent. En 2003, le nombre de mouettes tridactyles de certaines colonies était nettement bas, ce qui suivait deux années consécutives de glace de mer tardive et étendue bien que dans l'ensemble, il n'existait pas de relation importante entre le nombre de mouettes tridactyles faisant partie des colonies et l'étendue de la glace de mer dans le détroit de Barrow et le bras de mer de Lancaster. On ne sait pas pourquoi les colonies de mouettes tridactyles de l'Extrême-Arctique sembleraient avoir pris de l'ampleur, tandis que les colonies de l'ouest du Groenland et d'ailleurs se sont amincies. De plus, on ne connaît pas les facteurs qui ont influencé ces changements.

Mots clés : mouette tridactyle, *Rissa tridactyla*, Arctique, tendance caractérisant la population

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INTRODUCTION

Seabirds are a ubiquitous feature of the Canadian Arctic marine environment, with millions of birds migrating to this region to breed and feed during the brief Arctic summer (Brown et al., 1975; Mallory and Fontaine, 2004). As seabirds are strong indicators of the health of the marine ecosystem (Cairns, 1987; Montevecchi, 1993), long-term monitoring of seabird populations provides an index of overall changes in the marine food web (e.g., Frederiksen et al., 2004). Indeed, seabird monitoring in Arctic Canada has detected progressive shifts in the relative abundance of small forage fish in response to changing climate, as well as the effects of late, extensive sea ice on marine productivity (Gaston and Hipfner, 1998; Gaston et al., 2003, 2005a).

The black-legged kittiwake (*Rissa tridactyla*) is a small marine gull with a circumpolar distribution (Baird, 1994)

that includes colonies situated in the eastern Canadian Arctic (Brown et al., 1975). Recently concerns have been raised over declining numbers of kittiwakes at colonies around the North Atlantic Ocean, from the United Kingdom (Frederiksen et al., 2004) west to Greenland (Nyeland, 2004). Population reductions have been attributed principally to changes in marine food supplies linked to climate change and effects of commercial fisheries.

Although the kittiwake has been studied elsewhere in its breeding range (Baird, 1994), little research has been conducted on the species in Arctic Canada, despite the fact that the region supports an estimated 95 000 breeding pairs, or 48% of the Canadian breeding population (Mallory and Fontaine, 2004). Studies have been limited to regional surveys in the 1970s (e.g., Brown et al., 1975), contaminant monitoring (Braune, 2007), a single-season study in the Low Arctic (Gaston, 1988), and a multi-year assessment of

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breeding biology at one site in Lancaster Sound (Gaston et al., 2005b). However, recently we had the opportunity to census kittiwake colonies around Barrow Strait in the Canadian High Arctic archipelago (Fig. 1), as part of regional surveys for ivory gulls (*Pagophila eburnea*; Robertson et al., 2007). In this paper, we report on the population status of four colonies, as well as the trends in population size at one major colony inferred from three decades of intermittent plot monitoring. We also assess the suggestion by Alliston et al. (1976) that interannual variation in sea-ice distribution in this region leads to interannual variation in colony attendance, and specifically that fewer kittiwakes attend their colonies during breeding seasons when sea ice around the colony breaks up later, or is abnormally extensive.

METHODS

Our work focused on the five kittiwake colonies found around Barrow Strait in eastern Nunavut, Canada (Fig. 1), and specifically on Browne Island, Baillie-Hamilton Island, Separation Point (Cornwallis Island), Batty Bay (Somerset Island), and Prince Leopold Island. Aerial surveys of these colonies were conducted in July–August 1972 and 1973, and June–August 1974 and 1975 (Nettleship, 1974; Brown et al., 1975; Alliston et al., 1976). These surveys generally consisted of a single flight from fixed-wing aircraft, during which colony size was estimated. We used the published, estimated colony size from those surveys as our initial baseline (Table 1). For more recent censuses of the first four sites, we traveled to the colony by Bell 206L helicopter in the first week of July 2003–07. We hovered ~500 m from the colony (Batty Bay, Baillie-Hamilton, Separation Point), or landed and walked along the front of the colony (Browne Island), and then used a Canon® EOS 20D digital camera with a Canon EF 100–400 mm zoom lens (image stabilizer, 1:4.5–5.6) to produce a series of high-resolution, 8 megapixel photographs that encompassed each colony. These digital photographs were downloaded to computers and assembled in Microsoft® Powerpoint to produce an image of the entire colony at each site. Kittiwakes were counted from these images, with one exception. On Browne Island in 2003, two people counted all kittiwakes from the beach 100–200 m in front of the colony, using 10 × 42 binoculars or a 60× spotting scope.

At Prince Leopold Island, long-term monitoring plots were established on kittiwake breeding areas in the 1970s (G, M, Qupper, Qlower, Qnorth, S, T; Nettleship, 1977; Gaston et al., 2005b), and kittiwakes on these plots were counted daily whenever research teams were on the island between 1975 and 2008. Because of inclement weather (notably fog), not all plots could be counted each day, and in some years certain plots were under-represented. We used the annual mean count of birds present daily between 15 July and 15 August for plots G and M, because this figure maximized the number of years for which there were data ($n = 9$), but we note that the patterns were consistent when

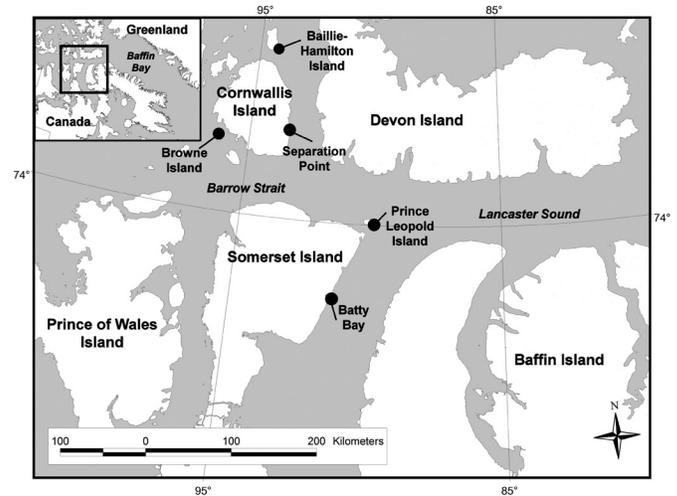


FIG. 1. Locations of black-legged kittiwake colonies around Barrow Strait in the eastern Canadian Arctic.

we aggregated counts from more plots representing fewer years.

We measured the distance from each colony to open water (or < 50% ice cover) during the third week of June each year, using archived sea ice distribution maps available at the Environment Canada – Canadian Ice Service Archive (<http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=11872&Lang=eng>). For Prince Leopold Island, following Gaston et al. (2005b), we scored the distance as “0” if the floe edge was at the colony, positive values if the floe edge was east of the colony (i.e., if sea ice was more extensive in Lancaster Sound), and negative values if the floe edge was west of the colony (i.e., if sea ice was less extensive in Lancaster Sound).

Trends in colony size were assessed for Prince Leopold Island by conducting a linear regression of \log_{10} transformed plot counts against year. The only other colony with sufficient data for a temporal comparison was Browne Island, where we compared counts from the 1970s to the 2000s using a t-test. To assess whether colonies had fewer kittiwakes in attendance during years when sea ice was more extensive, we created standardized values (Z scores) within each colony for annual kittiwake census or plot counts, as well as a standardized distance to open water (ice edge), thereby scaling all colonies to the same relative size and ice-edge distance. We then pooled data across colonies and regressed standardized annual colony size on standardized distance to the ice edge.

RESULTS

Browne Island

This colony is situated on east-facing, 100 m high sedimentary cliffs, and the site has been censused eight times since 1972. Estimated colony size has ranged from 1000

TABLE 1. Black-legged kittiwake colonies in the Canadian High Arctic that have recently been reassessed, showing locations and census estimates made since 1972. All counts from 2003 to 2007 are new data from this study.

Name	Location		Colony Census		Reference
	Latitude (°N)	Longitude (°W)	Year	Size	
Washington Point, Baillie-Hamilton Island	75.77	94.28	1972	1000	Nettleship, 1974
			1973	6000	
			2003	3464	
			2006	5488	
			2007	6273	
Separation Point, Cornwallis Island	75.12	93.48	1972	250	Nettleship, 1974
			2005	0	
			2006	0	
Browne Island	74.82	96.36	1972	2000	Brown et al., 1975
			1974	4000	
			1975	1000	
			2003	1692	
			2004	3430	
			2005	3221	
			2006	3941	
Batty Bay, Somerset Island	73.22	91.42	2007	3689	Alliston et al., 1976
			1974	700	
			1975	4000	
			2007	10007	

individuals (1975) to 4000 individuals (1974), with a maximum, photo-based count of 3941 individuals in 2006 (Table 1). The mean estimated colony size in the 1970s (2333 ± 883 SE, $n = 3$) did not differ from counts of kittiwakes at the colony since 2003 (3195 ± 395 , $n = 5$; Welch's $t_2 = 0.9$, $p = 0.46$), and annual census estimates have exhibited high variability (coefficient of variation [SD/mean] 40%).

Washington Point, Baillie-Hamilton Island

The colony at Washington Point, situated on sheer, southeast-facing, 200 m high cliffs, has been censused five times since 1972. Colony size has ranged from 1000 (1972) to 6273 (2007) kittiwakes. Like Browne Island, this site showed no obvious temporal trend in numbers of kittiwakes (Table 1), and annual counts have also been highly variable (CV 50%).

Separation Point, Cornwallis Island

This colony supported 250 kittiwakes in 1972 (Table 1; Brown et al., 1975). However, surveys in early July 2005 and 2006 found no kittiwakes at the site, and although lichens (*Xanthoria*, formerly *Caloplaca*) were found on the cliffs and two pairs of glaucous gulls (*Larus hyperboreus*) were present, there was no evidence (old nests or faecal remains) to indicate recent use by kittiwakes. This colony appears to have been abandoned.

Batty Bay, Somerset Island

This spectacular colony is situated on east-facing, sheer, 330 m high cliffs, and many of the kittiwake nests are located behind a waterfall. The colony has been counted only three times since 1974, with a maximum count of 10007 kittiwakes in 2007 (Table 1). However, this count is

2.5 times the colony size estimated in 1975, and 14 times the 700 individuals present in 1974, suggesting an increase in the size of the colony.

Using maximum estimates from 1973–75 for Browne Island, Baillie-Hamilton Island, and Batty Bay, these sites supported approximately 14 000 kittiwakes. However, in early July 2007, we counted 19 969 kittiwakes at these colonies, an apparent increase of 43%, due principally to the much higher numbers of birds found at Batty Bay in 2007.

Prince Leopold Island

This large kittiwake colony (~ 29 000 pairs; Nettleship, 1980) is situated principally on the east side of the island, on sheer, 330 m cliffs, among nesting thick-billed murres (*Uria lomvia*) and northern fulmars (*Fulmarus glacialis*). Although no complete colony census has been made since the initial census in 1973, kittiwakes attending breeding plots have been counted in 10 years since 1975. The mean number of kittiwakes counted on the study plots from 20 July to 6 August was 409 ± 21 SE birds in five years between 1975 and 1988, but 611 ± 74 SE birds for five years between 2001 and 2008 (Fig. 2), an apparent increase of 49%. This increasing trend in plot counts was statistically significant ($r^2 = 0.60$, $F_{1,8} = 12.1$, $p < 0.005$), described by the following relationship:

$$\log_{10}(\text{Plot Count}) = 0.0090 * (\text{Year}) - 15.278$$

Sea Ice Distribution and Colony Size

In the third week of June each year, kittiwakes had to travel as much as 200 km to reach areas with less than 50% ice cover (except for small leads that were not marked on maps; Fig. 3a). For the three smaller colonies, fewer kittiwakes were counted in years with more extensive sea ice,

but only at Baillie-Hamilton Island was this correlation significant ($r_{s5} = -0.97$, $p = 0.02$). Because there was a significant increase in kittiwakes at Prince Leopold Island over the 30-year period (above), we separated annual counts into pre-2000 and post-2000 categories. We calculated the difference between annual mean plot counts in each period and the overall average for that period to create a residual plot count for each year. Using these residuals, numbers of kittiwakes were not significantly correlated with distance to the ice edge at Prince Leopold Island (Fig. 3b; $r_{s9} = -0.05$, $p = 0.9$). Pooling standardized colony or residual plot count and distance to ice edge values for all colonies, we found a general pattern of fewer kittiwakes at colonies in years with more extensive ice, but this relationship was not significant ($r_{25} = -0.27$, $p = 0.19$). Despite this, we noted that since 2001, the lowest counts of kittiwakes at Browne Island, Baillie-Hamilton Island, and Prince Leopold Island all occurred in 2003 (Table 1), following two consecutive years of late, extensive sea ice and consequent poor reproduction in Lancaster Sound (Gaston et al., 2005b).

DISCUSSION

Our evidence suggests that there are perhaps 78 000 black-legged kittiwakes breeding around Barrow Strait, Nunavut (41% of the estimated Canadian Arctic kittiwake population; Mallory and Fontaine, 2004), which represents an increase from estimates in the 1970s. This contrasts somewhat to the pattern found in nearby Greenland, where kittiwake numbers declined in the 20th century (Nyeland, 2004). However, as in Greenland, there was considerable variability in annual and long-term colony size.

Annual variation in the size and occupancy of kittiwake colonies has been observed previously for colonies in Britain (Coulson, 1983) and eastern Canada (Chapdelaine and Brousseau, 1989). Some black-legged kittiwakes will emigrate from one breeding colony to another in response to poor feeding or breeding conditions (Danchin et al., 1998; Suryan and Irons, 2001). However, these studies examined movements among numerous colonies of kittiwakes situated within ~100 km of each other, and in locations without sea ice. In our study, there were only five colonies in the region, and most were at least 100 km from each other. Moreover, in the Arctic, it seems likely that the constraints of a short period of available food and extensive sea ice would strongly favour birds that had experience with feeding conditions near their colony, so we anticipate selection against intercolony movements.

Whether or not some of the variation in colony size was due to emigration, the overall increase of more than 40% at the smaller colonies, as well as on the study plots at Prince Leopold Island (PLI), suggests a real increase in the number of kittiwakes breeding around Barrow Strait. Two other lines of evidence support this conclusion. First, estimates of colony sizes from the early 1970s were made from aerial surveys (except for PLI), not with detailed counts as in

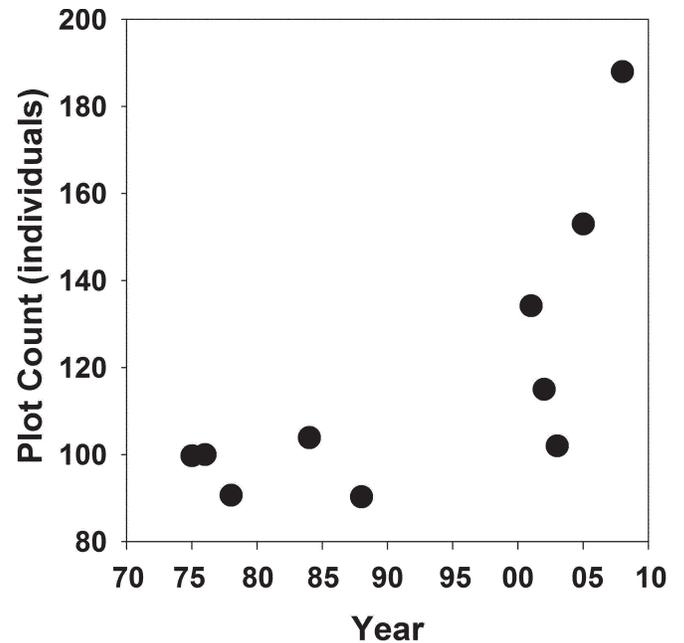


FIG. 2. Trends in black-legged kittiwake numbers from an index of plot counts (1976 = 100) at the Prince Leopold Island colony.

recent years, although large-format photographs were taken of some sites. In many cases, original estimates of colony sizes for kittiwakes and fulmars (*Fulmarus glacialis*) were too high, and in subsequent years counts were reduced as other survey techniques were applied (e.g., Brown et al., 1975; Gaston et al., 2006) or original estimates were reassessed from photograph counts (Nettleship, 1980). Thus, the 14 000 kittiwakes at the three smaller colonies in the 1970s may have been an overestimate. Second, some local Inuit hunters at Pond Inlet have reported that breeding kittiwakes have apparently increased at the Cape Graham Moore colony at the eastern entrance to Lancaster Sound, noting that more kittiwakes now nest there in places formerly occupied by murres (J. Akearok, unpubl. data). Such an observation would be consistent with an overall increase in kittiwake numbers in this region.

While numbers may have increased at some colonies, we did note the loss of one small colony at Separation Point. Colony dynamics of kittiwakes vary with colony size (Danchin et al., 1998; Suryan and Irons, 2001), and Chapdelaine and Brousseau (1989) found that moderate-sized colonies grew in the Gulf of St. Lawrence, Canada, while small colonies remained stable. We do not know why the Separation Point colony disappeared, or for how long it may have existed. In a similar pattern, many small colonies of ivory gulls have also disappeared in the Canadian High Arctic in recent years, while one large one persists (Robertson et al., 2007).

We failed to find a significant relationship between the distance to open water during late June (around the time that birds would be initiating nesting) and numbers of kittiwakes attending colonies, and hence could not support the hypothesis of Alliston et al. (1976). The exception was the

Baillie-Hamilton colony, the most remote from open water of all kittiwake colonies in Canada, where birds might have to cross 400 km of sea ice to reach open water in late ice years, especially if the polynya that forms in Queen's Channel beside the nesting island is small (Mallory and Fontaine, 2004). Colony counts were generally low in 2003 at all of the colonies, after two years of late, extensive sea ice and consequent low marine productivity. During those years, kittiwake breeding success was low at Prince Leopold Island, although colony attendance was average (Gaston et al., 2005b). Thus, extensive sea-ice cover may affect kittiwake breeding effort and success and consequent recruitment in later years, rather than immediate colony attendance. Such effects may be manifested at certain thresholds (i.e., non-linear relationship) or may occur across temporal scales that we could not address with these data.

Black-legged kittiwake numbers are declining at many colonies around the North Atlantic Ocean (e.g., Frederiksen et al., 2004), including West Greenland (Nyeland, 2004). However, our surveys suggest that this is not the case for colonies in eastern Nunavut, Canada, near the northern limit of the species' range, and just west of declining Greenlandic colonies. We expect that West Greenlandic and High Arctic Canadian kittiwakes probably mix during migration and possibly during the winter, which makes the contrasting trends surprising. Regional differences in population trends have also been reported recently for thick-billed murres across the North Atlantic (Irons et al., 2008), which may be linked to long-term patterns in oceanographic drivers of marine food webs. We currently lack sufficient data on the year-round ecology of High Arctic kittiwakes to speculate reliably on why Canadian kittiwake numbers appear to have increased, while populations elsewhere have declined. Two information gaps must be filled before we can interpret trends in Arctic kittiwake populations. First, we need to determine the migratory pathways and wintering locations of Canadian Arctic kittiwakes (e.g., by telemetry), to assess whether they are experiencing the same ecosystem constraints as declining populations elsewhere. Second, we need to conduct a current census at other colonies in Arctic Canada (Mallory and Fontaine, 2004) to determine whether the pattern we have observed in Barrow Strait can be extrapolated to the majority of the Canadian Arctic breeding population.

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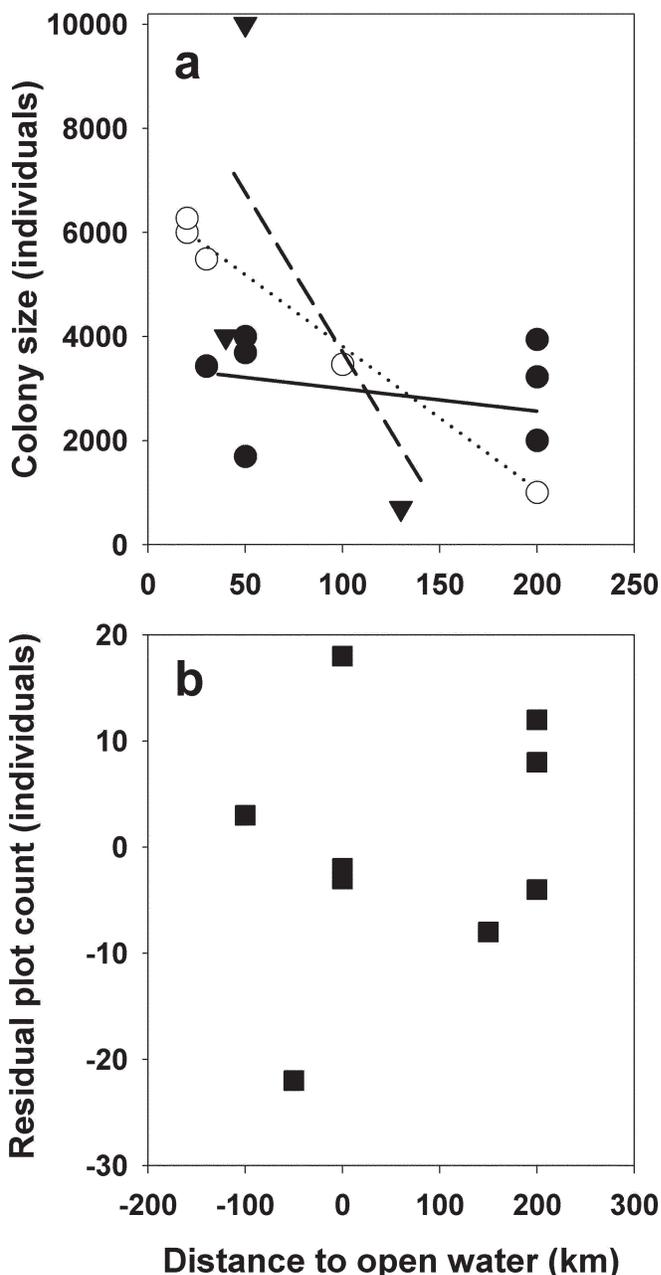


FIG. 3. Relationships between distance to open water in the third week of June and site attendance, represented by (a) annual colony counts at smaller kittiwake colonies (● = Browne Island, ○ = Baillie-Hamilton Island, and ▼ = Batty Bay) or (b) mean annual plot counts at Prince Leopold Island.

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