UNIVERSITY OF MANITOBA

Climate Change: Linking Traditional and Scientific Knowledge includes papers written by over 50 community experts and scientists addressing theoretical concerns, knowledge transfer, adapting to climate change, implications of changing weather, water and ice conditions for northerners and wildlife, and the impact of climate change on tourism, fire, and industrial development. Northern communities, politicians, managers, policy makers, scientists, and schools will find valuable insights gained by exploring linkages between traditional and scientific knowledge in the north.

> "Climate change is not an abstract ivory tower concept to the peoples of northern Canada; rather it is a very real and important part of their everyday lives. This book provides insights into how traditional and scientific knowledge can act as integrated pedestals supporting our quest to understand and predict the impacts of Arctic climate change."
>
> **Dr. David G. Barber,**
> **Director, Centre for Earth Observation Science (CEOS)**
> **and ArcticNet Leader for Theme 3: Hudson Bay**

Aboriginal Issues Press
Clayton H. Riddell Faculty of
Environment, Earth, and Resources
University of Manitoba
Winnipeg, MB
R3T 2N2
Aboriginal_Issues_Press@umanitoba.ca

Climate Change: Linking Traditional and Scientific Knowledge

Aboriginal Issues Press U of M

Climate Change:
Linking Traditional and Scientific Knowledge

Edited by Rick Riewe and Jill Oakes

Combining Scientific and Local Knowledge to Study Common Eider Ducks Wintering in Hudson Bay

Grant Gilchrist, Joel Heath, Lucassie Arragutainaq, Gregory Robertson, Karel Allard, Scott Gilliland and Mark Mallory[1]

Abstract

The Hudson Bay common eider spends the winter in a remote and inhospitable environment where few other birds could survive. Here we describe how initial local knowledge observations led to a revealing, five-year study by scientists and local residents of the winter ecology and underwater habitat use of this arctic marine specialist.

Introduction

In February, 2001, our team travelled south across the smooth, land fast sea ice of the Belcher Islands. We slowed to a stop and climbed from the snowmobiles and sleds to stretch our legs, warm our feet, and for some, enjoy a cigarette. Despite the temperature of -32°C, everyone acknowledged the sunshine and good travelling conditions. Anyone watching us from a distance would have seen that there were two heights to our group; three were short and of stocky build, whereas the other two were thinner and clearly stood over 6 feet tall. This reflected the make up of our team which consisted of 3 Inuit and 2 biologists.

After Elijah Oqaituk was assured that we were warm enough, he noted the wind direction and commented that eider ducks would be arriving at the *Agiarraluk* polynya that evening; the open water area that was our destination. Elijah took the opportunity to discuss some of the safety precautions related to our destination,

> *The currents are very strong ... so don't fall in. We all smiled at the obvious understatement.*

> *When we are there, we must also watch for bears and for the wind direction when the birds are taking off in the morning. There will be so many of them, that the water falling from them is like rain. If you are standing under them when they fly from the water, this can soak your parka and you can soon freeze to death. Many years ago, one hunter was lost this way.*
>
> *He drew on his cigarette and directed one final comment to us, … and you guys have to be really careful,[gesturing to our height],… because you're already designed to freeze to death.*

Documenting Eider Population Decline: Links to Tropical Volcanoes

In 1996, members of the Hunters and Trappers Association (HTA) of the community of Sanikiluaq, Nunavut, contacted the Canadian Wildlife Service (CWS) to report that common eider ducks in the Belcher Islands had declined dramatically. Common Eiders in Hudson Bay nest along coasts (Schmutz *et al.* 1983), and on small, offshore islands (Manning 1976). These Common Eiders are recognized as a distinct race that does not migrate out of Hudson Bay (Reed & Erskine 1988), but instead spends the entire year in Arctic waters; one of the few marine bird species to do so. A key nesting area for this race of eider duck is the Belcher and Sleeper Islands located in south east Hudson Bay (Freeman 1970).

The community invited the CWS to repeat a survey of nesting islands that had been conducted in the early 1980s (Nakashima & Murray 1988). A repeat of this survey would confirm whether the eider population had declined, and to what extent. With the financial support of the Nunavut Wildlife Management Board, surveys of nesting islands were repeated in 5 regions in the summer of 1997, and it was found that eiders had indeed declined by 80% since the early 1980s despite apparently ideal nesting conditions in that year (Robertson & Gilchrist 1998).

During the summer survey, Inuit commented that in the winter of 1991-92, sea ice had been severe in this region and that eiders had few open water areas in which to feed. Eiders were observed flying around the islands in search of open water, and on several occasions had flown into town to land among the houses; apparently having mistaken the black roof tops for open water. Elsewhere, eiders were found frozen in piles encased in ice having grouped together to conserve energy before they had died.

The timing of this mass die off event, which had previously gone undetected by western science, coincided with the winter of 1992, a year in which lower temperatures were documented throughout the circumpolar arctic. Low temperatures persisted into the summer of 1992 in which many Arctic bird species experienced reproductive failure due to late ice melt and heavy snow cover (Ganter & Boyd 2000). The ultimate cause of these conditions was the Pinatubo volcanic eruption which occurred in the Philippines in 1991. The volcanic effluent from the eruption entered the earth's atmosphere and resulted in lower temperatures throughout the circumpolar Arctic. Although, residents of the Belcher Islands did not know that a volcanic eruption was the ultimate cause of the severe winter in 1992, the heavy sea ice and mass die-off of eider ducks that resulted were quickly detected by them.

Eider Population Dynamics: The Importance of Winter Ecology

The nesting surveys conducted in 1997 confirmed that the regional eider population had declined by as much as 80%, and pointed to the vulnerability of the Hudson Bay eider to die-offs in winter if sea ice conditions constrained their ability to forage. To understand the population dynamics of these sea ducks, both Inuit and biologists agreed that it was necessary to study aspects of their winter ecology in greater detail. In response, the CWS and the community embarked on a multi-year, collaborative research project to examine what marine habitats eiders used in winter, how eiders responded to changes in weather and ice conditions, and how vulnerable they were to starvation.

Many aspects of eider ecology are well understood by Inuit of the Belcher Islands, particularly relating to their nesting locations, winter distribution, and diet (Freeman 1970, Nakashima & Murray 1988). This may reflect that eiders are harvested throughout the year (Wein *et al.* 1996). Indeed, the historical ability of Inuit to persist in the Belcher Island archipelago, where caribou occurred in low numbers or were absent entirely in some years (Flaherty 1918), may have been partly attributable to their ability to hunt eiders even in fall and spring when travel at sea was difficult, and harvest of other marine species was limited.

Here, we briefly review how we integrated methods of both western science and information collected through interviews of local residents in our studies of eider duck ecology. The project necessarily operated at several spatial scales including the entire Belcher and Sleeper islands region (including off-shore marine areas), the landfast ice and polynyas found within the island archipelago itself, and finally at specific polynyas where detailed studies of eider foraging ecology were conducted. We discuss the information in the order in which the research program unfolded, and provide examples of how local ecological knowledge (LEK) directed the research, and in particular, helped identify which environmental parameters most influenced eider foraging ecology in winter; several of which may have otherwise gone undetected (see below).

Collecting Local Ecological Knowledge: General Methods

From the outset of the project in 1998, the team collected LEK regarding eider duck ecology in several ways (Gilchrist *et al.* 2005, Mallory *et al.* in press). Interviews were conducted in the community itself with the assistance of the local Hunters and Trappers Association (HTA) who identified individuals (both men and women) that they felt were particularly knowledgeable about common eider ducks. Two key parameters were communicated to us. Those individuals who used eiders most throughout the year were considered particularly knowledgeable (e.g. meat, down feathers, egging). Second, the degree of knowledge of an individual was thought to vary based upon their time spent in different geographic areas of the island archipelago. For example, portions of the local population grew up in the southern islands as children, before being relocated north to the present day community site of Sanikiluaq in the early 1970s . Those who had grown up in the southern islands were often considered to be most knowledgeable about those geographic areas.

Translators were often required and these individuals were also recommended to the project by the HTA. Topographic maps were familiar to both Inuit and biologists, and their use during interviews helped ensure that everyone was considering the same place, locations were properly named, and that the information collected could be accurately attributed to specific locations (McDonald *et al.* 1997). For example, the average extent of landfast ice edges along coastlines (termed, 'floe edges') could be drawn onto maps directly, as could the movements of eider ducks along their margins (often in relation to prevailing winds).

Informal, but productive discussions were also conducted with Inuit while traveling in winter throughout the Belcher Islands; both among participants of the project and also among other Inuit who we met while travelling. These chance meetings typically resulted in Inuit of both parties discussing their recent experiences while travelling, particularly relating to ice conditions, the wildlife they had seen, and the risks of sudden weather changes. In this way, our team gathered information of eider distribution, movements, and their numbers from a wide geographic region and often over short time scales of only hours or days. Our original travel plans were often adapted to take advantage of new information obtained through these chance meetings and information exchanges.

Marine Habitat Use by Eiders in Winter

During the winters of 1998 and 1999, we circumnavigated the Belcher Islands by snowmobile, visiting accessible open water habitats which included floe edges and polynyas (Figure 1). For each, we recorded their co-ordinates and physical features including depth, and also surveyed the number of birds present at each (Gilchrist & Robertson 2000). Inuit remarked that the eiders present at these sites were the 'polynya birds', and that many more eiders resided further out to sea and only visited polynyas when forced to do so by heavy ice conditions offshore. Under these conditions, which were often temporary, polynyas apparently acted as refugia of open water. In the south, eiders often commuted from floe edges and offshore habitats, arriving at dusk to the *Agiarraluk* polynyas where they roosted over night before returning to offshore habitats at dawn.

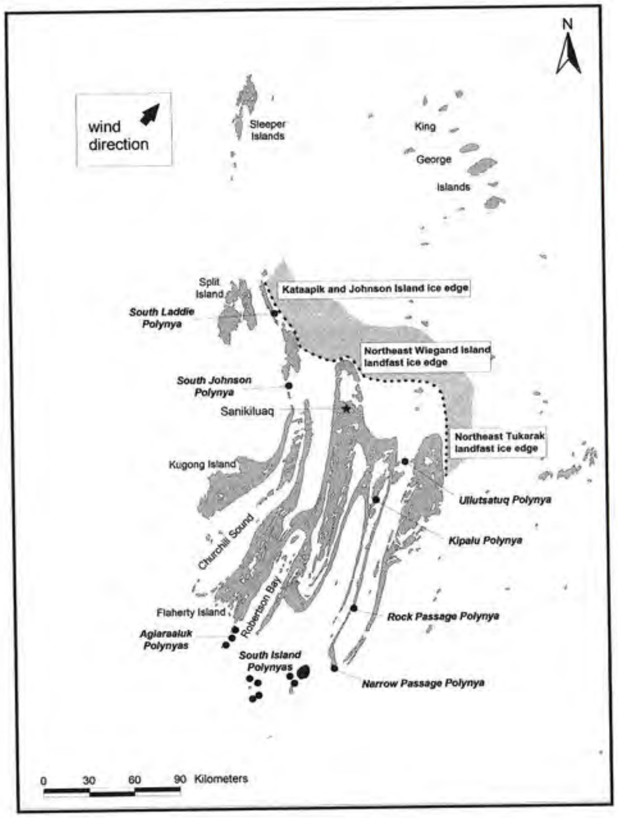

Figure 1. Open water areas of the Belcher islands (based on Gilchrist and Robertson 2000).

It became apparent from these reports that the majority of the eiders rarely visited polynyas. Thus, at least two wintering strategies occurred among eiders in the Belcher Islands; birds that wintered offshore and who occasionally visited polynyas, and those that wintered exclusively at polynyas. Flocks of eiders occurring along coasts in open water were predominantly mature birds in breeding plumage, whereas those residing continuously in polynyas were immature eiders (Nakashima & Murray 1988). However, as biologists and only occasional visitors, we had observed little of this. In fact, we had often arrived at polynyas during the day to find only small numbers of eiders or none at all (Gilchrist & Robertson 2000).

Thus, large numbers of eiders apparently survived offshore and beyond reach of both Inuit and biologists alike, because we could not travel to these areas over the moving pack ice. To confirm the size of these large, offshore flocks and to identify the specific marine locations where they occurred, we all agreed that we required a survey aircraft. In 2001-2003, a deHavilland Twin Otter aircraft and its crew were provided to us by a research grant from the Polar Continental Shelf Project. Although not considered an ideal survey aircraft, its twin engines, two person flight crew, and proven reliability made it a safe option when flying over sea ice in extreme cold. The capacity of the aircraft also allowed a variety of people to participate, including a survey biologist, members of the field crews (both biologists and Inuit), and interested members of the local HTA.

Aerial surveys were flown during February of each year; the period when eiders were most constrained by ice conditions (Figure 2). We anticipated that eiders would be concentrated in narrow "leads" of open water rather than evenly distributed over the marine environment (which was 98% covered with ice at the time). This necessitated that we flew from one open water area to the next, rather than in standardized linear transects typical of most wildlife surveys. This had the combined effect of unsettling everyone's stomachs as we banked in tight circles above eider flocks, and made navigating by visual markers almost impossible when flying over the flat, featureless landscape. The first issue was largely overcome with *Gravol*, and the second by using a computer system linked to the GPS of the aircraft. The system allowed observers to look out the window while simultaneously reporting the number of eiders counted directly into a microphone. This information was instantly recorded as a 'sound-bite' on the computer, and each of these entries was automatically geo-referenced and presented on a map projected on the computer screen. Thus, a quick glance at the computer screen indicated our position, and whether we were flying over a previous flight path and had counted an eider flock already.

The birds themselves were easy to locate because the eider flocks generated their own weather. At temperatures of -30°C or colder, low-lying clouds hung over eider flocks during calm wind conditions. This cloud was apparently generated by the temperature differential between the air and the open water maintained by the ducks themselves, as well as their breath. The size of the common eider flocks at sea (which often exceeded 10 000 individuals), as well as their locations had never been witnessed.

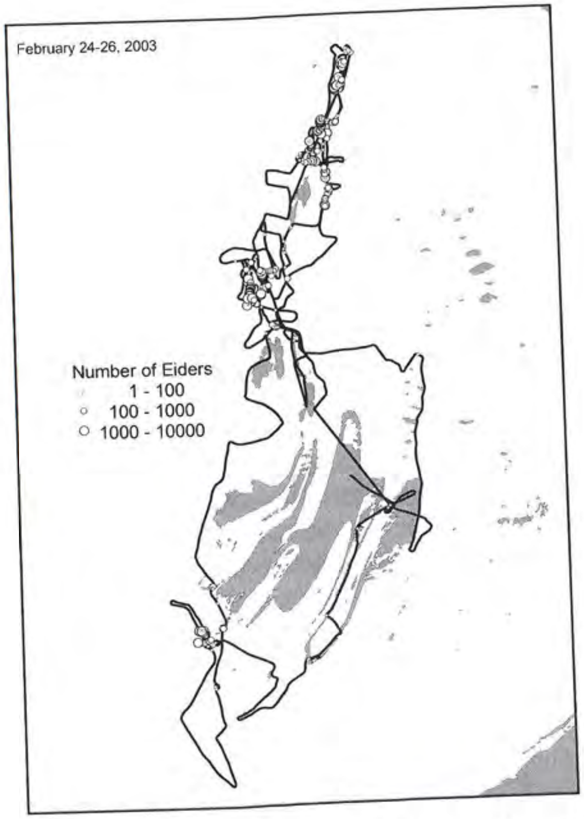

Figure 2. Winter distribution of eider ducks in the Belcher and Sleeper Islands in relation to aerial flight path and eider flock size.

These aerial surveys confirmed that in years of favourable ice conditions, the majority of the Hudson Bay eider population wintered offshore beyond reach of Inuit hunters. Consequently, eiders hunted in winter at polynyas within the Belcher Islands (which were often juvenile birds), suggested that a harvest much greater than exists could be sustained if eiders shot at polynyas were replaced by new recruits each year. Further, harvest of juveniles is known to have a lower impact on waterfowl population dynamics than a harvest that takes predominantly adult birds of breeding age.

Identifying Foraging Constraints of Eiders in Winter

Field Methods

At least two wintering strategies occur among eiders in the region; those wintering predominantly offshore in temporary leads in the sea ice, and those wintering exclusively in polynyas. This scenario, if accurate, may partly explain the observation of Inuit that large numbers of eiders died in polynyas in 1992 even though some polynyas remained open. These reports appeared at first to be contradictory to us, because we had assumed that as long as sea ducks had access to open water and the benthic invertebrates on the sea floor, they could likely maintain themselves. Perhaps the number of eiders and the duration of attendance in polynyas that year depleted their benthic prey and had resulted in their mass starvation (see below). This scenario will never be known with certainty, but forms one of our continuing research priorities.

To address these issues, we initiated research of eider foraging ecology at two polynya areas in the Belcher Islands: *Ullutsatuq* in the northeast, and the *Agiaarluk* polynya cluster located 120 km further south (Figure 1). At each site, we established camps and erected small wooden observation huts (blinds) on the ice edge of the polynyas. These blinds allowed us to observe eiders from concealment, but even more importantly, provided us with shelter from the wind (which often generated wind chills of -50°C or more). Each blind accommodated two people in cramped conditions, but was equipped with a small camp stove that raised the temperature to bearable levels (-15°C).

From blinds, we monitored the foraging activity of eiders in relation to time of day, light conditions, wind speed, weather conditions, and the presence of predators. We also lowered a computerized data logger through the ice that recorded the velocity and direction of tidal currents. Using this equipment, we could later relate the behaviour of eiders to tidal current velocities within the polynyas themselves.

Sea Ice, Water Depth, and Tidal Current Velocity

The polynyas found among the Belcher Islands in winter are maintained by the tidal currents of Hudson Bay which circulate counter clockwise. With each tide, vast quantities of sea water are forced into the Belcher Islands producing strong local currents as water moves between islands and over underwater shoals. Where these passages are both narrow and shallow, the current velocities can exceed 1.5 m/sec and are sufficient to maintain areas of open water even at -40°C. At these temperatures, ice begins to form immediately at slack tide, only to be broken up again as the currents switch direction and accelerate once again.

These areas of open water, termed *polynyas*, recur each year in predictable locations (McDonald *et al.* 1997). In February and March, the periods of the most extensive ice cover, there are about 15 polynyas present in the Belcher Islands, and at some of these, clusters of 3-6 open water areas occur in close proximity to each other (Figure 1). When viewed from an adjacent hill top, these polynyas appear as oases of open water in a landscape of ice. Common eiders and long-tailed ducks often occupy these open water areas, and they in turn attract predators such as arctic fox, snowy owls (Robertson & Gilchrist 2003), and at the *Agiaralluk* polynya, resident gyrfalcons.

All the polynyas but one in the Belchers are shallow, 12 m depth or less; Gilchrist & Robertson 2000). If you were to lay down on the ice edge of a polynya and peer into its clear waters, you could see the bottom in most cases and could make out the mussels and sea urchins on which eiders feed. Thus, the depth of the sea floor within polynyas is well within the foraging range of eiders, and is hardly a foraging constraint when tidal currents are slack. However, tidal currents in polynyas are rarely slack, and eiders attempting to forage on the sea floor at high current velocities are at risk of being swept under the ice to their death. When feeding at polynyas, we observed that eiders dove into the current and under the sea ice. As the currents gradually accelerated, the birds congregated together on the sea surface in large flocks. As the current continued to strengthen, the eiders cold no longer dive nor maintain their positions when swimming against it; at which point they left the water entirely to sit on the ice edge. There, they roosted together to wait for the tide to slacken. When this behaviour was related to the current data in 10 m of water, we found that eiders left the polynya when currents reached approximately 0.8 m/sec.

Diving Energetics, Oxygen Constraint, and Computer Simulations

After feeding underwater, eiders returned to the surface, sometimes holding an urchin in their bill. They manipulated them to break off their spines and then swallowed them whole. Consequently, when observing eiders from blinds, we had the impression that urchins were the primary prey item of their diet. Given the clear water and relatively shallow depths, it was feasible to photograph eiders foraging underwater on the sea floor. We designed an underwater video photography system in which we lowered a camera in a waterproof casing through a hole in the ice, and then controlled its use from a blind on the sea ice above.

This video photography showed that eiders ingested mussels underwater, and only occasionally returned to the surface with an urchin. Thus, our surface observations had clearly over-represented the relative importance of urchins in their diet. This video also allowed us to quantify the number of wing strokes required by eiders to swim to the bottom, their rate of descent, and the time spent foraging on the bottom during each dive; all in relation to tidal currents. The energetic expenditure of diving increased as currents accelerated over the tide cycle, whereas time available for eiders to feed on the bottom simultaneously declined (Heath *et al.*, in press).

As predicted, eiders gained most energy per dive when foraging in slack currents. Further, the energy expended to dive during moderate currents sometimes exceeded the energy ingested per dive (depending on water depth); thereby generating a 'negative energy balance'. This generated the counter-intuitive result that, to conserve their energy, eiders should stop foraging during extended periods of the tide cycle under conditions when diving to the bottom was still feasible (Heath *et al.*, in press). A negative energy balance could also occur if prey were depleted and/or thinly distributed over the sea floor. If these foraging conditions persisted, as may have occurred in 1992, they would result in the eventual starvation of eiders. Thus, although tidal current maintained open water habitats for eiders, it was also one of the key foraging constraints of eiders which determined their energetic gain (or loss) each day.

Digestive Constraints

Underwater video photography provided the information necessary to explore interactions between locomotion, oxygen balance, energy gain, and tidal currents. Eiders make many dives within a day, and it is necessary to evaluate energy budgets of eiders in response to changing currents over successive tide cycles. For example, when considering the influence of current velocity alone on energy intake, we had already calculated that eiders gained most energy per dive when currents were slack. However, we observed in the wild that many eiders were inactive and sleeping on the water during these slack periods, and instead foraged actively in moderate currents. We were overlooking something.

Eiders feed on mussels and sea urchins which they swallow whole and subsequently grind internally in the gizzard. The internal processing of hard shelled prey takes time, and limits the number and quantity of prey items an eider can ingest at once (termed a "digestive rate constraint"). Integrating information of energetic intake and this digestive constraint in a computer simulation model, generated the prediction that eiders should feed intensively as currents slacken, digest this prey during slack tide, and then feed intensively in moderate currents before being forced to leave the polynya prior to the peak of the tidal current velocities (see above). Thus, eiders could leave the polynya full of benthic prey which they could digest during a period of forced inactivity. In doing so, eiders could feed twice during a tide cycle, whereas they could feed only once if they only foraged during slack tide.

These findings emphasized the importance of integrating physiological processes and environmental constraints over time. We now are extending this approach to evaluate the energy budgets of eiders during the lunar cycle, and over an entire winter.

Habitat Protection

Our LEK and scientific investigation had shed considerable new light on the ecology and seasonal constraints placed on eiders over-wintering in Hudson Bay. However, the work also yielded a critical, more applied result: identifying key habitats of eiders in winter.

It has been known for some time that many eiders bred in Hudson Bay and remained in this region over the winter (Freeman 1970, Manning 1976), although accurate population estimates were not available. Based on some of these early studies, several nesting areas of the Belcher Islands were identified as key terrestrial habitat sites, and important bird areas in Canada (Alexander *et al.* 1991, CEC 1999). The new information has shown that many of the polynyas are critical winter habitat, perhaps more important than any one nesting area, and that in fact there are essential, recurrent offshore lead areas where the bulk of the eider population over-winters. Based on the recent findings, these areas are now identified as key marine habitats for birds in Arctic Canada (Mallory & Fontaine 2004). Furthermore, the size of the eider population they support, and the other wildlife which rely on these areas (Gilchrist & Robertson 2000, Robertson & Gilchrist 2003), provide strong support for protecting these leads and polynyas as Marine Wildlife Areas.

Summary

In the pre dawn twilight we waited in silence overlooking the *Agiarraluk* polynya. We watched a flock of eiders that was so dense, we had first mistaken it as sea ice that had formed across the polynya during the night. The timing and location of our presence, and the opportunity to observe this spectacle was the culmination of five years of research that applied a diversity of approaches including the collection of LEK. Here, in the Belcher Islands, LEK and scientific methods had complemented each other and had quickly directed our studies to those factors most relevant to the conservation of eiders. Scientific methods including offshore aerial surveys, standardized observation techniques, computer simulation models, and underwater photography had also provided new insights into their winter ecology.

As we watched the eiders milling on the sea surface of the polynya, we now knew what had brought them here, where they had come from, and why they wouldn't stay. We also knew the exact timing of their departure (sunrise), and that if you visited the polynya at noon, you would have underestimated the number of eiders these polynyas sometimes supported.

As the sun rose, the light penetrated the ice fog hanging over the polynya and obscured the eiders behind a shimmering curtain of orange light. Within moments, the eiders took flight in a thunderous roar and left the polynya in a long line, flying low over the ice in the direction of the offshore leads that we had observed from a plane just a few days earlier. The departure of 40 000 eiders from the polynya took nearly 40 minutes. Only after the last eiders had disappeared over the ice did we suddenly acknowledge our extreme cold. As we climbed stiffly from the blind, having finally observed the eider exodus, we consoled ourselves that at least we had not been sitting in the rain underneath their departure.

Acknowledgements

ArcticNet Network of Centres of Excellence of Canada Project 2.1 Changing Food Diversity, Wildlife Patterns and Exploitation, and Project 3.6 People and Environmental Change: Engaging Local and Scientific Knowledge in Hudson Bay Coastal Communities are thanked for financial support which made this research possible.

References

Alexander, S., Ferguson R., & McCormick, K. 1991. *Key migratory bird terrestrial habitat sites in the Northwest Territories.* Canadian Wildlife Service Occasional Paper No. 71, Ottawa.

CEC. 1999. *North American Important Bird Areas.* Commission for Environmental Cooperation, Montreal. 359 pp. (see also www.ibacanada.com).

Flaherty, R. 1918. The Belcher Islands of Hudson Bay: their discovery and exploration. *Geographical Review* 5: 433-458.

Freeman, M. 1970. Observations of the seasonal behavior of the Hudson Bay Eider. *Canadian Field Naturalist* 84: 145-153.

Ganter, B., & Boyd H. 2000. A tropical volcano, high predation pressure, and the breeding biology of arctic waterbirds: a circumpolar review of breeding failure in the summer of 1992. *Arctic* 53:289-305.

Gilchrist, H. , Mallory, M. & Merkel, F. 2005. *Can Local Ecological Knowledge contribute to wildlife management: Case Studies of migratory birds.* Ecology and Society 10: 20 [online]. http://www.ecologyandsociety.org/vol10/iss1/art20

Gilchrist, H. & Robertson, G. 2000. Observations of marine birds wintering at polynyas and ice edges in the Belcher Islands, Nunavut. *Arctic* 53: 61-68.

Gilchrist, H. & Robertson, G. 1999. Population trends of gulls and Arctic terns nesting in the Belcher Islands, Northwest Territories. *Arctic* 52: 325-331.

Goudie, R. , Robertson, J. & Reed A. 2000. Common Eider (*Somateria mollissima*). *In: The Birds of North America*, No. 546. Poole, A. & Gill, F. (Eds.). Birds of North America, Inc., Philadelphia, PA.

Hamilton, D. 2000. Direct and indirect effects of predation by common eiders and abiotic disturbance in an intertidal community. *Ecological Monographs* 70: 21-43.

Heath, J., Gilchrist, H. & Ydenberg, R. (In Press) Regulation of stroke patterns and swim speed across a range of current velocities: diving by Common Eiders wintering at polynyas in the Canadian Arctic. Journal of Experimental Biology.

Heath, J., Gilchrist, H. & Ydenberg, R. Can dive cycle models predict patterns of foraging behaviour? Diving by Common Eiders in an Arctic polynya. Submitted.

Mallory, M., Braune, B., Wayland, M., Gilchrist, H. & Dickson, D. 2004. Contaminants in Common Eiders (*Somateria mollissima*) of the Canadian Arctic. *Environmental Reviews* 12: 197-218.

Mallory, M., Akearok, J. & Gilchrist, H. 2006. Local ecological knowledge of the Sleeper Islands and Split Island: a baseline for future study. *In press.*

Mallory, M. & Fontaine, A. 2004. *Key marine habitat sites for migratory birds in Nunavut and the Northwest Territories.* Canadian Wildlife Service Occasional Paper No. 110.

Manning, T. 1976. *Birds and mammals of the Belcher, Sleeper, Ottawa, and King George Islands, of the Northwest Territories.* Canadian Wildlife Service Occasional Paper No. 28.

McDonald, J., Arragutainaq, L. & Novalinga, Z. 1997. *Voices in the Bay.* Canadian Arctic Resources Committee, Ottawa. 98 pp.

Nakashima, D., & Murray D. 1988. *The common eider (Somateria mollissima sedentaria) of eastern Hudson Bay: a survey of nest colonies and Inuit ecological knowledge.* Ottawa: Environmental Studies Revolving Fund Report No 102.

Robertson, G.,& Gilchrist, H.. 2003. Observations of Snowy Owls, *Nyctea scandiaca*, wintering in the Belcher Islands, Nunavut. *Journal of Raptor Research* 37: 164-166.

Robertson, G., & Gilchrist, H. 1998. Evidence of population declines among female Common Eiders breeding in the Belcher Islands. *Arctic* 51: 300-315.

Schmutz, J., Robertson, R, & Cooke, F.. 1983. Colonial nesting of the Hudson Bay eider duck. *Can. J. Zool.* 61: 2424-2433.

Wein, E., Freeman, M., & Makus, J. 1996. Use and preference of Traditional Foods among the Belcher Island Inuit. *Arctic* 49: 256-264.

---

[1] Grant Gilchrist works for the Canadian Wildlife Service in Ottawa. Joel Heath is a PhD student in the Biology Department at Simon Fraser University. Lucassie Arragutainaq works for the Hunters and Trappers Association in Sanikiluaq, Nunavut Territory. Gregory Robertson works for the Canadian Wildlife Service in Newfoundland. Karel Allard is a PhD student in the Biology Department at the University of New Brunswick. Mark Mallory works for the Canadian Wildlife Service in Iqaluit, Nunavut.