

# Observations of Marine Birds and Mammals Wintering at Polynyas and Ice Edges in the Belcher Islands, Nunavut, Canada

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**ABSTRACT.** In the Belcher Islands, southeast Hudson Bay, Canada, two types of open water exist during winter: 1) large, wind-driven expanses of water along landfast ice edges and 2) recurring polynyas located between small islands (most < 10 ha and < 15 m deep). In severe winters, only polynyas persist. In March 1998 and 1999, we recorded the species and numbers of birds and marine mammals present at ten polynyas and along four landfast ice edges around the Belcher Islands. To help interpret our observations, we also collected traditional ecological knowledge from local Inuit. Large flocks of common eiders *Somateria mollissima* (200–12 500 birds) were seen along floe edges, and small groups occurred in some polynyas. King eiders *S. spectabilis* were also observed at several locations, always associated with common eiders. Oldsquaw ducks *Clangula hyemalis* were common (flocks of 100–500 birds) and occurred primarily at polynyas. Our observations of king eiders represent a significant northern range expansion for this species in Canada during winter. Ravens *Corvus corax* and snowy owls *Nyctea scandiaca* were observed along landfast ice edges. Ravens were feeding on the remains of seals killed by Inuit hunters and polar bears *Ursus maritimus*, and owls apparently hunted sea ducks that were loitering on ice edges at night. We regularly observed bearded seals *Erignathus barbatus* and ringed seals *Phoca hispida* at polynyas and floe edges. One beluga whale *Delphinapterus leucas* was observed by our Inuit guides along a western landfast ice edge, and three walrus *Odobenus rosmarus* were observed at a floe edge along the southern margin of the Belcher Islands. Clearly, the small recurring polynyas and ice floe edges around the Belcher Islands are important wintering habitat for oldsquaw and common and king eider ducks.

**Key words:** Belcher Islands, eiders, *Somateria*, oldsquaw, *Clangula hyemalis*, ice floe edge, polynyas

**RÉSUMÉ.** L'hiver, dans les îles Belcher, au sud-est de la baie d'Hudson (Canada), l'eau libre est présente sous deux formes: 1) de vastes étendues d'eau créées par le vent, longeant la lisière de la glace de rive et 2), des polynies récurrentes situées entre de petites îles (dont la plupart ont une superficie < 10 ha et une profondeur < 15 m). Durant les hivers très rigoureux, seules persistent les polynies. En mars 1998 et 1999, nous avons relevé les espèces et le nombre d'oiseaux et de mammifères marins présents à dix polynies et le long de quatre lisières de glace de rive autour des îles Belcher. Afin de nous aider à interpréter nos observations, nous avons aussi procédé à la collecte de savoir écologique traditionnel auprès des Inuit de la région. On a observé de grandes volées d'eider à duvet *Somateria mollissima* (200 à 12 500 oiseaux) le long de floes, et on en a trouvé de petits groupes dans quelques polynies. On a également observé à plusieurs endroits la présence de l'eider à tête grise *S. spectabilis*, toujours en association avec l'eider à duvet. On a souvent retrouvé le harelde kakawi *Clangula hyemalis* (en volées de 100 à 500 oiseaux), et ce, surtout dans les polynies. Nos relevés de l'eider à tête grise révèlent, pour cette espèce, une expansion notable de son territoire septentrional au Canada durant l'hiver. On a observé le grand corbeau *Corvus corax* et le harfang des neiges *Nyctea scandiaca* sur la lisière de la glace de rive. Les corbeaux se nourrissaient des restes de phoques tués par les chasseurs inuit et les ours polaires *Ursus maritimus*, et il semble que les harfangs chassaient le canard de mer qui s'aventurait la nuit sur la lisière de glace. On a vu de façon régulière des phoques barbus *Erignathus barbatus* et des phoques annelés *Phoca hispida* dans les polynies et au bord des floes. Un bélouga *Delphinapterus leucas* a été aperçu par nos guides inuit le long d'une lisière occidentale de glace de rive, et trois morses *Odobenus rosmarus* ont été observés au bord d'un floe longeant la rive méridionale des îles Belcher. Il est évident que les petites polynies récurrentes et les bords des floes de glace autour des îles Belcher représentent un habitat d'hivernage majeur pour le harelde kakawi ainsi que l'eider à duvet et l'eider à tête grise.

**Mots clés:** îles Belcher, eiders, *Somateria*, harelde kakawi, *Clangula hyemalis*, bord de floe de glace, polynies

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## INTRODUCTION

Polynyas are areas of open water that occur in polar oceans that are otherwise frozen during winter. In effect, they are oases of open water in a sea of ice that enable marine birds and mammals to gain access to food and air. Polynyas that recur each year are very important ecologically because many marine wildlife species rely on them as wintering areas (Stirling and Cleator, 1981; Stirling, 1997).

Winters during which open-water areas do not occur or are much reduced may have important effects on the population levels of polar marine birds. For example, in the Beaufort Sea in April 1964 and 1990, ice movements and low temperatures caused open-water leads to close. These conditions left king eider ducks unable to feed during critical periods of low temperature and resulted in mass starvation of over 100 000 birds (Barry, 1968; Fournier and Hines, 1994). Despite this example, the ecology of sea ducks that use polynyas and recurring leads is poorly known. Indeed, use of open-water areas in the Bering Sea and the Sireniki Polynya by wintering spectacled eiders *Somateria fischeri* has only recently been discovered (Konyukhov et al., 1998; Petersen et al., 1999).

Small recurring polynyas form among the Belcher Islands in south Hudson Bay, Canada, because strong tidal currents prevent the formation of ice (Stirling and Cleator, 1981; Nakashima and Murray, 1988). As well, the shifting pack ice driven by wind and the currents of Hudson Bay provide temporary open leads around the Belcher Islands. The polynyas and floe edges of the Belcher Islands and western Quebec are the only permanent areas of open water in southeast Hudson Bay during winter (Smith and Rigby, 1981). These areas represent some of the most important marine habitats in Hudson Bay during winter. Marine mammals and birds that winter in the region (e.g., walrus, seals, and common eiders; McDonald et al., 1997; Stirling, 1997) are restricted to these open-water areas and are apparently vulnerable to mass winterkills because they cannot escape to alternative habitats should the polynyas freeze (Nakashima and Murray, 1988).

Most of the population of the Hudson Bay subspecies of the common eider *Somateria mollissima sedentaria* winters in the open-water areas around the Belcher Islands (Snyder, 1941; Todd, 1963; Freeman, 1970a; Nakashima and Murray, 1988). The population of Hudson Bay common eider breeding in the Belcher Islands has declined by 75% since the 1980s (Robertson and Gilchrist, 1998). Residents of Sanikiluaq attribute this population decline to a mass die-off of eiders that occurred in the winter of 1991–92, when calm wind conditions and weak tidal currents caused pack ice and polynyas to freeze (Nakashima and Murray, 1988; Robertson and Gilchrist, 1998).

In the winters of 1997–98 and 1998–99, we initiated a study on the wintering ecology of common eiders, in response to conservation concerns and to further our understanding of the ecology of polynyas. In this paper, we describe the physical characteristics of polynyas and ice

floe edges around the Belcher Islands and quantify for the first time the bird and marine mammal species wintering in them. We discuss the dynamic relationship between open-water areas and the distribution and movements of birds in relation to changing ice conditions. Finally, we augment our observations and interpretations by incorporating traditional ecological knowledge of local Inuit residents.

## METHODS

We conducted field work in the Belcher Islands from 2 to 25 March in 1998, and for two periods (3–12 February and 16–30 March) in 1999 (Fig. 1). The timing of trips to polynyas and ice edges depended on the availability of our Inuit guides and weather conditions. We were able to obtain daily assessments of ice conditions and locations of birds from Inuit hunters. Destinations were chosen on the basis of this information and prevailing weather. In 1998, 11 day trips were taken by snowmobile to 11 different areas of open water. In 1999, field work was expanded to include snowmobile trips of several days to the southern region of the Belcher Islands. In 1999, 17 trips were taken to 12 different areas of open water (8 of these were polynyas). The areas covered represent 89% (8 of 9) of the polynyas present in 1998 and 1999.

Upon arriving at a water body, we estimated the numbers and species of birds. Flocks of sea ducks were counted repeatedly by all members of the crew until we arrived at a number within 10% of everyone's estimate. Occasionally, a persistent, low-level ice fog occurred at polynyas, and under these conditions, observations were limited. In both years, a description and estimated surface area of the water body were recorded. In 1999, we also recorded water depth during each visit, using a depth sounder. The sounder was placed in the water at several locations around the margins of polynyas. Water depth is presented as the mean and standard deviation of these repeated measurements.

### *Traditional Ecological Knowledge*

Studies in the North are logistically challenging and expensive, especially those conducted during winter. To maximize the amount of information we were able to gather, we incorporated traditional ecological knowledge (TEK) into our data collection. In several instances, TEK has provided reliable information regarding wildlife distribution and abundance (Freeman and Carbyn, 1988; Inglis, 1993; Ferguson and Messier, 1997; Ferguson et al., 1998; Huntington, 1998).

Eiders are harvested throughout the year by residents of Sanikiluaq (Reed and Erskine, 1986) and are an important source of food and down (Nakashima, 1991; Wein et al., 1996). Consequently, local Inuit from Sanikiluaq have broad experience and understanding of eider ecology in the region. We engaged in conversation with local hunters as often as possible, both in town and with hunting parties

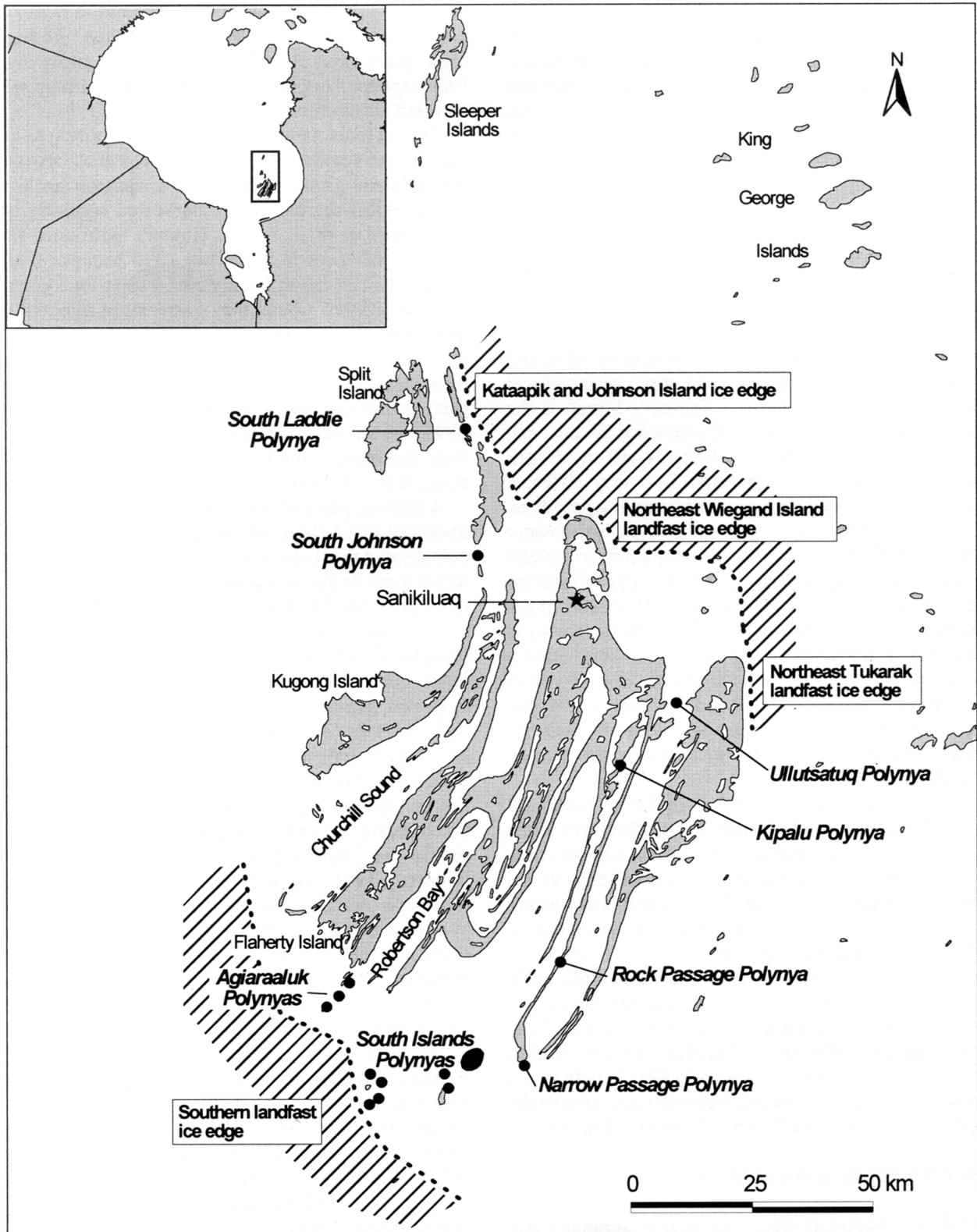


FIG. 1. Locations of polynyas and ice edges within the Belcher Islands, Hudson Bay, Nunavut, in March 1998 and 1999.

encountered on the ice. We used informal semidirective interviews to gather TEK (Huntington, 1998; Wenzel, 1999). In general, we posed the following questions: 1) Where are the eiders? 2) How do they respond to

shifting pack ice in various regions of the Belcher Islands? 3) How does the ice move with different wind and tidal conditions? and 4) Which other marine bird and mammal species have been sighted wintering in the Belcher Islands

in 1998 and 1999, and previously? When in town, we placed this information on topographic maps (1:60 000 scale). We also obtained specific information about the winterkill that occurred in 1991–92. Once conversations had begun, we did not steer the direction of the conversation back towards the above questions. Information that our primary guide gathered from his hunting colleagues was also incorporated.

## RESULTS AND DISCUSSION

### *Ice Conditions and Open Water Areas*

Descriptions of open-water areas visited in 1998 and 1999 are presented in Table 1, and their geographical locations are shown in Figure 1. February–March is the time of maximum ice coverage in the Belcher Islands, and presumably the time when marine birds are most constrained by limited foraging habitat. Two very different types of open water occurred: 1) small recurring polynyas, often less than 900 m in diameter, and 2) open water adjacent to landfast ice, which often extended for several kilometres. In general, water bodies at the edge of landfast ice were much bigger than polynyas. However, these open-water areas were also more dynamic. When the wind shifted onshore, pack ice would move in (often within a few hours), leaving only small pockets of water (5–10 m in diameter). In contrast, the size and location of polynyas remained constant, with no changes observed between repeated visits during a winter or between years (e.g., South Laddie and Ullutsatuq).

In general, ice conditions were similar to those described by Nakashima and Murray (1988). However, there was more open water and less extensive ice coverage during the two years of our study than in most years. Residents of Sanikiluaq described these winters as warmer than usual, and climate data confirmed that seasonal winter temperatures in the region were 2.2°C above normal (Environment Canada, unpubl. data). Warmer winters made hunting difficult for local Inuit, because sea ducks and seals were not restricted to small areas of open water where they could be shot. The spring breakup of pack ice also began early in the spring of 1998 and 1999. In both years, residents communicated to us that meltwater appeared on the ice in April, approximately 2–3 weeks earlier than normal.

### *Species Sighted at Open Water Areas*

Overall, six mammals were seen near or at open-water areas: red fox *Vulpes vulpes*, polar bear *Ursus maritimus*, beluga whale *Delphinapterus leucas*, ringed seal *Phoca hispida*, bearded seal *Erignathus barbatus*, and walrus *Odobenus rosmarus*. Eight bird species were also observed: common eider, king eider *Somateria spectabilis*, oldsquaw *Clangula hyemalis*, common merganser *Mergus merganser* (1 pair), black guillemot *Cephus grylle*,

glaucous gull *Larus hyperboreus*, common raven *Corvus corax*, and snowy owl *Nyctea scandiaca*. Additionally, rock ptarmigan *Lagopus mutus* and snow buntings *Plectrophenax nivalis* were sighted incidentally while we traveled across the ice by snowmobile.

Ringed seals were often seen at both polynyas and floe edges. One bearded seal was observed at a polynya in the South Island group. Both of these species are known to winter in this region and are harvested regularly by local Inuit (Stirling et al., 1981). Hunters mentioned that seal hunting was poor in 1998 and 1999 because seals were widely distributed in open water, rather than confined to breathing holes where they were more accessible. The amount of open water may also have influenced the foraging success of the polar bear. Hunters commented that polar bears taken during the annual bear harvest in 1998 carried little fat and were unusually aggressive. Also in 1998, the stomachs of several harvested bears contained only seaweed, something that local hunters considered atypical for that time of year.

A hunting party on the west coast of the Belcher Islands observed one beluga whale, and residents of Sanikiluaq commented that beluga whales commonly winter in open-water areas to the southwest of the Belcher Island group (Jonkel, 1969; McDonald et al., 1997).

Freeman (1967, 1970b) mentioned that oldsquaw occasionally wintered in the southern and western areas of open water in the Belcher Islands. One oldsquaw was collected before 1 March in 1961 in a polynya near Robertson Bay (Freeman, 1970b). During the years of our study, oldsquaw were abundant winter residents of the Belcher Islands, and they tended to occur in single-species flocks. Our observations confirm those of Freeman (1970b) and indicate that published species accounts wrongly omit the Belcher Islands from the wintering range of oldsquaw (Godfrey, 1986). Todd (1963) dismissed an observation of oldsquaw (and eider) wintering near Cape Fullerton, Roes Welcome Sound, in 1905 (Low, 1906). From our observations, and the fact that eiders are likely wintering in Roes Welcome Sound (Eifrig, 1905; Prach et al., 1981; Abraham and Finney, 1986), we suggest it is likely that oldsquaw also winter in the large polynya there.

We did not expect to find king eiders wintering in the Belcher Islands, and several authors make no mention of king eiders wintering in the region (Todd, 1963; Freeman, 1970b; Manning, 1976). However, in both years we saw them mixed within large flocks of common eiders at two polynyas and along all floe edges visited (Table 2). This suggests that the king eiders we observed were not just a single group of aberrant birds. These observations represent a range expansion for wintering king eider ducks in Canada (Godfrey, 1986) and identify the only known location in North America where king eiders winter entirely within polynyas and leads. The two winters during this study were unusually warm, and this may have influenced sea duck distribution. However, local residents stated that both oldsquaw and king eider ducks commonly

TABLE 1. Physical characteristics of open-water areas in the Belcher Islands, Nunavut, Canada, in March 1998 and 1999.

Name	Latitude	Longitude	Size	Depth (m) <sup>1</sup>	Description
<b>Polynyas</b>					
South Laddie	56°38.12'	79°36.76'	1998: ~300 m × 700 m (~21 ha) 1999: ~30 m × 800 m (~2.4 ha)	7.2 (± 1.8, n = 3)	Recurring polynya, maintained by very strong currents passing south of the main body of the Laddie Islands.
South Johnson	56°36.23'	79°34.28'	1998: ~30 m × 50 m (~0.2 ha) 1999: ~30 m × 50 m (~0.2 ha)	38.1 (± 8.9, n = 4)	Small polynya, yet recurring. Deep. Maintained by strong currents passing south of Johnson Island
Kipalu	56°13.14'	79°04.31'	1998: ~100 m × 500 m (~5 ha) 1999: ~500 m × 500 m (~25 ha)	5.8 (± 4.2, n = 3)	Recurring polynya, maintained by currents through Kipalu Inlet that pass by a narrowing southwest of Ney Island.
Ullutsatuq	56°18.71'	78°52.08'	1998: ~300 m × 1000 m (~30 ha) 1999: ~100 m × 1500 m (~15 ha)	11.6 (± 11.6, n = 6)	Recurring polynya, maintained by strong currents that pass by a narrowing in Omarolluk Sound at Tragedy Point.
Rock Passage	55°51.31'	79°13.0'	1998: ~ 0.5 ha 1999: ~ 0.5 ha	2.7 (n = 1)	Small recurring polynya at only one of two exits in southern Omarolluk Sound. Very shallow.
Narrow Passage	55°39.22'	79°18.58'	1998: unknown 1999: Three polynyas i) ~100 m × 500 m (~5 ha) ii) ~30 m × 50 m (~0.2 ha) iii) ~30 m × 50 m (~0.2 ha)	Too dangerous to approach ice edge	Small recurring polynyas at the other exit in southern Omarolluk Sound.
South Islands	55°35.50'	79°47.43'	1998: ~ 1 ha each 1999: unknown	7.8 (± 1.9, n = 3)	A series of small polynyas regularly occurring near the small islands south of the main Belcher Island groups. Strong currents in this whole area maintain the polynyas.
Agiaraaluk group	55°45.47'	79°56.20'	1998: unknown 1999: Three polynyas i) 1000 m × 40 m (~4 ha) ii) 500 m × 400 m (~20 ha) iii) ~30 m × 50 m (~0.2 ha)	i) 7.8 (± 1.9, n = 3) ii) 10.1 (± 1.5, n = 4) iii) 3.7 (n = 1)	Three recurring polynyas maintained by very strong currents passing south of Flaherty Island. Used by eiders as refuge when southeast floe edge closes in.
<b>Floe edge</b>					
Northeast Wiegand Island, landfast ice edge	56°35–40'	79°10'	1998 and 1999: Highly variable, from no open water to 100s km <sup>2</sup>	13.1 (± 1.7, n = 4)	Open water present after S, W, and especially SW winds. Open water begins at the landfast ice edge, which may be as close as 100 m from shore. Closes after 2 to 3 days of N or NE winds. Small leads of open water persist for 1 to 2 days after ice moves back in.
Ice edge between Kataapik and Johnson Island	56°35'	79°20–30'	1998 and 1999: Highly variable, from no open water to 100s km <sup>2</sup>	unknown	Opens when shifting pack ice north of the main Belcher group is pushed north by winds. Edge moves north as the season progresses as ice within Coat's Bay solidifies. Ducks are generally not present in these waters, as it far from shore and deep.
Northeast Tukarak, landfast ice edge	56°25'	78°40'	1998 and 1999: Highly variable, from no open water to 100s km <sup>2</sup>	unknown	Similar to ice edge at NE Wiegand Island, opens with westerly winds.

<sup>1</sup> Measured in 1999 only. Presented as Mean (± 1 SD, n).

occur in the Belcher Islands during cold winters as well.

Black guillemots were observed at the Southern Islands and South Laddie Polynyas, and along the Wiegand Island landfast ice edge (Table 2). Black guillemots are known to winter in Arctic waters (Todd, 1963; Brown and Nettleship, 1981), including those near the Belcher Islands (Todd, 1963; Manning, 1976).

Although glaucous and herring gulls *Larus argentatus* are seen in most winters by residents (Todd, 1963;

Nakashima and Murray, 1988), neither species was observed by us or by residents of Sanikiluaq in the winter of 1997–98. We did observe glaucous gulls in 1999, usually in association with eiders along floe edges.

Five of the marine bird species observed in the Belcher Islands region (king eider, common eider, oldsquaw, black guillemot, and glaucous gull) also occur in the Sireniki Polynya adjacent to the Chukotka Peninsula, Russia (Konyukhov et al., 1998). This suggests that their diet and

TABLE 2. Bird species observed at open-water areas in the Belcher Islands during March of 1998 and 1999.

Water body	No. visits ( <i>n</i> )	Common Eider	King Eider <sup>1</sup>	Oldsquaw	Black Guillemot	Snowy Owl	Glaucous Gull	Raven
<b>Polynyas</b>								
South Laddie	7	2.7 ± 2.5 (0–8)	0	167 ± 132 (0–300)	0.5 ± 0.8 (0–2)	0.7 ± 0.5 (0–1)	0	(0–2)
South Johnson	3	0	0	0	0	0	0	0
Kipalu	3	0	0	2.6 ± 4.6 (0–8)	0	0	0	0
Ullutsatuq	6	106 ± 115 (0–300)	0.5 ± 0.8 (0–2)	22 ± 23.3 (0–50)	0	0.7 ± 0.5 (0–1)	0.2 ± 0.4 (0–1)	0
Rock Passage	2	0	0	0	0	0	0	0
Narrow Passage	1	49	0	0	0	0	0	0
South Islands	1	8	2	0	1	0	0	0
Agiaraaluk polynya # 1	4	5.7 ± 4.0 (1–10)	0	9.8 ± 8.9 (2–18)	0	0	0	0
Agiaraaluk polynya # 2	4	8.5 ± 4.2 (3–13)	0	15 ± 23.4 (0–50)	0	0	0	0.25 ± 0.5 (0–1)
Agiaraaluk polynya # 3	3	0.7 ± 0.6 (0–1)	0	1.3 ± 1.5 (0–3)	0	0	0	0
<b>Floe edge</b>								
Northeast Wiegand Island, landfast ice edge	14	2694 ± 2491 (225–9000)	present (18–720)	112.9 ± 239 (0–600)	0 ± 0 (0–1)	0.76 ± 1.2 (0–4)	3.2 ± 8.6 (0–30)	0.84 ± 1.1 (0–3)
Ice edge between Kataapik and Johnson Island	2	4500 ± 6363 (0–9000)	present (0–720)	5 ± 7.0 (0–10)	0	1.5 ± 2.2 (0–3)	0	0
Northeast Tukarak, landfast ice edge	3	50 ± 86.6 (0–150)	present (0–12)	1.7 ± 2.8 (0–5)	0	0.3 ± 0.5 (0–1)	0	0
Southern ice edge	2	10250 ± 3181 (8000–12500)	present (640–1000)	100 ± 141.4 (0–200)	0	0.5 ± 0.7 (0–1)	12.5 ± 17.6 (0–25)	0

<sup>1</sup> King eiders were observed within flocks of common eiders; exact numbers could not be determined reliably (e.g., female king eiders could not be reliably distinguished from female common eiders). Estimates are based on the ratio of king eiders to common eiders among eiders shot randomly by Inuit hunters at floe edges in March (i.e., 2:25).

related marine habitat requirements can be met at polynyas in the circumpolar Arctic. However, rare stochastic events when polynyas freeze or are much reduced may affect the population levels of these species if the birds cannot escape to other open-water areas. This appears to be the situation in the Belcher Islands.

Two terrestrial bird species were seen occasionally near open-water areas. Ravens were observed at the floe edge and the town dump. At the ice edge, ravens scavenged items brought to shore by eiders and remains of seals killed by polar bears and Inuit. Hunters kept up considerable snowmobile traffic along the landfast ice edge, and remains of seal kills were not uncommon. We also saw snowy owls regularly at the margins of open-water areas, and they had previously been known to winter in the Belcher Islands (Todd, 1963). Snowy owls are predators of eiders and take both sexes and all ages (Nakashima and Murray, 1988). We observed that owls were always associated with large groups of eiders. Local Inuit have observed

snowy owls taking adult eiders, typically when the eiders loiter on ice edges at night. We also saw a snowy owl take an oldsquaw duck directly from the water. It appeared from our observations that snowy owls moved around the Belcher Islands in response to the changing distribution of eiders, which were responding to variable ice conditions.

#### *Habitat Selection by Marine Birds*

Oldsquaw ducks occurred primarily in polynyas, while king and common eiders occurred at both polynyas and floe edges. Only a few black guillemots were observed at polynyas. In general, numbers of birds in polynyas appeared to be relatively stable over time (Table 2). For example, in five trips to the South Laddie Polynya between 5 and 23 March in 1998, we saw between 80 and 300 oldsquaw. In contrast, birds in open-water areas at floe edges responded to the shifting distribution of ice. For example, the 1000–1500 eiders seen northeast of Wiegand

Island on 6 March 1998 were almost completely gone only three days later, when the ice moved into this area. We could not determine where these birds went, but hunters believe that when ice moves in from the north or east, the birds move to other open-water areas west of the Split or Kugong Islands. This is reasonable, because there was no obvious increase in numbers of eiders in polynyas when the open water at the eastern floe edges disappeared. When the open-water area northeast of the Wiegand Islands opened up again, the eiders returned.

Local hunters conclude that the small numbers of common and king eiders found at polynyas spend the entire winter at these sites and do not move to other open-water areas at floe edges (Nakashima and Murray, 1988). Tests of this theory would require radio or satellite tracking of birds to monitor and compare their movements. If such a dichotomy of habitat use exists, we also predict that diet differences may occur between “resident polynya eiders” and more transient “floe-edge eiders.” Preliminary observations suggest that eiders at floe edges near shore feed on benthic molluscs. In contrast, eiders at polynyas forage on pelagic invertebrates (e.g., Euphausiids), even though all but the South Johnson Polynya are shallow, and eiders can dive to reach the bottom (Table 1). In severe winters, when the landfast ice edge extends far offshore over deep water, we predict that “floe edge eiders” would be forced to forage on pelagic fauna as well.

#### *Utility of Traditional Ecological Knowledge*

Several recent studies have found that traditional ecological knowledge provided valuable information regarding wildlife distribution and abundance (Freeman and Carbyn, 1988; Inglis, 1993; Huntington, 1998). In our study, Inuit hunters were easily engaged in conversations about ice conditions and the ecology of the animals wintering in the open-water areas. Interestingly, the topics and depth of the information depended somewhat on the location where conversations occurred. For example, interviews on the ice were most useful because hunters would relate current conditions of animal distributions and abundance to sea ice conditions. Conversations with individuals in communities were also important, especially those with older men who did not hunt as regularly, because they provided historical information.

We also gathered information about the winterkill of eiders that was reported in the winter of 1991–92 (Robertson and Gilchrist, 1998). The consensus among hunters was that the die-off occurred when open-water areas froze over. Similar die-offs of eiders had occurred previously. In 1964, an estimated 100 000 king eiders died during spring migration in the Beaufort Sea, when open-water leads closed up and prevented birds from feeding (Barry, 1968). A smaller die-off of king eiders also occurred in the Beaufort Sea in 1990 (Fournier and Hines, 1994).

The 1991–92 freeze-up in the Belcher Islands was due to a number of factors that occurred simultaneously over

three days: a period of cold (although not unseasonably cold) weather, the absence of wind, and—most importantly—a weak neap tide. Many groups of frozen eiders (each containing more than 100 birds) were found in “piles” in the northeastern portions of the Belcher Islands after this winterkill. This pile-up may have occurred as ice pushed dead birds together. Alternatively, they may have died in groups as they tried to conserve body heat. Under extreme conditions in which eiders had to spend the night exposed on sea ice, Inuit hunters had observed that several hundred ducks would cluster together into living mounds, apparently to keep warm. Those individuals that landed first and formed the bottom of the pile were often suffocated and crushed. When the flock flew away in the morning, hunters would find these dead individuals frozen into the ice (Nakashima, 1991; Z. Novalinga, pers. comm. 1998). All age and sex classes appear to have been equally vulnerable. Local residents estimate the mortality of common eiders during this single winterkill at more than 10 000 birds. During this time, eiders were also observed flying and landing in abnormal places. For example, they flew through the community, apparently in search of open water. In the most extreme cases, they landed on rooftops and among tethered dog teams.

#### CONCLUSIONS

To date, most research has focused on large polynyas, such as the North Water Polynya in the Canadian High Arctic. Series of small recurring polynyas, such as those in the Belcher Islands, are also biologically important (Stirling, 1997). We found that the polynyas and ice floe edges around the Belcher Islands provide important wintering habitat for populations of marine birds. Significant numbers of common eiders and oldsquaw and smaller numbers of king eiders spend the winter at these areas of open water. Any environmental conditions that alter the formation or maintenance of these polynyas could have important impacts on sea duck populations within Hudson Bay, as apparently occurred in the winter of 1991–92.

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## REFERENCES

- ABRAHAM, K.F., and FINNEY, G.H. 1986. Eiders of the eastern Canadian Arctic. In: Reed, A., ed. Eider ducks in Canada. Report Series No. 47. Ottawa: Canadian Wildlife Service. 55–73.
- BARRY, T.W. 1968. Observations of natural mortality and native use of eider ducks along the Beaufort Sea coast. *Canadian Field-Naturalist* 83:140–144.
- BROWN, R.G.B., and NETTLESHIP, D.N. 1981. The biological significance of polynyas to arctic colonial seabirds. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Occasional Paper No. 45. Ottawa: Canadian Wildlife Service. 59–65.
- EIFRIG, C.W.G. 1905. Ornithological results of the Canadian *Neptune* expedition to Hudson Bay and northward, 1903–1904. *Auk* 22:223–241.
- FERGUSON, M.A.D., and MESSIER, F. 1997. Collection and analysis of traditional ecological knowledge about a population of Arctic tundra caribou. *Arctic* 50:17–28.
- FERGUSON, M.A.D., WILLIAMSON, R.G., and MESSIER, F. 1998. Inuit knowledge of long-term changes in a population of Arctic tundra caribou. *Arctic* 51:201–219.
- FOURNIER, M.A., and HINES, J.E. 1994. Effects of starvation on muscle and organ mass of king eiders, *Somateria spectabilis*, and the ecological and management implications. *Wildfowl* 45:188–197.
- FREEMAN, M.M.R. 1967. An ecological study of mobility and settlement patterns among the Belcher Island Eskimo. *Arctic* 20:154–174.
- . 1970a. Observations on the seasonal behaviour of the Hudson Bay eider (*Somateria mollissima sedentaria*). *Canadian Field-Naturalist* 84:145–153.
- . 1970b. The birds of the Belcher Islands, N.W.T., Canada. *Canadian Field-Naturalist* 84:277–290.
- FREEMAN, M.M.R., and CARBYN, L.N. 1988. Traditional knowledge and renewable resource management in northern regions. Edmonton: IUCN Commission on Ecology and the Boreal Institute for Northern Studies.
- GODFREY, W.E. 1986. The birds of Canada. Rev. ed. Ottawa: National Museums of Canada.
- HUNTINGTON, H.P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. *Arctic* 51:237–242.
- INGLIS, J.T., ed. 1993. Traditional ecological knowledge: Concepts and cases. Ottawa: International Program on Traditional Ecological Knowledge and International Development Research Centre.
- JONKEL, C.J. 1969. White whales wintering in James Bay. *Journal of Fisheries Research Board of Canada* 26:2205–2207.
- KONYUKHOV, N.B., BOGOSLOVSKAYA, L.S., ZVONOV, B.M., and VAN PELT, T.I. 1998. Seabirds of the Chukotka Peninsula, Russia. *Arctic* 51:315–329.
- LOW, A.P. 1906. The cruise of the *Neptune*, 1903–4. Report on the Dominion government expedition to Hudson Bay and the Arctic islands on board the D.G.S. *Neptune*, 1903–1904. Ottawa: Government Printing Bureau.
- MANNING, T.H. 1976. Birds and mammals of the Belcher, Sleeper, Ottawa, and King George Islands, Northwest Territories. Occasional Paper Series No. 28. Ottawa: Canadian Wildlife Service.
- MCDONALD, M., ARRAGUTAINAQ, L., and NOVALINGA, Z. 1997. Voices from the Bay: Traditional ecological knowledge of Inuit and Cree in the Hudson Bay bioregion. Ottawa: Canadian Arctic Resources Committee.
- NAKASHIMA, D.J. 1991. The ecological knowledge of Belcher Island Inuit: A traditional basis for contemporary wildlife co-management. Ph.D. Thesis, McGill University, Montreal.
- NAKASHIMA, D.J., and MURRAY, D.J. 1988. The common eider (*Somateria mollissima sedentaria*) of eastern Hudson Bay: A survey of nest colonies and Inuit ecological knowledge. Report No. 102. Ottawa: Environmental Studies Research Funds. 198 p.
- PETERSEN, M.R., LARNED, W.W., and DOUGLAS, D.C. 1999. At-sea distribution of spectacled eiders: A 120-year-old mystery solved. *Auk* 116:1009–1020.
- PRACH, R.W., BOYD, H., and COOCH, F.G. 1981. Polynyas and seabirds. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Occasional Paper No. 45. Ottawa: Canadian Wildlife Service. 67–70.
- REED, A., and ERSKINE, A.J. 1986. Populations of the common eider in eastern North America: Their size and status. In: Reed, A., ed. Eider ducks in Canada. Report Series No. 47. Ottawa: Canadian Wildlife Service. 156–175.
- ROBERTSON, G.J., and GILCHRIST, H.G. 1998. Evidence for population declines among common eiders breeding in the Belcher Islands, Northwest Territories. *Arctic* 51:378–385.
- SMITH, M., and RIGBY, B. 1981. Distribution of polynyas in the Canadian Arctic. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Occasional Paper No. 45. Ottawa: Canadian Wildlife Service. 7–28.
- SNYDER, L.L. 1941. On the Hudson Bay eider. Occasional Papers of the Royal Ontario Museum of Zoology 6:1–7.
- STIRLING, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. *Journal of Marine Systems* 10:9–21.
- STIRLING, I., and CLEATOR, H., ed. 1981. Polynyas in the Canadian Arctic. Occasional Paper 45. Ottawa: Canadian Wildlife Service. 73 p.
- STIRLING, I., CLEATOR, H., and SMITH, T.G. 1981. Marine mammals. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Occasional Paper No. 45. Ottawa: Canadian Wildlife Service. 45–58.
- TODD, W.E.C. 1963. Birds of the Labrador peninsula and adjacent areas. Toronto: Carnegie Museum and University of Toronto Press.
- WEIN, E.E., FREEMAN, M.M.R., and MAKUS, J.C. 1996. Use and preference for traditional foods among the Belcher Island Inuit. *Arctic* 49:256–264.
- WENZEL, G.W. 1999. Traditional Ecological Knowledge and Inuit: Reflections on TEK research and ethics. *Arctic* 52: 113–124.