A PELAGIC SEABIRD SURVEY OF ARCTIC AND SUB-ARCTIC CANADIAN WATERS DURING FALL

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SUMMARY

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We provide results of ship-based surveys undertaken in Canadian Arctic and sub-Arctic waters during September and October 2005, a time of year when very few systematic surveys of that region have been conducted. We performed 500 strip transects (10-minute durations), covering approximately 553 km^2 throughout the Northwest Passage, along the east coast of Baffin Island, in Hudson Strait and Hudson Bay, and along the Labrador Coast, ending in the Strait of Belle Isle. Density indices of seabird species were generally low (≤5 birds/km^2) in the eastern Canadian Arctic, with the exception of a few areas of high concentration along the southeast coast of Baffin Island (≤33 birds/km^2) and at the eastern mouth of the Hudson Strait (≤132 birds/km^2). We recorded 951 birds of 13 species sitting on the sea and, during instantaneous counts within transects, 1564 birds of 14 species in flight. In Arctic waters, mean density indices were highest in Hudson Strait (8.3 ± 1.9 birds/km^2) and lowest in southern Hudson Bay (0.34 ± 0.2 birds/km^2). Across all regions, however, mean density indices were highest in transects off the coast of Labrador (10.8 ± 1.8 bird/km^2). Where mean density indices were high, sightings were dominated by Northern Fulmars *Fulmarus glacialis* or Dovekies *Alle alle* (or both). Our abundance and distribution data are consistent with previously published studies, suggesting that several marine bird populations migrating eastward through Hudson Strait and south along the coast of Baffin Island converge at the eastern mouth of the Hudson Strait. Our study presents further evidence that the eastern margin of Hudson Strait constitutes an important staging area for migrant seabirds during September and October, particularly for the Northern Fulmar, Dovekie and Thick-billed Murre *Uria lomvia.*

Key words: Shipboard surveys, Northwest Passage, Baffin Island, Hudson Bay, Hudson Strait, Labrador, marine birds, PIROP

INTRODUCTION

Most ecological data on the biology and population dynamics of Arctic seabirds are derived from studies conducted on the breeding grounds, where species are more easily enumerated. Information on the distribution and abundance of seabirds in Arctic regions during the non-breeding season is sparse (but see Forsell & Gould 1981, Gaston 1982, Gould *et al.* 1982, Brown 1986). The present study examines the distribution and abundance of seabirds during the non-breeding season at several locations in the eastern Canadian Arctic. Monitoring of seabird populations during the non-breeding season and comparisons with historical data are important in these polar regions, where changes in sea-ice cover have been documented (Maslanik *et al.* 2007) and recent mining initiatives propose to increase shipping traffic dramatically (Baffinland 2008). Given these new developments, it is important to document current habitat use by seabirds during the non-breeding season and to characterize migratory movements and habitat requirements in Arctic Canada.

We present systematic ship-based data on seabird distribution and abundance collected during fall 2005 in the Canadian Arctic. We compare our findings with those of the only other published vessel-based survey of seabirds in the same area and time of year, conducted 23 years earlier (Brown 1986).

STUDY AREA AND METHODS

Study areas

The study was conducted in four marine regions of the eastern Canadian Arctic and sub-Arctic (Fig. 1) in September and October 2005:

- Northwest Passage and East Coast Baffin Island,
- Hudson Strait,
- Hudson Bay, and
- Labrador Coast/Strait of Belle Isle.

Transects in the Northwest Passage and East Coast Baffin Island (six days, 16–21 September) were initiated in Dease Strait (68°37′N, 109°09′W), covered the eastern portion of the Northwest Passage to North Baffin Island and down the eastern coast of Baffin Island to 62 degrees latitude, and ended just north of Cumberland Sound (62°51′N, 64°78′W). Transects in Hudson Strait were conducted from its eastern margin just northeast of Resolution Island (64°13′N, 61°78′W) to its western limit between Coats and Mansel islands (81°0′N, 62°35′W) over 11 days split over two time periods (22–27 September from east to west, and 17–21 October from west to east). Transects in Hudson Bay were conducted at several sites over a period of 18 days (28 September–21 October). Transects in Labrador and the Strait of Belle Isle were conducted just east of the Button Islands (60°09′N, 68°17′W) and continued south along the coast of Labrador into the Strait of Belle Isle (51°11′N, 57°20′W) over three days (22–24 October).

Survey techniques

Surveys were conducted daily during daylight hours from 17 September until 24 October as part of the 2005 ArcticNet research expedition aboard the Canadian Coast Guard icebreaker *Amundsen.* The 2005 ArcticNet expedition was a multidisciplinary expedition involving research on sea surface properties, bathymetry, zooplankton and fish abundance, and contaminants at more than 200 oceanographic stations by a team of 100 scientists and technicians. Data were collected according to standardized protocols for pelagic seabird surveys from moving vessels established by the Canadian Wildlife Service (CWS 2006) similar to those in Gould *et al.* (1982). Specifically, each survey was composed of an uninterrupted 10-minute observation period during which all seabirds within the transect area were recorded. The transect extended forward from the bow of the vessel (Fig. 1 inset, adapted from CWS 2006). Transect width (300 m) was estimated using the slide calliper method (Heinemann 1981). Transect length was variable, being a function of vessel speed during the 10-minute observation period. The survey was conducted while the vessel was moving at a minimum of 7.4 km/h (four knots). All transects were georeferenced using the global positioning system of the vessel.

Each 10-minute observation period was separated by a 10-minute rest period to increase distance and independence between observation periods. Seabirds on the water (hereafter "sitting on the sea") were

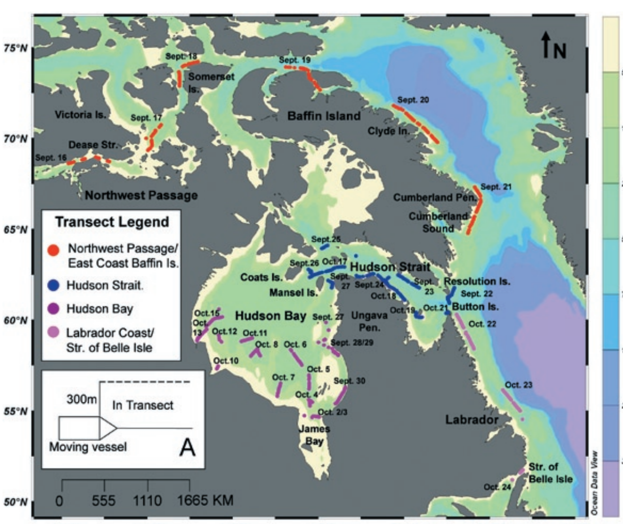

Fig. 1. Locations of transects and diagram of the strip transect (insert A, adapted from CWS 2006). Dates indicated for each set of transects.

recorded continuously throughout the 10-minute observation period; birds in flight were recorded during instantaneous observations (as suggested by Tasker *et al.* 1984). Instantaneous counts of flying birds were conducted at intervals dependent on the speed of the vessel: two and a half minutes at 7.4 km/h, two minutes at 9.3 km/h, one and a half minutes at 11.1–14.8 km/h, one minute at 16.7–22.2 km/h, half a minute at 24–35 km/h.

At the beginning of each transect, the date, time, latitude and longitude at start, and vessel speed (knots) and direction (degrees) were recorded. In addition, visibility (kilometres) and wind force (Beaufort scale) were recorded for each transect. Ice concentration in transects was quantified using daily ice analysis charts available online from the Canadian Ice Service Archive, Environment Canada (http://ice-glaces.ec.gc.ca/). Transects were considered ice-free if the concentration of ice was less than 1/10. When marine birds were observed within the transects, individuals were identified to species and the number of individuals and their distance from the platform were recorded. Whenever possible, information on age, sex, plumage, association with the platform and flight direction was recorded. Correction factors to account for differential probabilities of detection among species could not be calculated, because the distance recorded between birds and the platform was not perpendicular. As a result, data are reported raw or as density indices (birds per square kilometre), which are consistent within the database and suitable for comparisons of distribution and abundance of seabirds across time and space (Gould *et al.* 1982).

This survey was conducted in coordination with a diversity of other research projects. As a result, the sampling was non-random, and it was not possible to generate unbiased estimates of population size for the regions covered (Clarke *et al.* 2003). One method to correct for non-random sampling is to base estimates on geostatistical models that consider spatial autocorrelation between observations (Vandermeer & Leopold 1995). The software Ocean Data View (Schlitzer 2007) provides a geostatistical model (VG Gridding) that estimates density over large areas by interpolating results between observations. VG Gridding uses a variable-resolution grid (high resolution in areas of high data density, low resolution in areas of low data density) to estimate data for unsampled regions. Density data for unsampled regions is estimated by a distance-weighted average of surrounding real data values. We generated maps of seabird density indices for all species combined and separate maps for the three most abundant species (Northern Fulmar *Fulmarus glacialis,* Dovekie *Alle alle* and Thick-billed Murre *Uria lomvia*) using the VG Gridding function in Ocean Data View 3.3.2 (Schlitzer 2007). Our intention was to identify areas of high indices of seabird density geographically, not to estimate population size. It is important to note that most transects were conducted out of sight of the coastline, and thus species such as sea ducks, which typically use shallow areas along coastlines during moult and migration, were likely underrepresented in the counts.

All means are presented ± standard error.

Comparison with historical data

Data on the distribution and abundance of seabirds in the North Atlantic and eastern Arctic waters was extracted from the Programme Intégré des Recherches sur les Oiseaux Pélagiques (PIROP) database (Brown 1986). Between 1970 and 1983, 4085 ship-based surveys were conducted during September and October

TABLE 1
Abundance of birds at sea in Arctic and sub-Arctic regions of Canada in fall, 2005

Parameter	Northwest Passage	Hudson Strait	Hudson Bay	Labrador Coast/ Strait of Belle Isle
Summary values				
Survey dates	16–21 Sep	22–27 Sep, 17–21 Oct	28 Sep–15 Oct	22–24 Oct
Transects (n)	132	144	174	50
Area covered (km^2)	158	165	164	66
Mean area/transect (km^2)	1.2±0.02	1.2±0.02	0.9±0.03	1.3±0.03
Transects with sea ice (%)	52	0	0	0
Mean birds (km^{-2})	3.6±0.5	8.3±1.9	0.36±0.2	10.8±1.8
Mean birds on sea (km^{-2})	1.6±0.4	4.5±1.4	0.05±0.0	1.0±0.2
Mean birds flying (km^{-2})	2.0±0.3	3.7±0.9	0.32±0.2	9.8±1.7
Species observed (n)	10	7	11	8
Species on sea (n)	8	5	4	4
Species flying (n)	6	7	9	8
Birds on sea [n (% all birds observed)]				
Northern Fulmar *Fulmarus glacialis*	96 (37.8)	411 (65.8)	0	2 (3.2)
Dovekie *Alle alle*	128 (50.4)	89 (14.2)	0	36 (57.1)
Thick-billed Murre *Uria lomvia*	3 (1.2)	65 (10.4)	1 (11)	17 (27.0)
Unidentified Alcidae	6 (2.4)	45 (7.2)	0	7 (11.1)
Black-legged Kittiwake *Rissa tridactyla*	15 (5.9)	10 (1.6)	0	1 (1.6)
Unidentified species	0	3 (0.5)	4 (44)	0
Ivory Gull *Pagophila eburnea*	2 (0.8)	0	0	0
Pacific Loon *Gavia pacifica*	2 (0.8)	0	0	0
Black Guillemot *Cepphus grylle*	0	2 (0.3)	0	0
Common Eider *Somateria mollissima*	0	0	2 (22)	0
Herring Gull *Larus argentatus*	0	0	2 (22)	0
Glaucous Gull *L. hyperboreus*	1 (0.4)	0	0	0
Long-tailed Duck *Clangula hyemalis*	1 (0.4)	0	0	0
TOTAL	254	625	9	63
Birds in flight [n (% all birds observed)]				
Northern Fulmar *Fulmarus glacialis*	122 (36.5)	230 (38.7)	3 (5.5)	435 (74.9)
Dovekie *Alle alle*	187 (56.0)	287 (48.3)	0	25 (4.3)
Thick-billed Murre *Uria lomvia*	0	17 (2.9)	9 (16.4)	42 (7.2)
Black-legged Kittiwake *Rissa tridactyla*	2 (0.6)	33 (5.6)	1 (1.8)	25 (4.3)
Glaucous Gull *L. hyperboreus*	12 (3.6)	13 (2.2)	1 (1.8)	17 (2.9)
Common Eider *Somateria mollissima*	0	11 (1.9)	1 (1.8)	14 (2.4)
Unidentified Alcidae	2 (0.6)	2 (0.3)	0	17 (2.9)
Canada Goose *Branta canadensis*	0	0	20 (36.4)	0
Herring Gull *L. argentatus*	0	0	13 (23.6)	2 (0.3)
Unidentified species	5 (1.5)	0	4 (7.3)	3 (0.5)
Black Guillemot *Cepphus grylle*	3 (0.9)	1 (0.2)	2 (3.6)	0
Sabine's Gull *Xema sabini*	1 (0.3)	0	0	0
Long-tailed Duck *Clangula hyemalis*	0	0	1 (1.8)	0
Northern Gannet *Morus bassanus*	0	0	0	1 (0.2)
TOTAL	334	594	55	581

in northern Atlantic and eastern Arctic marine areas that overlapped with the regions surveyed in 2005. As with the surveys conducted in the present study, each PIROP survey was composed of an uninterrupted 10-minute observation period during which all seabirds located within a transect (both flying and sitting on the sea) were recorded. In the PIROP surveys, instantaneous counts of flying birds were not conducted, and thus all flying birds were included. Surveys incorporated a transect of unlimited width, as opposed to our fixed-width transect, and thus indices of species density were reported in birds per linear kilometre as opposed to birds per square kilometre as in the present study. Consequently, quantitative comparisons were not possible. Instead, we made qualitative comparisons by generating maps of seabird density indices and comparing locations of peak density for Northern Fulmar, Thick-billed Murre and Dovekie between the PIROP survey (birds/km, 1970–1983) and the current survey (birds/km^2, 2005). Maps for the PIROP data were generated using the VG Gridding function in Ocean Data View 3.3.2 (Schlitzer 2007) as described earlier.

RESULTS

Seabird abundance

Northwest Passage and East Coast of Baffin Island

We recorded 588 individual marine birds of 10 species in 132 transects covering an area of 158 km^2 (Table 1) in the Northwest Passage and East Coast of Baffin Island. Ice was present in only 52% of transects during the period of the survey. Birds were counted in 61% of transects. On 17 September, the set of transects just east of Victoria Island (Fig. 1) were conducted in close pack ice (ice concentration: 7–8/10) and on 18 September, the set of transects along the northwest coast of Somerset Island (Fig. 1) were conducted in open drift ice (ice concentration: 4–6/10) and very open drift ice (ice concentration: 1–3/10). The mean density index of birds sighted within transects (both sitting on the sea and flying) was 3.6 ± 0.5 birds/km^2. The species documented most commonly sitting on the sea were Dovekie (50.4% of sightings) and Northern

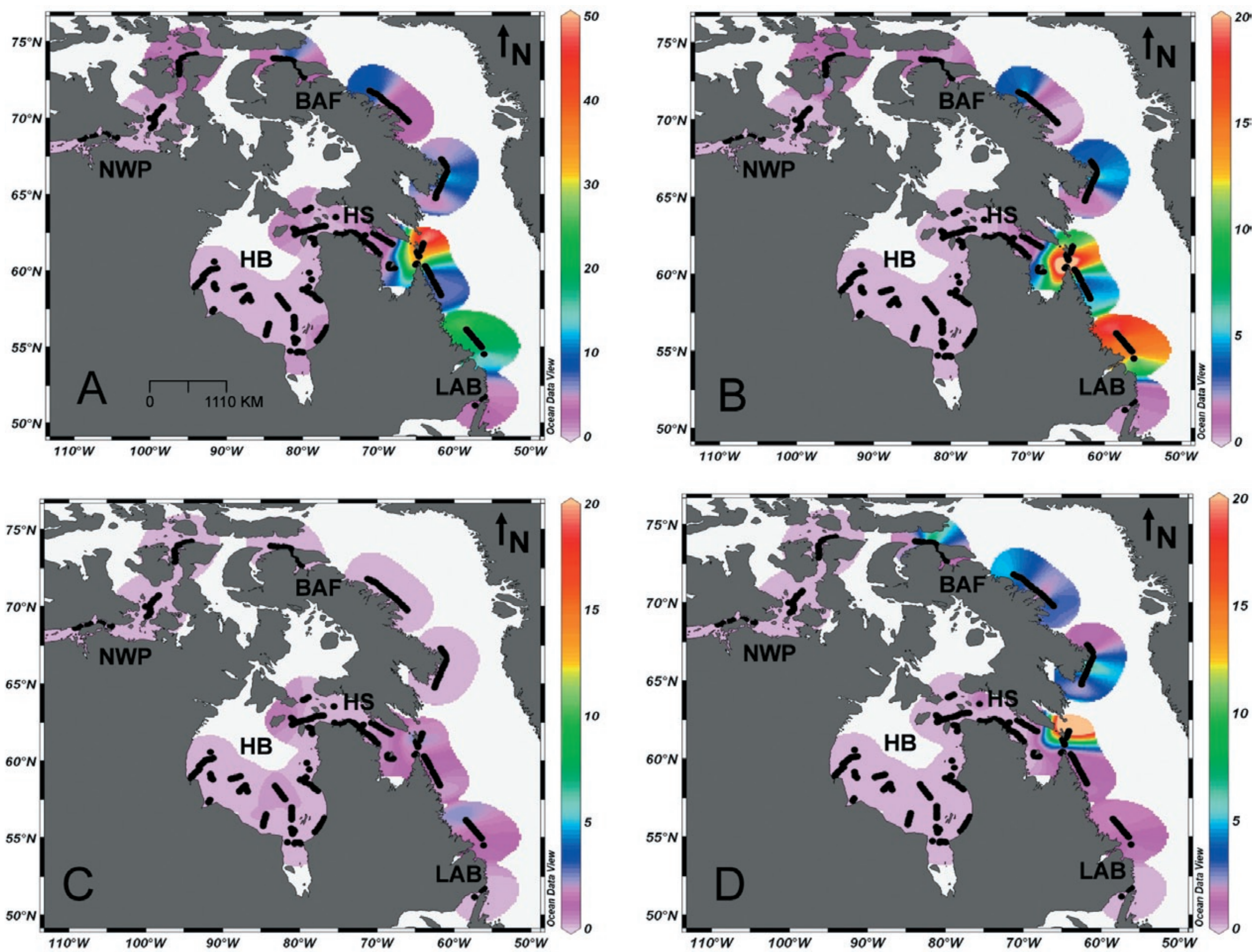

Fig. 2. Distribution and density indices from the 2005 survey: (a) all species, (b) Northern Fulmar *Fulmarus glacialis,* (c) Thick-billed Murre *Uria lomvia,* and (d) Dovekie *Alle alle.* Density indices are presented as birds per square kilometre. Five marine regions—Northwest Passage and East Coast Baffin Island (NWP and BAF), Hudson Strait (HS), Hudson Bay (HB), Labrador Coast and the Strait of Belle Isle (LAB)—are identified on each map.

Fulmar (37.8%). The species most commonly documented flying within transects during instantaneous counts were also Dovekie (56.0% of sightings) and Northern Fulmar (36.5%; Table 1). Other species sighted (sitting on the sea and flying within transects) included, in order of abundance, Black-legged Kittiwake *Rissa tridactyla,* Thick-billed Murre, Glaucous Gull *Larus hyperboreus,* unidentified Alcidae, Ivory Gull *Pagophila eburnea,* Pacific Loon *Gavia pacifica,* Long-tailed Duck *Clangula hyemalis* and Sabine's Gull *Xema sabini* (Table 1).

Hudson Strait

In Hudson Strait, we recorded birds of seven species totalling 1219 individuals in 144 transects covering an area of 165 km^2 (Table 1). Birds were counted in 55% of transects, which were all ice-free. The mean density index of birds sighted within transects (both sitting on the sea and in flight) was 8.3 ± 1.9 birds/km^2. The species most commonly documented sitting on the sea were Northern Fulmar (65.8% of sightings) and Dovekie (14.2%). The species most commonly documented flying within transects during instantaneous counts were Dovekie (48.3% of sightings) and Northern Fulmar (38.7%; Table 1). Other species sighted (sitting on the sea and flying within transects) included, in order of abundance, Thick-billed Murre, unidentified Alcidae, Black-legged Kittiwake, Glaucous Gull, Common Eider *Somateria mollissima* and Black Guillemot *Cepphus grylle* (Table 1).

Hudson Bay

In Hudson Bay, we counted 64 individual marine birds of 11 species in 174 transects, all ice-free, covering an area of 164 km^2 (Table 1). Birds were detected in only 18% of transects. The mean density index of birds within transects (both sitting on the sea and flying) was 0.36 ± 0.2 birds/km^2. Species sighted sitting on the sea included Thick-billed Murre, Herring Gull *Larus argentatus,* and Glaucous Gull. The species documented most commonly flying within transects during instantaneous counts were Canada Goose *Branta canadensis*; 36.4% of sightings) and Herring Gull (23.6%) (Table 1). Other species sighted flying within transects included, in order of abundance, Thick-billed Murre, Northern Fulmar, Black Guillemot, Black-legged Kittiwake, Glaucous Gull, Common Eider, and Long-tailed Duck (Table 1).

Labrador Coast and Strait of Belle Isle

We counted 644 individual marine birds of eight species in 50 transects, all ice-free, covering an area of 66 km^2 (Table 1) along the Labrador Coast and Strait of Belle Isle. Birds were counted in 96% of transects. The mean density index of birds sighted within transects (both sitting on the sea and flying) was 10.8 ± 1.8 birds/km^2. The species most commonly documented sitting on the sea were Dovekie (57.1% of sightings) followed by Thick-billed Murre (27.0%). The species most commonly documented flying within transects during instantaneous counts was the Northern Fulmar (74.9% of sightings; Table 1). Other species sighted (sitting on the sea and flying within transects) included, in order of abundance, Black-legged Kittiwake, unidentified Alcidae, Glaucous Gull, Common Eider, Herring Gull and Northern Gannet *Morus bassanus* (Table 1).

TABLE 2
Behavioral comparison of most abundant species in Hudson Strait during two sampling periods, sitting on the sea or flying within the transect during instantaneous counts

Species	Sampling period			
	September 22–27		October 17–21	
	On sea	Flying	On sea	Flying
Northern Fulmar *Fulmarus glacialis*	116	161	295	69
Dovekie *Alle alle*	86	287	3	0
Thick-billed Murre *Uria lomvia*	43	11	22	6

Seabird distribution and abundance

Though density indices of birds ranged from zero to 132 birds/km^2, density indices greater than 5 birds/km^2 were rare [Fig. 2(a)]. The mean density index across all four regions was low (4.5 ± 0.6 birds/km^2). Peaks in density indices occurred mainly in the southern part of the eastern coast of Baffin Island, at the eastern limit of the Hudson Strait, and along the southern portion of the Labrador Coast [Fig. 2(a)]. These peaks were consistent between the two most commonly observed species, Northern Fulmar and Dovekie [Fig. 2(b,d)].

The highest peaks in density indices occurred in the Hudson Strait transects, both during September (east–west) and again in October (west–east). The maximum density index of birds sitting on the sea was 132 birds/km^2 on 21 October, when large groups of Northern Fulmars were encountered at the northeastern tip of Ungava Bay [60°40′N, 64°85′W; Fig. 2(b)]. One peak (mean density index: 38.8 ± 9.0 over 15 transects) was recorded east of Resolution Island (61°78′N, 64°13′W to 60°92′N, 64°70′W) on 22 September. Though sightings in transects comprising that peak were dominated by Dovekies (up to 27 birds/km^2 sitting on the sea and up to 93 birds/km^2 in flight; Table 2), incidental observations (birds not included within transects) of mixed flocks of up to 400 individuals (Northern Fulmars and Black-legged Kittiwakes) were also noted. A second, much higher peak (58.7 ± 19.3 birds/km^2 over eight transects) was encountered just south of the first, around the northeastern tip of Ungava Bay (60°39′N, 64°88′W to 60°47′N, 64°92′W) on 21 October [Fig. 2(a)]. Large flocks of Northern Fulmars (up to 108 birds/km^2 on the sea) were largely responsible for this peak in our density index [Table 2; Fig. 2(b)].

Smaller peaks in density indices also occurred along the east coast of Baffin Island, just north of Clyde Inlet (71°62′N, 69°76′W), where the maximum density index was 33 birds/km^2 on 22 September. Further south along the coast of Baffin Island, moderate density indices of seabirds (mean: 10.1 ± 1.6 birds/km^2 over 19 transects) were recorded along the Cumberland Peninsula (61°78′N, 64°13′W to 60°92′N, 64°70′W) on 21 September. Again, those peaks consisted largely of Northern Fulmars and Dovekies [up to 17 and 16 birds/km^2 respectively; Fig. 2(b)]. The density index of birds peaked again along the Labrador Coast, with a maximum of 63 birds/km^2 reflecting large flocks of Northern Fulmars in flight. The higher mean density index in Labrador Coast and Strait of Belle Isle transects (10.8 ± 1.8 birds/km^2) was almost entirely a result of observations of birds in flight (mostly Northern Fulmars) as opposed to birds sitting on the sea (Table 1).

Indices of seabird density were lowest in Hudson Bay, with most transects (82%) entirely devoid of birds. The maximum density index of birds in Hudson Bay was 19 birds/km^2 (one flock of Canada

Geese in flight) on 20 September [55°42′N, 77°30′W; Fig. 2(a)]. It is important to note that the observations in Hudson Bay were confined to the southern half of the Bay, well away from the significant breeding seabird concentrations of northern Hudson Bay.

Comparison with historical data

The mean density index of birds recorded during PIROP surveys in October and September between 1970 and 1983 was high (27.0 ± 5.5 birds/km). Though density indices of all birds ranged from zero to 19 000 birds/km, density indices above 30 birds/km were rare [Fig. 3(a)]. Peaks in density indices for Thick-billed Murre [Fig. 3(c)] occurred at the eastern limit of the Hudson Strait and midway down the Labrador coast (the same region as in 2005), whereas peaks in density indices for Dovekies [Fig. 3(d)] were located further north than in 2005. Peaks in density indices for Northern Fulmars [Fig. 3(b)] occurred both at the eastern limit of the Hudson Strait (the same region as in 2005) and just off the coast of Labrador, but further south than in 2005.

DISCUSSION

Most studies of seabird distribution at sea in the Canadian Arctic have focussed on presence/absence data (Huetttman & Diamond 2000) or radar observations (Gudmundsson *et al.* 2002). Because of the logistical challenges and rarity of vessel-based survey opportunities at this time of year, few studies have investigated marine bird distribution and abundance following colony departure (but see Gaston 1982, Orr & Ward 1982, Brown 1986). Given that little is known about the timing and routes of fall migrations (Huetttman & Diamond 2000), the importance of Arctic marine regions in fall is relatively unknown for most species and could be underestimated. Concern is growing that Arctic marine conditions are changing, particularly in relation to sea ice (Lindsay & Zhang 2005, Maslanik *et al.* 2007) and the potential for increased shipping traffic (Kerr 2002, Baffinland 2008). One project alone proposes to have icebreaker ore carriers passing through Hudson Strait every 1.3 days year-round, with increased frequency during ice-free periods (Baffinland 2008). These new developments emphasize the importance of documenting current seabird habitat use in Arctic Canada.

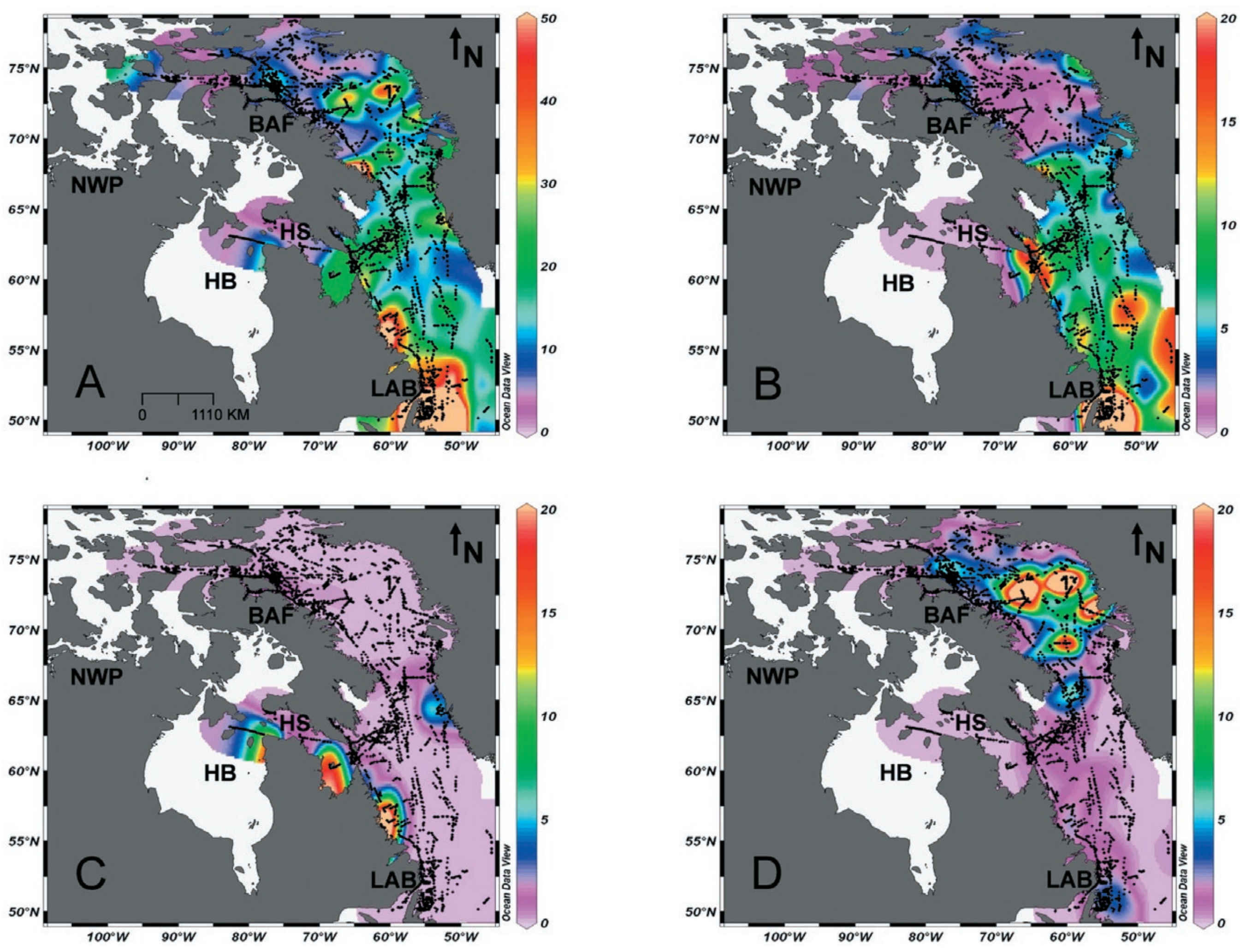

Fig. 3. Distribution and density indices from PIROP database (1972–1983): (a) all species, (b) Northern Fulmar *Fulmarus glacialis,* (c) Thick-billed Murre *Uria lomvia,* and (d) Dovekie *Alle alle.* Density indices are presented as birds per linear kilometre. Five marine regions—Northwest Passage and East Coast Baffin Island (NWP and BAF), Hudson Strait (HS), Hudson Bay (HB), Labrador Coast and the Strait of Belle Isle (LAB)—are identified on each map.

The results presented here offer compelling evidence that the eastern mouth of Hudson Strait is an important area for migrant seabirds, particularly Northern Fulmars and Dovekies during September and October (e.g. Mallory & Fontaine 2004). In September and October 2005, density indices of seabird species were generally low in the eastern Canadian Arctic with the exception of a few areas of high concentration in the southern section of the east coast of Baffin Island and at the eastern mouth of the Hudson Strait. Despite low density indices of seabirds throughout the Northwest Passage and along the east coast of Baffin Island, peaks in density indices along the southern part of Baffin Island indicate that seabirds, particularly Northern Fulmars and Dovekies, migrate south through this area during late September. More birds were seen in flight than on the sea, suggesting that most of the birds recorded were migrating. However, no dominant direction of flight was recorded, and so migratory status could not be confirmed. Further south, at the mouth of Hudson Strait, density indices of birds sitting on the sea increased greatly, suggesting that that area may be an important stopover site or staging area for several species migrating from colonies in the High Arctic and Hudson Bay. Indeed, most seabirds appeared to have left the breeding colonies in Hudson Bay by late September or early October, as indicated by the paucity of birds documented there despite ample effort (the highest number of transects were conducted in that region). By late October, many seabirds occurred as far south as the Labrador Coast and the Strait of Belle Isle. Those birds also appeared to be moving through the area, because most sightings were of flying birds rather than of concentrations of birds on the water.

Prior vessel-based seabird surveys in the eastern Canadian Arctic are few (but see Brown 1986, Huetttman & Diamond 2000), and the present survey is the first to provide indices of bird density at sea in the high Arctic during September and October, when it is thought that most colonial birds are starting to migrate south from their breeding sites. Although non-random sampling did not allow us to estimate population sizes, the overall density indices of seabirds at sea (4.5 ± 0.6 birds/km^2) that we recorded were much lower than levels previously reported from eastern Arctic and North Atlantic surveys in September and October (27.7 ± 5.5 birds/km; Brown 1986). The contrast can be attributed to several factors that varied between the two studies. Brown (1986) used larger transects (unlimited width as opposed to a 300-m width in the present study), counted all flying birds (as opposed to the instantaneous counts in this study), and sampled areas outside of the area covered by our transects. The larger study area of Brown (1986) included sampling of additional hotspots, especially those further south off the coast of Labrador. Despite such differences, peaks in density indices for species such as Northern Fulmars and Thick-billed Murres in 2005 occurred in the same region (southeastern coast of Baffin Island and the eastern mouth of Hudson Strait), and were of similar magnitude to those obtained before 1983 ($10 < x < 100$ birds/km, with one survey at >100 birds/km; Brown 1986).

In 2005, the Dovekie was the most numerous seabird species detected in the Northwest Passage and along the East Coast of Baffin Island, followed by the Northern Fulmar. Interestingly, those species were also among the most numerous seabirds detected in transects in the Hudson Strait region, although neither species breeds there. Given that transects were conducted in Hudson Strait during two different periods, 22–27 September and 17–21 October, and that peaks in density indices were recorded during both periods, the Hudson Strait region, particularly the eastern mouth of the Strait, may be an important area for migrating seabirds during the months of September and October. This possibility is not surprising, because Hudson Strait, and more precisely, the area around Resolution Island, has high macrozooplankton biomass (specifically copepods) in late summer (Percy & Fife 1993) and early fall (Harvey *et al.* 1997). Northern Fulmars generally feed on fish, squid and macrozooplankton (especially copepods and amphipods; Hatch & Nettleship 1998), and a high proportion of the diet of Dovekies consists of copepods (Hobson 1993), making the area a rich feeding ground for those species and other migrating seabirds.

Peaks of density indices during the first sampling period in the Hudson Strait were dominated by Dovekies and Northern Fulmars; the peaks during the second sampling period were dominated by Northern Fulmars, with Dovekies almost absent. The absence of Dovekies in late October is consistent with previous observations that Dovekies have already dispersed as far south as the Labrador Sea and eastern Newfoundland by that time (Brown 1986). Sightings of Dovekies in Labrador (late October) support the same conclusion. The longer persistence of fulmars in the Hudson Strait is not surprising, because some individuals (especially juveniles) remain in the vicinity of high Arctic breeding colonies until mid-September (Mallory *et al.* 2008) or mid-October (Hatch & Nettleship 1998).

During September and October 2005, we detected few large concentrations of seabirds. Instead, density indices for most species were low, and seabirds were dispersed. Nonetheless, this survey detected 14 species and is only the second to record the species, abundance and distribution of marine birds in remote regions of Arctic Canada following the breeding season, and the first to do in more than 23 years (Brown 1986). Our results highlight a potentially important stopover site for migrating seabirds and provide baseline information for detecting changes of seabird distribution and abundance in September and October, should surveys continue in the future. Comparison of current and historical seabird distribution and abundance in the study region was limited to qualitative analysis as a result of different sampling procedures. Given the potential for future environmental changes in Canadian Arctic waters—particularly changes in sea ice (Lindsay & Zhang 2005, Comiso *et al.* 2008) and growing concerns over industrial shipping and pollution (Kerr 2002, Baffinland 2008)—we recommend that future seabird surveys be conducted using well-established protocols (Tasker *et al.* 1984) to support quantitative comparisons of seabird distribution and abundance across datasets.

The concentration of birds that occurs at the eastern mouth of Hudson Strait (Brown 1986, the present study) likely results from birds stopping to feed (stage) in that region during their fall migration in September and October, before ice conditions force them south. This idea is supported by early aerial survey data of large concentrations of Thick-billed Murres migrating through Hudson Strait in September (Gaston 1982, Orr & Ward 1982) and recent satellite telemetry data of both King Eiders *Somateria spectabilis* (Mosbech *et al.* 2006) and Northern Fulmars (Mallory *et al.* 2008), which documented these species remaining in marine waters south of Resolution Island, the entrance to Hudson Strait (fulmars), and near the Button Islands at the northern tip of Labrador (both species) during the months of September and October. Given the apparent ecological importance of the eastern Hudson Strait, those areas merit further investigation as key marine habitat.

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